

# Update in Anaesthesia

Education for anaesthesia providers worldwide

**Volume 36**

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## **EDUCATION / COVID-19**

- Lesson planning for Anesthesiologists: A simplified approach
- Teaching in the clinical environment
- The effective planning and delivery of the large group lecture in medical education: Not a thing of the past
- Remote learning: Opportunity in necessity
- Simulation-based education – how to get started
- Introduction to debriefing
- Feedback in medical education is a journey; pack more than a sandwich
- Mentoring in medical education
- Anesthesia curriculum design for the global setting
- The practice of assessment
- The constancy of change – adapting anesthesia medical student education in the time of COVID-19
- The role of Anaesthesiologists in the COVID-19 pandemic: practical lessons from Groote Schuur experience
- Basic principles of ultrasound and the use of lung ultrasound in the COVID-19 pandemic
- Perceived stress levels among anaesthesia and intensive care staff during the third wave of COVID-19 pandemic: a report from Afghanistan
- Non-operating room anesthesia during COVID-19 pandemic era
- ICU experience of a Nigerian resident intensive care doctor on posting in United Kingdom at the height of first wave of COVID-19 pandemic
- Validation of Apple Watch heart rate monitoring for patients under general anaesthesia
- Atrial myxoma complicating the course of ARDS: A case report
- A Case Report: Anaesthetic management of a patient with suspected tracheal amyloidosis

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## Editorial

This edition of the UIA has been 2 years in the making, and I thank all the contributors for their patience and fortitude. We had hoped to publish it at the time of WCA in Prague in September last year, but no sooner had the COVID-19 pandemic subsided in one part of the world, then it raged in another part, and clearly our patients come first.

Volume 36 is the penultimate hard copy version of the UIA, as the WFSA Board has decided to continue the journal as an on-line one from now on, with all the peer-reviewed articles being published on the WFSA website. The final hard copy will be our Paediatric edition of the journal.

I feel very privileged to be editing volume 36, as our colleagues from the WFSA Education committee have contributed 11 fantastic Education in Anaesthesia articles. These have been written and peer reviewed by colleagues from all over the world and cover very many aspects of Anaesthesia Education. Faye Evans and Sonia Akrimi have commented as follows:

“Progress towards universal health coverage, and fulfilment of the UN Sustainable Development goals, require sufficient numbers of well-trained healthcare workers globally, and therefore requires investment in Human Resources for Health. This is especially evident within anaesthesia, where the current lack of physician and non-physician anaesthesia providers in many countries globally, significantly prevents the needs for safe anaesthetic care for the entire population being met.

Medical Education is an essential, indispensable component of Human Resources for Health. Without formal training in how to teach, we are, as a medical profession, limited in our ability to train new generations of high-quality specialists equipped with the clinical and non-clinical skills needed to help grow anaesthesia, and develop safer surgical care.

This contribution of Medical Education articles to Update in Anaesthesia is inspired by our belief that for anaesthetic care to develop, both training in medical education and the opportunity to share training ideas and resources must be easily accessible for all who

practice anaesthesia. This edition presents a range of articles developed with anaesthesia practitioners from around the world in mind, equipping each of us with practical tips on how to improve our teaching practice, how to develop our education programmes, and how to share innovations with each other to help advance anaesthesia training globally.

These articles are of course set against the backdrop of the COVID-19 pandemic, which continues to have huge impact on anaesthesia practice and training. Special attention has been given to recognise how the pandemic is shaping anaesthesia training, as well as advice, case studies and examples from medical education literature which help outline how we can continue to adapt to ensure high-quality education continues and grows.

Articles have been authored and reviewed by anaesthetists and educationalists from low, middle and high-income settings, with an ethos of sharing learning between institutions and countries and making examples of good practice easily available to others.”

I thank them both for making this happen.

We then have some fascinating insights into different aspects of the COVID-19 pandemic that have not previously been covered, from different parts of the world. This is followed by a few general topics covered in case reports and letters.

We welcome your contributions to the journal, and if you have any suggestions about the journal or manuscripts that you would like to be published, please do not hesitate to get in touch. You can find contributor guidelines and submit manuscripts directly through our online submission system at <https://resources.wfsahq.org/update-in-anaesthesia/uia-authors-page>

Once again, a huge thank you to all our contributors.

**Christina Lundgren**

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**Faye Evans and Sonia Akrimi**

Volume 36 Leads

## **Lesson planning for anesthesiologists: A simplified approach**

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### **Abstract**

Anesthesiologists are responsible for teaching in-person and online, often with little formalized training in medical education and lesson planning. This review presents a “backwards approach” to lesson planning with the aim of guiding and simplifying the process for anesthesiologist teachers. The first step in lesson planning is the creation of learning objectives which should be specific, measurable, and reasonable in number. The instructor then needs to consider which assessment methods might be used to measure the extent to which the learning objectives have been achieved by the learner group. A needs assessment of the learner group will help to refine the learning objectives and assessments methods and will provide context for the learning activities. The timeline and types of interactive learning activities chosen to present the material should be clearly outlined (often using a lesson planning template) so that a road map is created for the teaching session. Finally, the teacher’s reflections on the teaching session can incorporate the results of assessments and feedback from learners to guide future iterations. This backwards lesson planning method can be successfully implemented for both in-person and online learning and provides an organized approach for novice and experienced anesthesiologist teachers alike.

**Key words:** Backwards Lesson Planning; Medical Education; Learning Objectives; Needs Assessment; Assessment

### **INTRODUCTION**

Anesthesiologists are called upon to teach both didactically (in a “classroom” setting) and clinically (at the bedside or in the operating room), often without formal teacher training in either setting. While most anesthesiologists plan and execute their teaching using techniques modeled for them during their own pre-medical and medical education experiences, few anesthesiologists have received formalized training in lesson planning. However, some teachers in anesthesiology have completed advanced training in medical education. Examples of such training opportunities include medical education graduate level programs, specific teaching courses such as the INSPIRE course<sup>1</sup> and local variations of the “Teaching Excellence Program”<sup>2</sup>. Self-guided online teaching resources are also accessible to those with access to the internet<sup>3,4</sup>. Some anesthesiologists may have prior career experience in teaching and lesson planning (at the elementary, secondary school, or university level).

Since teachers in anesthesiology may not have received any formalized training in educational design and delivery, common issues encountered in teaching can

include a lack of focused learning objectives, inadequate measurement of student learning, and logistical issues related to the choice and delivery of lesson content. Approaches to lesson planning have been presented in the nursing<sup>5,6</sup> and medical education literature<sup>7</sup>. Articles related to lesson planning specifically in anesthesiology have also been published<sup>8</sup>. While these resources can be both informative and grounded in educational theory, for example Gagne’s educational theory<sup>8-10</sup>, they can sometimes be overly prescriptive or complex for novice teachers.

Educators must also take into account the differences in skill and knowledge level of medical learners, as well as the different learning styles that might appeal to these adult learners. When planning a lesson, medical educators must be deliberate and selective in choosing both the content and delivery methods of their lessons in order to maximize the chances of their students achieving the learning objectives.

This review article aims to present a simple guide to planning a lesson using a modified “backwards

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approach”, which was originally outlined by Wiggins and McTighe<sup>11</sup>. This approach emphasizes the crafting of measurable learning objectives and the creation of a clear, time-managed plan of interactive learning activities that can be deployed both in-person and online.

### Backwards approach to lesson planning

This article offers a “backwards approach” to lesson planning, which is visually depicted in Figure 1. The first step of the backwards approach is the creation of learning objectives which describe what the learner should be able to know or accomplish by the end of the lesson<sup>11</sup>. In the second step of lesson planning, the teacher determines which assessment methods will be used to decide if the learners have achieved the learning objectives. This step is important as otherwise it will be unclear to what extent the students have met the learning objectives. Step three is a needs assessment of the learner group, where the specifics of the learners are considered. This will include an evaluation of their baseline level of knowledge and experience related to the subject matter. The results of the needs assessment will help shape the lesson and may require some modification of the first two steps. Educators must keep in mind that the lesson planning process is iterative, so it would not be unusual to have to revise the learning objectives and the assessment methods based on learner needs determined in step three. The final step is the creation of the actual lesson, using a variety of teaching methods and activities. For illustrative purposes, this article will use the example of teaching anesthesiology residents about handover of patients to post-anesthesia care unit (PACU) staff using a standardized checklist (see Appendix 1 for checklist). This example will be expanded upon in each section of the article, in order to provide a real-world example of the backwards lesson planning method, as well as a sample lesson plan using a template.

The reason that this lesson planning approach is described as “backwards” is that it begins with the “end goal” in mind: the achievement of the learning objectives by the students. A more traditional approach to lesson planning might be one where the teacher creates a Powerpoint presentation or slide deck on a topic, and only then circles back to pick and choose learning objectives from the presentation content. The backwards approach is advantageous as it forces the instructor to be deliberate about creating learning objectives from the start, and to incorporate a plan to assess whether students have achieved the desired objectives.

Step 1 is the creation of specific, student-centred learning objectives, followed by Step 2 where the teacher chooses how to assess whether the desired learning has occurred. Step 3 is a needs assessment of the learner group, and this may help to refine the learning objectives and assessment methods. In step 4, the teacher chooses a variety of interactive learning activities to present the material in an engaging and time-conscious fashion.

After the teaching session is done and the lesson plan has been implemented, it is important to reflect on the effectiveness of the approach. The instructor should determine whether the students have achieved the intended learning objectives and if the material was presented in way that promoted active, participatory learning. Feedback from students and the results of any student assessments of learning will help to guide this reflective process, and this information can iteratively improve future teaching sessions.

#### Step 1: Learning objectives

A learning objective is a concise statement that clarifies what the learner should be able to know or do as a result of a learning experience<sup>12</sup>. Learning objectives should be student-centred and focus on what the student will achieve, rather than teacher-centred, concentrating on the information the teacher wishes to impart. While the nomenclature and theory behind the creation of learning objectives is a subject that warrants its own reviews<sup>13,14</sup>, this guide to lesson planning is meant to be a very practical one for anesthesiologist teachers looking to improve their teaching sessions in the real world. Teachers can start by asking themselves: “By the end of my teaching session, what do I expect the student to know, and in how much detail?” Guidance from online resources can be helpful for medical educators crafting learning objectives<sup>12,15</sup>.

Medical educators have traditionally used Bloom’s Taxonomy to classify objectives at various levels of learning, and to help them create objectives using descriptive verbs<sup>14</sup>. Bloom’s Taxonomy is a hierarchical classification of learning, from lowest complexity (remember) to highest complexity (create). There are 6 levels or categories of learning/skill within Bloom’s taxonomy. The taxonomy is often presented as a pyramid, with associated key verbs for each level that can be incorporated into learning objectives.

Suggestions for verbs to incorporate into learning objectives at the various different levels of Bloom’s taxonomy are presented on the right hand side of the diagram.

Using the example of teaching handover in the PACU, imagine that you are given an hour to speak to the residents over Zoom (online teaching/meeting platform) at their academic half day. The residency

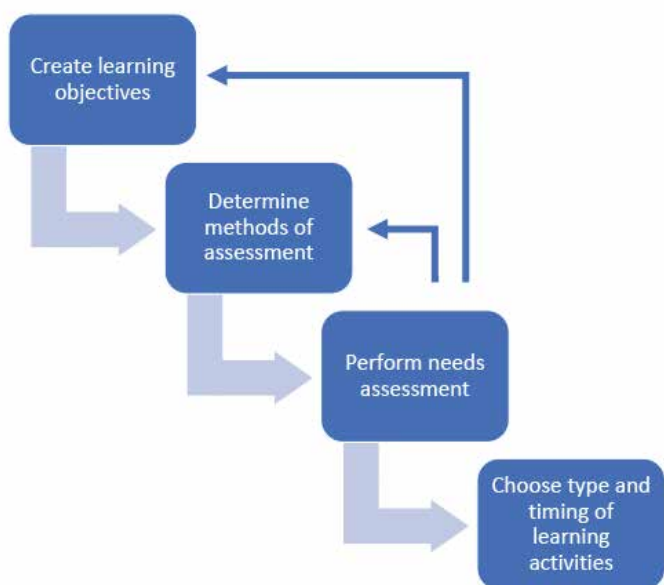
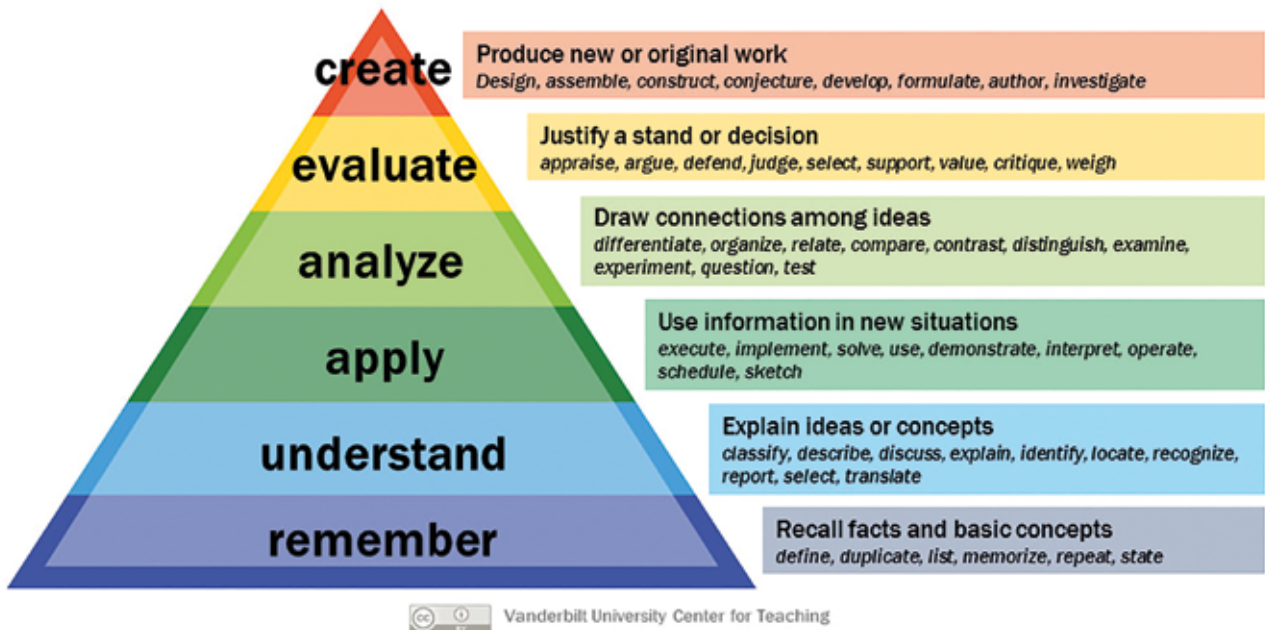


Figure 1. A modified “backwards” approach to lesson planning

# Bloom's Taxonomy



**Figure 2.** Bloom's Taxonomy (used with permission from Vanderbilt University, under Creative Commons Attribution-NonCommercial 4.0 International License)

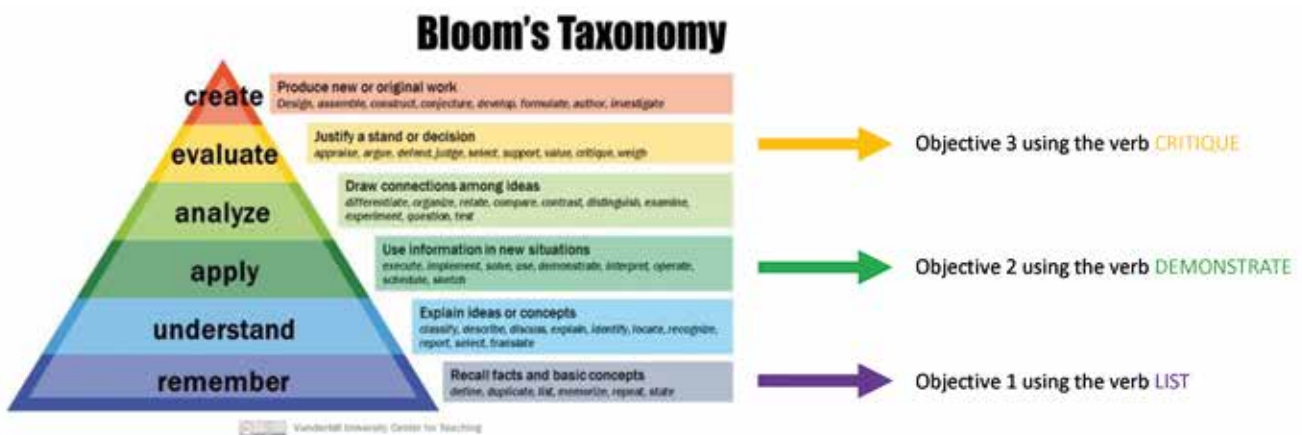
program has asked that you teach about the Anesthesia Patient Safety Foundation (APSF) succinct PACU checklist/approach to handing over patients to the nursing staff after surgery (See Appendix 1 or visit <https://www.apsf.org/article/improving-post-anesthesia-care-unit-pacu-handoff-by-implementing-a-succinct-checklist/>).

In this scenario, you may be given several learning objectives (often based on the residency program training curriculum) or you may need to develop a reasonable number of learning objectives. Let's say that you decided to develop 3 learning objectives for your 1 hour session. Depending on your learner group, it is a good idea to create learning objectives at different levels of Bloom's taxonomy, with some objectives at the lower levels (remember, understand, apply) and some at the higher levels, if appropriate (analyze, evaluate, create).

Using the suggested verbs from Figure 2, you create the following 3 specific and measurable learning objectives for the residents:

By the end of the session, students will be able to:

1. List the three elements of the APSF's succinct PACU handover checklist (REMEMBER level)
2. Demonstrate a PACU handover during a role-play with a partner, using the succinct PACU handover checklist (APPLY level)
3. Critique a sample video of a PACU handover, providing 2 examples of desirable handover behaviours and 2 examples of undesirable handover behaviours (EVALUATE level)



**Figure 3.** Mapping learning objectives to Bloom's taxonomy

Learning objectives at 3 different levels of Bloom's taxonomy have been created using appropriate verbs

### Step 2: Determination of assessment method

Assessments of learning can take many forms, and assessments can be formative or summative. Formative assessments are those intended to provide feedback to the learner at a certain point in time, usually without high stakes consequences. Formative assessments are frequently used to frame daily feedback in residency training<sup>16</sup>. Summative assessments are usually the final stages of assessment, are tied to an outcome, and relate the learner's performance to a certain standard or benchmark<sup>16</sup>. Summative assessments are those which are used to make decisions about pass/fail status or progression to next level of training. Most of the assessments taking place in the context of lesson planning in anesthesiology education are therefore formative. Examples of various methods of assessment are presented in Figure 4.

Despite providing clear learning objectives and engaging in stimulating participatory teaching activities, anesthesiologist teachers sometimes fail to assess the learners for evidence that they have achieved the intended learning objectives. While it is important to consider the consequence and scope of the chosen assessment methods<sup>17</sup>, teachers must incorporate some form of assessment of the learning objectives, as it will foster learner participation and provide the instructor with information about the success of the content delivery. This feedback will shape future iterations of the teaching sessions. If none of the students can achieve the intended learning objectives, the instructor must consider whether there is a mismatch between the objectives, the knowledge level of the learner group, the educational delivery methods, or the assessment methods themselves.

Coming back to our example of the PACU handover, there are several possible assessment methods that could be considered for the resident group. These might include a written multiple-choice quiz (in-person or online), a simulation session where the residents

practice the PACU handover and receive formative feedback on their performance, or a videotaped "live" handover in the actual PACU, with a checklist evaluation that documents any crucial missed steps or information. One can see that while some assessment methods might involve a minimal amount of time or resources, others might represent expensive, time-consuming or resource-heavy activities.

### Step 3: Conducting the needs assessment

A needs assessment is a set of steps or processes that is used to determine the gap or deficit between the current skill and knowledge level of an intended learner group and the desired outcome of the teaching<sup>18</sup>. Without the results of a needs assessment, a teacher will not be aware if the lesson is covering information that the learners already know well, or if the information that will be presented is well above the current knowledge level of the learners and thus the learning objectives may prove to be unrealistic for a particular group. A needs assessment may be performed by having the learners provide information to you directly about their learning needs or by completing some form of pre-test prior to the lesson. Alternatively, you can acquire information from a course coordinator, previous teachers, or by looking at the broader curriculum to see what the learners have covered in the past.

Depending on the situation, the learner group may be quite homogenous and the gap between current knowledge status and desired outcome may be obvious and realistically surmountable for both the students and the teacher. However, if the learner group is quite varied (novices and experts in the same group) or if the desired learning outcomes of the students compared to those of the teacher are quite different, this must be addressed before choosing appropriate teaching methods and activities. The results of a needs assessment may lead the teacher to review and refine the learning objectives to meet the needs of the learner group rather than to arbitrarily address learning objectives selected from a standardized curriculum. There will usually exist some level of discrepancy between the learning objectives as determined by the instructor, and the learning needs and desires of the learner group.

For our PACU handover example, the instructor will want to know the following information about the resident learners: What level of clinical experience do the learners have? Have they previously had lectures of this subject, and what is their level of baseline knowledge on handovers in general? How will the teaching session take place (in-person or online) and how familiar is the group with the proposed technology? Are there any barriers to the learning in the session (including resources, technology, divided attention, fatigue, biases)? What do the learners themselves wish to know about PACU handovers, especially if this differs from the prescribed learning outcomes as chosen by the instructor or as outlined in the residency curriculum? A quiz, survey or brief group discussion can provide much of this information to the instructor.

### Step 4: Planning the learning activities

The choice of learning activities and instructional delivery methods in medical education is a vast topic<sup>19,20</sup>. Much of our medical education delivery can be opportunistic and loosely-planned, especially in the clinical setting). When the opportunity to plan ahead and be selective



Figure 4. Examples of various methods of assessment



about learning activities presents itself, it makes good sense to ensure that the chosen activities are engaging, participatory and varied throughout a teaching session<sup>21</sup>. Medical educators have generally moved away from the podium-style lecture where the presenter reads a succession of slides to the audience. Instead, teachers are using different media (art, photos, videos) to stimulate group discussion. Small group debates and partner activities where learners interact can often be included during teaching sessions. Case-based examples and interdisciplinary learning opportunities are options that provide variety compared to traditional “lecture-style” content delivery. With the COVID-19 pandemic, there has been a shift to online educational activities for many medical learners. While this technology-facilitated learning can be limiting in some ways, it has also opened avenues to teaching and learning collaborations that span time zones and geography in a way that has not been previously embraced. There are also major implications for the delivery of medical education to groups in areas with previously limited access, although this may still be technology- and resource-dependent.

Many interactive teaching activities can still occur online, including small group activities using breakout room technology, where the larger group is broken into a number of smaller groups for discussion before all students are “returned” to the lecture. The use of whiteboards and polling allows for interaction between the online presenter and the participants. The option for participants to type in questions to a chat or to interact with a question/answer function within presentation software also ensures engagement of the participants without undue disruption to the lesson.

Both in-person and online teaching sessions must be planned out using a realistic timeline which ensures that all objectives are addressed. Interactive learning activities may take longer than purely didactic teaching. Time may need to be built into lesson plans for breaks and anticipated technological interruptions or difficulties. Limitation in available time for teaching sessions due to clinical commitments further reinforces the importance of choosing a reasonable number and scope of learning objectives as the first step of lesson planning. Creating too many learning objectives or using learning objectives at too high of a Bloom’s level can lead to frustration on the part of the teacher and the learner.

Lesson plan templates are useful tools for mapping out the timing and scope of learning activities. Different examples of lesson plans can be found online<sup>22</sup> and these can be customized to suit the needs of the teacher/learning group. An example of a completed lesson plan template for the sample PACU handover lecture is included (Appendix 2). This example includes a variety of interactive learning activities including viewing and discussion of a PACU handover video, and a role-playing exercise among learners. It incorporates and outlines all 4 steps of the backwards lesson planning process.

Sharing lessons plans with students before or after a lecture may increase their motivation and engagement with the lesson<sup>23</sup>. Having a written lesson plan can also provide direction for a colleague should an instructor become unavailable at short notice. The sample lesson plan presented in Appendix 2 incorporates a clear activity timeline and includes links to various resources used in the lesson. The lesson plan can be used and modified by a variety of anesthesiologist teachers, based on the needs of current and future learner groups.

## Reflection on teaching

Feedback on the lesson plan can be obtained in multiple ways. One method is the use of planned formative student assessments as a means of determining the “success” of the teaching session. These assessments can reveal the extent to which students achieve the learning objectives that were chosen and can identify major learning gaps. Other practical aspects of the lesson should be considered as well. For example, if the instructor ran out of time and had to skip over important material, the lesson plan for future iterations should be altered. If there were technologic or connectivity difficulties, these can be addressed before future lessons. If the teacher perceived that certain learning activities failed to engage student participation, other methods of lesson content delivery might be chosen in the future.

Many online meeting and teaching platforms have a recording function available. The ability to record the teaching session (with the learners’ consent) provides the opportunity for peer teacher review. This can provide useful insights for the instructor. Since many lessons will be delivered again to future groups of students/residents, lesson planning is an iterative process that can be modified and improved each time the content is delivered. Furthermore, reflection on the instructor’s teaching and the feedback from learners can help with the instructor’s professional development as a medical educator.

## CONCLUSION

The backwards approach to lesson planning ensures that the instructor begins “with the end in mind.” Learning objectives and assessment methods for these objectives are created prior to determining the type and scope of learning activities that will best suit the needs of the learners. The use of a lesson plan template can help the anesthesiologist teacher create a clear road map and ensure that all steps of the backwards lesson planning method have been addressed. Reflection on the quality of the teaching, and feedback from learners and from learner assessments can refine future lessons. The simplified approach to lesson planning presented in this review will promote skills and confidence for anesthesiologists teaching medical learners in-person and online.

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**Appendix 1**

**Figure 1. PACU Handoff Checklist**

Patient	Patient Identification (Nameband check)	
	Time In	
	Allergies	
	Surgical Procedure and Reason for Surgery	
	Type of Anesthesia (GA, TIVA, regional)	
	Surgical or anesthetic complications	
	PMH and ASA Scoring	
	Preoperative Cognitive Function	
	Preoperative Activity Level (METs)	
	Limb Restriction	
Preop Vitals		
Procedure	Positioning of Patient (if other than supine)	
	Intubation conditions (grade of view, airway, quality of bag mask ventilation, bite block?)	
	Lines/catheters (IVs, a-lines, CVs, foley chest tubes, surgical drains, VP shunt)	
	Fluid Management	Fluids= EBL= UO=
Medications	Analgesia Plan - During Case, Postop Orders	
	Antiemetics Administered	
	Medications due during PACU (antibiotics, etc.)	
	Other Intra-Op Medications (steroids, antihypertensives)	

**"Do you have any questions or concerns?"**

Available online: <https://www.apsf.org/article/improving-post-anesthesia-care-unit-pacu-handoff-by-implementing-a-succinct-checklist/>

**Appendix 2:** Sample lesson plan for PACU Handover teaching session

Course	Academic Half Day	Date		
Lesson title	PACU Handover			
Summary	This one hour teaching session is intended to present an approach to postoperative handover in the PACU for anesthesiology residents, including the importance of a structured handover and the use of a cognitive aid/tool for a complete handover			
Learning objectives	<ol style="list-style-type: none"> <li>List the three elements of the Anesthesia Patient Safety Foundation (APSF) succinct PACU handover checklist (REMEMBER level)</li> <li>Demonstrate a PACU handover during a role-play with a partner, using the succinct PACU handover checklist (APPLY level)</li> <li>Critique a sample video of a PACU handover, providing 2 examples of desirable handover behaviours and 2 examples of undesirable handover behaviours (EVALUATE level)</li> </ol>			
Formative assessment	<ol style="list-style-type: none"> <li>Quiz on elements of the PACU handover (multiple choice) at the end of the lesson</li> <li>Post-class homework: perform a handover on your next OR case using the PACU handover checklist; tape yourself, with RN/patient permission, and send recording for review/feedback</li> </ol>			
Needs assessment	Learners will complete a questionnaire about knowledge of handover principles, experience with handover prior to the session, and demographic data (level of training, previous health care career experience, etc).			
<ul style="list-style-type: none"> <li>Students receive an email copy of the APSF Succinct PACU Handover cognitive aid to print out before the lesson</li> <li>Complete the needs assessment survey (see above)</li> <li>Read the following article (10 mins) <ul style="list-style-type: none"> <li><a href="https://www.apsf.org/article/improving-post-anesthesia-care-unit-pacu-handoff-by-implementing-a-succinct-checklist/">https://www.apsf.org/article/improving-post-anesthesia-care-unit-pacu-handoff-by-implementing-a-succinct-checklist/</a></li> </ul> </li> </ul>				
<b>2: THE LESSON</b>				
Time	Activity	Learner activities	Instructor activities	Resources
5 mins	Introduction	Review learning objectives	Introduce lesson timeline Reinforce importance of handover for patient safety Present learning objectives	Google slides
5 mins	APSF PACU handover tool review	Review printed checklist	Review the 3 components of the tool (Patient, Procedure, Medications) and the sub components	APSF PACU handout/tool
5 mins	Video	Active listening/watching	Presents videos	<a href="https://youtu.be/3HhXz5QhDzw">https://youtu.be/3HhXz5QhDzw</a>
15 mins	Reflective exercise	Active participation and feedback on videos	Leads large group discussion of videos with guiding questions- desirable vs. undesirable handover behaviours	Large group exercise
10 mins	Role play PACU handover	Partner activity/active participation	Ask patient to use the PACU handover tool to guide role play conversation Use your most recent memorable case in the OR	Role play: one person anesthesiologist/one person PACU RN
5 mins	Quiz	Fill in the quiz	Provide link to online quiz (Socratic app)	Learner assessment using Socratic app
5 mins	Summary/conclusion	Ask any relevant questions	Present homework Summarize the session	Google slides
<b>3: AFTER THE LESSON</b>				
Learner Assessment		Learner will record a PACU handover and submit to instructor for review		
Lesson Evaluation		Residents will complete the academic half day evaluation – evaluate both the lesson and the presenter		
Follow up		Follow up at academic day in 4 weeks for brief discussion of residents' handover experiences since the lecture Follow up with PACU RNs at teaching site to see if any noticeable changes/improvements to handover		

## Teaching in the clinical environment

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### Abstract

The nature of clinical teaching is challenging due to the complex and demanding nature of the clinical environment. Many clinical teachers have little formal teacher training or knowledge of medical educational theory and will be simultaneously responsible for teaching and delivery of safe patient care, while busy operating theatres can be particularly intimidating for students and new trainees. Experiential and sociocultural theories of learning are useful to help clinical educators derive sound principles for fostering learning in the clinical context. Anaesthesia and the perioperative setting are a rich source of learning opportunities for medical curricula, with opportunities for learning practical skills, applied physiology and pharmacology and the understanding of critical illness. By promoting participation, belonging and reflective practice to embed deep learning, many teachers manage to create powerful learning experiences even in busy, time-poor environments. Professional educators seek out feedback from learners and develop their own educational portfolios.

**Key words:** medical education; experiential learning; active learning; social cognitive theory

### INTRODUCTION

Teaching effectively in the clinical environment is a challenging task with competing demands on the teacher's time and attention. Traditionally called bedside teaching, clinical teaching has been defined as learning focused on patients and their problems<sup>1</sup>. Not all learning in the clinical environment is actually at the patient bedside and it can include inpatient, outpatient and community settings, ward rounds, clinics, operating lists, multidisciplinary meetings and handovers. It is important to recognise the complexity of the learning environment and that each may present different challenges<sup>2</sup>. Of particular relevance to anaesthesia will be the perioperative pathway as a locus of learning, with the difficulty of teaching well in a busy theatre environment.

Common to all of these locations and learning opportunities will be the usual problems facing healthcare systems; these include service and time pressures and the unpredictability of the learning environment and teaching opportunities. There may be issues around space, noise, and comfort for learners, consent and dignity for the patients, and the teacher may be simultaneously responsible for education and safe medical care. Few doctors have formal teaching training, and may not be familiar with educational theory or the formal university curriculum. Despite extensive medical knowledge they may lack the tools

to facilitate effective learning in a busy, complex environment. These problems can have far-reaching ramifications and research has linked an ineffective clinical learning environment to poor patient care and burnout for both learners and doctors<sup>2</sup>.

Despite these challenges, on-the-job learning is unavoidable if we wish students to become capable doctors. In many healthcare systems, learners are also workers relied upon for service delivery. It has been noted that learners frequently feel ill-prepared for stages of transition, whether becoming a new doctor, registrar or consultant<sup>3</sup>. Work-based learning allows students to learn "real-time" from patients, alongside future colleagues in the various clinical environments they will be working in when fully qualified. It contextualises abstract knowledge and keeps learning patient-focused and memorable. It also supports the development of communication skills, interprofessional teamwork and plays an essential role in the development of professional identity.

With an increased emphasis in medical education on competency-based learning, professionalism and student-centred teaching that facilitates self-directed and self-regulated learning, it is important that clinical teaching is delivered in such a way as to support these outcomes<sup>4</sup>. As I will set out in this article, anaesthesia

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is particularly well-placed as a specialty for teaching multiple skills and knowledge across a typical undergraduate curriculum. I will review some of the relevant medical educational theories of relevance to the clinical learning environment then set out some practical examples of how to teach effectively in the face of the challenges above and how to develop one's own role as a professional educator.

## THEORIES OF MEDICAL EDUCATION

### *Theory relevant to work-based learning*

An in-depth study of medical educational theory may not suit all doctors, but a grounding in basic principles is essential for anyone interested in teaching in the clinical environment. It is worth asking ourselves what methods of teaching we tend to fall back on when faced with a group of students. Doctors may find themselves simply replicating teaching approaches that they themselves have experienced, but an understanding of theory can inform our choices more critically. It is important to grasp that there has been a paradigm shift in medical education, from seeing education as a pure acquisition of knowledge, to an appreciation of the active role of the student in constructing their learning, and a requirement for learners to develop higher order thinking, professionalism and reflective skills. A sound theoretical footing is required to effectively facilitate this kind of educational growth, particularly in busy, time-poor clinical environments.

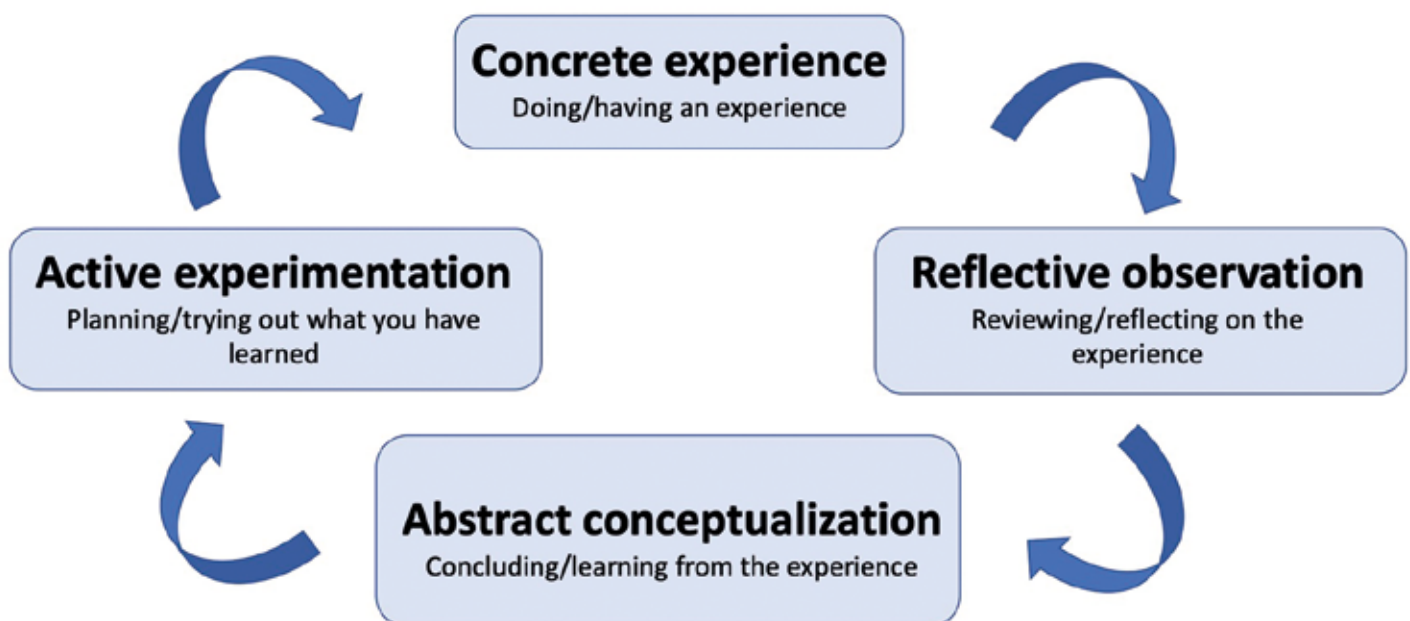
Of particular relevance to learning in the workplace are theories of experiential learning and sociocultural theories of education which this review will discuss in more detail here<sup>3,5</sup>. Both of these approaches to learning view learning as an active process which is indivisible from the context and "situation" (physical or social) in which it occurs.

### *Experiential learning*

The most well-known of these theories is Kolb's theory of experiential learning. Kolb's theory is an individual constructivist theory of learning in that it focuses on the learner's internal cognitive processes and sees the learning as actively constructed by the individual<sup>3,5,6</sup>. Kolb describes learning as "a holistic process of adaptation to the world" and the learning process as occurring in four cyclical stages (Figure 1). First the learner must involve themselves fully in a new concrete experience, and reflect upon it from a number of different perspectives. He or she then forms abstract concepts or theories to be applied more flexibly in ongoing active experimentation<sup>6</sup>. It has been pointed out that real life learning may not occur in such neat stages<sup>5</sup>. However it has remained a useful model over time which emphasises the active role of the learner and the central role of reflection in assimilating practical learning experiences. Reflection is often considered to be more effective when it is a structured, mentored process, which allows underlying assumptions to be challenged where necessary<sup>5</sup>.

### *Sociocultural theories of learning*

Sociocultural theories of learning have become increasingly significant in medical education and these emphasise experiential learning as a collective and social activity, rather than an internal individual phenomenon. The emphasis is on context, participation and sociocultural interactions, and these theories are argued to be more relevant to the complexity of working in the medical community<sup>(3)</sup>. Vygotsky was one of the first thinkers to insist that social and cultural interactions were essential to the process of making meaning<sup>(3,5)</sup>. He stressed the importance of language as a tool to mediate learning, and the role of the facilitator (or "teacher") in keeping the learner



**Figure 1:** Kolb learning cycle

working in their “Zone of Proximal Development”. This zone describes the activities that the learner is close to mastering, but isn’t quite comfortable doing alone yet, requiring appropriate supervision or assistance from a teacher<sup>3,5</sup>.

Modern sociocultural theories go further in breaking down distinction between learning and work altogether. Put simply, work is learning. Lave and Wenger describe “situated learning in communities of practice”. Through active participation in clinical activities of a community the learner builds confidence and assumes greater responsibility, moving from the periphery of a community to its core<sup>3,7</sup>. These theories suggest we should take full advantage of natural community processes and opportunities for participation for our learners when teaching in the clinical environment.

Medical education is the construction of a professional identity and this process is indivisible from the acquisition of knowledge and skills<sup>8</sup>. There is a significant moral and ethical dimension to medical practice, the transmission of which relies heavily on a process of professional socialisation. As this is a social and collective activity, role modelling by educators plays a central role here<sup>3,8</sup>. The “hidden curriculum” has been described as the unwritten values and beliefs that are transmitted (often unintentionally) alongside explicit learning goals and is mediated by the actions and language of educators and role models, as well as the organisational culture<sup>3,8</sup>. We need to be aware of our power as role models in both clinical care and our approach to professional self-improvement.

#### **BOX 1: How to be a good role model**

- Be aware of yourself as a role model
- Demonstrate clinical competence and commitment to excellence
- Engage with improving institutional culture
- Show respect for patients, colleagues and learners
- Have a positive attitude to life-long learning
- Be passionate about teaching and engaging with learners
- Demonstrate good communication skills

#### **Theories of motivation and self-regulation**

Deci and Ryan identified three factors driving intrinsic human motivation: autonomy, competence, and relatedness and these are seen as key forces fuelling learner self-determination education<sup>9</sup>. It follows that as well as participation, which can bring a sense of autonomy and competence to the learner, a sense of belonging to the working community is essential. Simple actions such as introducing medical students and encouraging involvement in learning from senior team members will help learners to feel included and encouraged to learn. Ensuring an inclusive environment regardless of gender, race and other is important here as all learners should feel able to belong equally, and all team members need to be aware of and challenge any systemic and personal biases that they encounter.

There is a growing emphasis on self-regulation in medical education, which requires a high level of intrinsic motivation. Doctors are required to take responsibility for their own learning throughout their career. This requires the learner to reflect critically on their learning processes and formulate their own strategies for improvement. Too often theories of motivation and self-regulation in learning are seen as individual traits, but we should be conscious of how the learning

environment and the observed practices of the community affects their development in students and trainees. When we understand the power of the hidden curriculum and role modelling, we can make our own methods of self-inquiry and self-regulation explicit in such a way that help learners develop their own self-monitoring and self-regulation skills<sup>8</sup>.

In summary, most modern educational theories view the learner as an active participant in the process while sociocultural and experiential perspectives on learning help us to see that it is inseparable from the work-based context, activities and relationships in which it happens. A focus on participation and community can inform our choices of teaching strategies. For example, if learning is a social activity then appropriate support and mentorship in the workplace is critical and the teacher-learner relationship becomes more significant. From the above theories we can formulate some principles to underpin our approach to teaching (box 2) before we look at some simple practical ways to use this in time-poor clinical environments, particularly those relevant to anaesthesia.

#### **BOX 2: Principles of clinical teaching derived from educational theory**

- Focus on facilitating learning rather than didactic teaching
- Foster a sense of belonging for all students
- Support active participation by all students
- Involve whole team (“community of practice”) in supporting learning
- Make learning explicit as it occurs in everyday practice
- Make powerful use of reflection and feedback in integrating learning
- Avoid teaching by humiliation, psychological safety is paramount for developing capability
- Facilitate the development of self-regulation and self-direction in learners
- Consider yourself a professional role model at all times

#### **EFFECTIVE TEACHING STRATEGIES**

##### ***Common problems with clinical teaching***

While certainly useful, theories do not always acknowledge the messy reality of the clinical environment in which learning takes place. Spencer identifies some common problems with clinical teaching, including a lack of clear objectives, teaching pitched at wrong level (often too high), a failure to promote problem solving skills and critical thinking, as well as inadequate time for feedback, reflection and discussion<sup>10</sup>.

In particular, the operating theatre can be a stressful and intimidating space, with a perception of a traditional hierarchy that may leave learners feeling passive, excluded or, at worst, humiliated. Students report feeling like a nuisance, anxious about violating protocol, and not knowing where to stand or what they are allowed to touch<sup>11</sup>. Teaching is frequently opportunistic which makes planning and structure difficult. There may be multiple students with different members of the operating team causing issues with comfort, communication and safety, as well as the challenge of managing differing learning needs of the multidisciplinary team.

##### ***What to teach: useful anaesthesia and perioperative care opportunities for learners***

Despite the difficulties above, many educators still manage to deliver excellent teaching. Medical students may not recognise the wealth of relevant experience and skills that anaesthetists have to offer and many medical schools do not offer specific anaesthetic attachments,

considering it largely of postgraduate interest. However, anaesthetists are specialists in the management of airway, ventilation, circulation, consciousness and pain, as well as skilled in the assessment and management of critically ill patients with a deep understanding of applied physiology and clinical pharmacology. The perioperative environment also offers multiple opportunities for learning practical skills. Anaesthesia is the single largest hospital specialty in most parts of the world and in the UK 68% of hospital inpatients interact with an anaesthetist<sup>12</sup>. Medical schools in the UK are beginning to offer perioperative medicine modules in which anaesthetists can play a significant role in teaching.

### BOX 3: Ideas for ad-hoc teaching content in theatre

Use patients on the list to start a case-based discussion on the patient's presentation or an aspect of their medical history  
 Choose an aspect of the patient's monitoring or an investigations to discuss: for example, arterial blood gas interpretation or ECG monitoring  
 Use a perioperative risk calculator to stimulate a discussion around risk and shared decision making  
 Choose a guideline or protocol to centre a short teaching session around for example major haemorrhage or cardiac arrest  
 Teach practical pharmacology by involving students in drawing up drugs and infusions and preparing fluids, discussion of possible affects, for example, using anaesthetic drugs to teach on automatic nervous system  
 Use ultrasound to demonstrate practical anatomy  
 Discussions on patient safety and cognitive aids such as the WHO checklist  
 Use handovers for explicit teaching on non-technical and communication skills  
 Introduce end of life topic: eg DNACPR and discuss how decisions should be made and communicated  
 Remember other perioperative settings: preassessment clinics, CPEX clinics for cardiorespiratory physiology, pain rounds, morbidity and mortality meetings

### *How to teach: tips and models for teaching in the clinical environment*

The qualities that make a good educator have been studied widely and learners regularly identify the following as characteristic; a passion for teaching, good rapport with students, accessibility and supportiveness, clinical competence, compassion, integrity, with organisation and flexibility in teaching approach<sup>(4,13)</sup>. When we are engaged in clinical teaching, we should consider these qualities and the principles set out above of fostering participation, belonging, and self-regulation skills. The best way to educate in the clinical environment has been summed up as follows:

“Support students’ participation in clinical practice; help them step outside their comfort zones, learn reflectively from doing so, and become more capable”<sup>14</sup>.

The authors suggest the following three questions to ask yourself as an educator<sup>14</sup>. The answers provided are my own suggestions for a theatre list and there will be many more, depending on the clinical context. Bear in mind the qualities of an excellent teacher and the principles derived from educational theory as you plan your teaching opportunities for the session.

### 1. *What opportunities to participate can this placement (or theatre list/clinic/round) offer?*

For example, pre-assessing and presenting patients, reviewing patient notes and images, assisting with monitoring, practical skills such as cannulae, catheters, basic airway management, drawing up drugs and infusions, and reviewing patients postoperatively. Communicate these opportunities to the student and help them to formulate their own.

### 2. *What capabilities can students develop from those opportunities?*

For example, the development of technical skills, an understanding of the perioperative pathway, the impact of surgery and anaesthesia on chronic disease and vice versa, human factors and patient safety issues, management of airway, ventilation and circulation in critically ill patients, practical pharmacology, drugs for anxiolysis, nausea and pain management, and interpreting basic monitoring. Establish baseline knowledge, communicate these broader learning goals to the learner and help them formulate their own.

### 3. *How can we support students’ participation and development of those capabilities?*

- Create a safe and welcoming learning environment with introductions and appropriate orientation to theatres and protocols.
- Clarify roles, responsibilities and expectations at start of the list.
- Have student be present at WHO briefing.
- Involve whole team in learning.
- Make learning explicit, and where possible state clear learning goals in advance.
- Ensure student actively participates as much as patient safety (and consent) allows.
- Role modelling professional behaviour, excellent patient care and enthusiasm for teaching.
- Make explicit your clinical reasoning skills; explain why you are doing things.
- Role model a commitment to self-inquiry, reflection and life-long learning behaviours.
- Make time for student feedback and reflection to encourage deep learning.
- Promote self-direction, encourage students to make their own plans for improving their future performance.
- A professional teacher will also elicit feedback and reflect on their own performance.

Sometimes we may only have students for an even shorter period of time, or we may wish to use some downtime when the patient is anaesthetised to teach some general principles. The microskills model of clinical teaching (also known as the one minute preceptor) consists of five tasks to be accomplished when discussing a clinical case with a learner<sup>15</sup>. It can be used easily in a short space of time, for example when asked for advice on a patient by a junior trainee, and it can be



useful for less experienced teachers to increase the use of key teaching behaviours.

1. **Get a commitment:** ask learner to formulate their own plan for the situation.
2. **Probe for supporting evidence:** for example ask, what made you come to that conclusion? This helps learner and teacher identify gaps in knowledge.
3. **Teach general rules:** Tailor this to the information above. Try not to overload the learner; select a few general rules. If there is a big knowledge gap, make a plan for addressing it at a later time.
4. **Reinforce what was done right and 5. correct mistakes.** Use constructive feedback rules to reinforce what was done well and correct any errors.

#### **BOX 4: Possible feedback questions for one minute papers**

What question remains uppermost in your mind after today's teaching?

What is the main way you will change your practice after this session?

Was this topic relevant to your practice?

Would you attend another session held by this educator?

What could the educator do to improve this session?

Did this educator inspire you?

#### **Professionalism as a clinical educator**

As few doctors receive formal teacher training, it is up to the clinical teacher who aims for excellence to develop their own professional identity as an educator. Performing essential teaching tasks and assessments well is the beginning, while the application of a greater understanding of theory and enthusiasm will take one further as an educator. However, a fully developed professional approach includes asking for, and acting on, learner feedback, reflecting on one's own teaching capabilities, developing an educational portfolio, seeking out mentorship, and engaging in educational scholarship<sup>4</sup>.

Collecting feedback from learners in the clinical environment is essential to improve your teaching skills. Some simple methods for getting feedback on the session content can be done in conversation with the learners; for example asking students to summarise key learning points and to identify areas they still feel unsure about. This will have the dual role of embedding learning for the students and feeding back to the teacher about their delivery. However it may be difficult to get honest feedback about your teaching skills face-to-face, so make use of anonymous written feedback as well. Beware of feedback fatigue and keep things short: try using post it notes, one minute papers (box 4), or Stop, Start, Continue techniques (students are asked to write down one thing the teacher should stop doing, one to start doing and one to continue doing). To develop your teaching further, you can design your own self-evaluation forms based on the principles we have discussed above and consider whether you

have met your own standards. Seeking out the mentorship of a professional clinical educator can be invaluable as you develop your own educational portfolio.

#### **CONCLUSION**

With a basic grasp of medical educational theory and a clear understanding of what anaesthesia and perioperative medicine have to offer, it is possible for us to create powerful educational experiences with limited time and resources. A small amount of planning and reflection will help you develop your role as an educator and keep your own skills, knowledge and passion alive. As well as being rewarding in its own right, excellent perioperative teaching promotes anaesthesia as a specialty and can improve future recruitment by encouraging students to choose special modules in anaesthesia and take part in departmental audit and research.

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## The Effective Planning and Delivery of the Large Group Lecture in Medical Education: Not a thing of the past

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### Abstract

All medical professionals will be expected and required to deliver lectures throughout a medical career. This instills fear in many: the lecturer, and the attendee. Despite an overwhelming increase in smaller-scale learning environments and situations, lectures continue to be well-utilized; they are effective means to easily access the largest group possible with the smallest intervention.

Many lecturers continue to not identify the need for incorporating attendee participation, nor do they target information appropriately to attendees. This can easily create disinterest and non-engagement...and frustration in both lecturer and audience. Good and effective lectures require a clear plan, preparation, and practice. This article seeks to highlight practical steps to ensure that the information delivered by the lecturer is tangible and clear, adhering to principles of "adult learning theory". The basic principles of effective visual aids (including a PowerPoint "6x6" guideline) and keys to audience participation is implemented throughout the presentation. Examples of this include assessing the audience needs prior to lecture preparation, a change in pace (or approach) every 10 – 15 minutes, different means of audience engagement (even amongst themselves). The excellent lecture is not necessarily delivered by the best speaker, but by those that plan well.

**Key words:** audiovisual aids; visual aids; learning; lectures; teaching/methods; active learning; adult learning theory; public speaking

### INTRODUCTION

When one imagines the medical education environment, a picture of a white-coat clad individual standing at the front of a lecture hall full of young faces may come to mind. Indeed, the large group teaching format is still a cornerstone of not only medical education, but the entire medical profession. Those who have completed their formative education will no doubt be asked, or even compelled, to give a lecture to younger generations of learners as well as to their peers. The continued reliance on large group teaching in medicine raises an interesting paradox, though – medical professionals are expected to give lectures, but are rarely, if ever, taught the skills needed to execute an effective lecture. Anyone in the field could certainly recount numerous hours spent in low-quality lectures. However, there are recommendations derived from experts and research that lecturers can implement in order to deliver an engaging transfer of knowledge.

Although the large group lecture format has been criticized for being inconsistent with adult learning theory – it is passive, teacher-centered, and associated with low knowledge retention – it is still widely used. Moreover, it is a more efficient teaching method compared to smaller-scale (small group) settings, such as problem-based learning or bedside teaching<sup>1-3</sup>. Since lectures are here to stay, the critiques levied at them can be addressed by incorporating elements of "adult learning theory": adult learners tend to be self-motivated, seeking out learning opportunities that incorporate or expand upon their prior knowledge. They prefer to play an active role in the learning process, as opposed to being "talked at". Adult learners desire to actively think through tasks, and implement their new knowledge immediately<sup>1,4,5</sup>. Therefore, delivering a lecture (with these considerations in mind) can result in a more positive experience for learners.

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## PREPARING A LECTURE

### Content

Often the topic of a lecture is predetermined, but there may be instances when you are asked to lecture on a topic of the learners' choosing<sup>2</sup>. In the latter case, investigate what topics are relevant to them<sup>1</sup>. If they are medical students, for example, a program (or course) director would be a valuable resource. When the learners are peers, asking colleagues – or even the potential learners themselves – may prove useful. Whenever possible, choose a topic in which you have prior knowledge, and which is of interest to you (the lecturer). This should immediately result in a more effective lecture<sup>2</sup>.

Once the topic is chosen, define the primary learning points to be delivered and the allotted duration. It is recommended that a one-hour lecture should contain only three to five salient learning points; you can adjust the number up or down depending on the amount of time allotted for the lecture<sup>1,6</sup>. It is better for the learning points to be concepts, as opposed to facts. Effective lectures provide learners with new information and ways to apply it<sup>6</sup>.

Furthermore, ensure that the learning points are appropriate for your audience<sup>1,5</sup>. For example, imagine you are lecturing on pulmonary hypertension. If your learners are cardiologists, presenting the epidemiology, presentation, and diagnosis of the disease process as primary learning points are far too basic (and unnecessary). These would be more appropriate for junior medical students. Alternatively, discussing the indications, side-effects, and comparative studies of novel therapeutics for pulmonary hypertension would be a better selection for the audience of cardiologists.

### Visual aids

Next, determine what – if any – visual aids you will employ to support your lecture. It is recommended to utilize visual aids as they have been shown to improve learning and retention<sup>1,2</sup>. It is advisable, though, to investigate the lecture venue well in advance: supported visual aids, available equipment, and general layout all need to be determined<sup>6</sup>. The most commonly used medium by far is PowerPoint, but paper flip charts or handouts can also be useful. Given its prevalence, strategies for creating effective PowerPoint slides will be presented, but these can be easily applied to other electronic and the non-electronic media as well.

The best PowerPoint slides serve merely to support a lecture, rather than being the focal point. When creating effective slides, the principle that underlies all recommendations is: “Keep it simple”. For every twenty minutes of lecture time, approximately ten slides should be used. While this is not a firm rule, the key point is to limit the visual content so as not to overwhelm learners<sup>1</sup>. Use a font size of at least 28 and font style that is “sans serif” (e.g. – Arial, Helvetica), as opposed to “serif” fonts (e.g. – Times New Roman), as these are easier to read on slides<sup>5,6</sup>. Choose text and background color combinations with high contrast (i.e. – navy letters on a white background, or white letters on a black background) to further ensure the text is easy to read<sup>1,6</sup>. The slide background should be a single color and free of designs, and red-and-green combinations should be avoided as these can appear gray to those with colorblindness<sup>1</sup>.

The text on the slides should be kept to a minimum and guided by a “6x6” rule: no more than six words per line, and no more than six lines per slide. Variations in the text style (different colors, italics) should be used sparingly, if at all<sup>1,6</sup>. Moreover, the use of slide animations is best avoided as it is distracting. Using appropriate/applicable images in addition to, or even instead of, text is encouraged. Additionally, graphs or charts can be utilized to present data, but avoid copying them directly from sources as they can be complex and distracting. Rather, make new, simpler charts or highlight one or two key elements for learners to focus on<sup>1,5,6</sup>. Regardless of the exact content of the slides, they should be simple enough to be easily taken in and used to complement the orally delivered content<sup>6</sup>. An example of an effective slide is shown in Figure 1.

### An Effective Slide

- Keep it simple
- Background and text with high contrast
- Avoid red/green combinations
- 6 x 6
- Sans serif font
- Avoid using animations

**Figure 1:** An example of an effective PowerPoint slide. It adheres to recommendations and incorporates an image that supports the text.

### Structure

It is helpful to consider the overall structure of your lecture and how you will deliver your content. Creating an outline or flow chart can aid in your initial planning and ensures that the content is delivered in a logical fashion<sup>1,2</sup>. Several suggested models are listed in Table 1, but are not meant to be absolute, rigid, or exhaustive.

The first few minutes should be spent introducing the topic. This should include what the learners can expect to gain by the end of the session, commonly achieved by providing a list of learning objectives (concise, discrete, measurable behaviors or outcomes). Since adult learners prefer to play an active role in learning, these allow them to benchmark their own learning. The objectives need to provide a reference for you (the lecturer) to ensure that the subsequently delivered content fulfills the stated objectives<sup>1,7</sup>. Bloom's taxonomy (and subsequent revisions of it) provides a framework for creating learning objectives by organizing educational goals into a hierarchy of increasing complexity. While a review of Bloom's taxonomy is beyond the scope of this paper and can be viewed elsewhere<sup>7</sup>, Figure 2 provides an overview of the hierarchy and examples of verbs associated with each level. When creating learning objectives, include a verb from the targeted level along with a measurable outcome. For example, “Explain the differences between primary and secondary forms of pulmonary hypertension.”

**Table 1:** Models used for structuring a lecture. Each is presented with a brief description<sup>1,2</sup>

<b>MODEL</b>	<b>Description</b>
Hierarchical	One unifying topic, with parallel subgroups branching out
Problem-centered	A problem is presented along with solutions supported by evidence
Chaining or Storytelling	And idea or problem is presented along a timeline, and sequential reasoning leads to a conclusion
Comparative	Two or more methods or sides of a problem are presented and evaluated
Thesis	A declaration is made, then proved or disproved using reasoning and evidence
Cause and effect	Events or issues are explained relative to what caused them

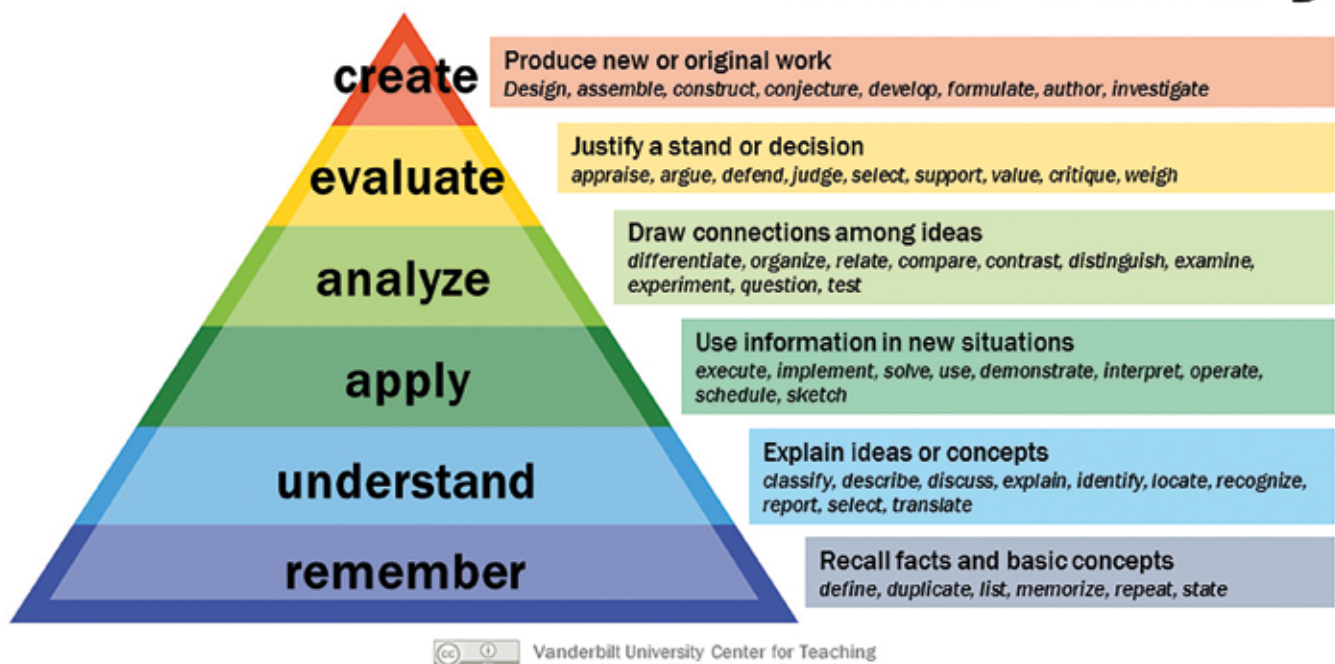
Once you set your learning objectives, try to engage or “hook” your learners by priming their interest in the topic. This can be as simple as a brief overview of what they already know, thus activating their prior knowledge<sup>1</sup>. An interesting clinical case or vignette can stimulate interest, or even a personal anecdote<sup>5</sup>. After this, provide an overview of the structure of the lecture, and refer back to it periodically during the lecture. Providing brief reviews or summaries of what has been covered so far can enhance consolidation for your learners<sup>1</sup>.

After the introduction, much of the lecture is spent delivering the key points and supporting content. Evidence shows that retention is highest at the beginning and end of lectures<sup>1,5</sup>, so take this into consideration when timing the delivery of new information. Interactive lectures (teacher and learners engage with each other, and information flows both ways) have, not surprisingly, shown better learning outcomes compared to a passive, unidirectional flow of information<sup>1,5,6</sup>. This is consistent with adult learning theory.

Moreover, learners begin to lose focus after only ten minutes<sup>5</sup>. Therefore, it is recommended to incorporate interactive techniques into your lecture (Table 2) and to change the learning activity approximately every ten minutes to maintain learners’ attention. For example, you could spend ten minutes giving the learners new information, then present a clinical scenario to which they can apply the new information using a “think-pair-share” activity for another ten minutes. It is vital to ensure that engagement is a priority throughout the lecture, and not just a novelty<sup>3</sup>. As you create your lecture, resist the urge to incorporate many details on the topic as this may overwhelm your learners<sup>2,5</sup>. Focus instead on conveying your primary learning points; spend the majority of the time providing support to those points<sup>1,6</sup>.

Once you have delivered your content, it is vital to spend a few minutes summarizing the material, reminding the learners of your

## Bloom's Taxonomy



**Figure 2:** An illustration of the hierarchy of Bloom’s Taxonomy which can be used to create learning objectives. Each level of the pyramid represents a higher-order educational goal. A brief description of each level appears to the right, along with examples of verbs relating to each level (Anderson).

**Table 2:** Examples of techniques to increase in-lecture interaction; the descriptions and tips for utilization appear alongside.<sup>1,5,8</sup>

<b>Activity</b>	<b>Description</b>
Ask questions	<ul style="list-style-type: none"> <li>• Can be posed to individuals, groups, or everyone</li> <li>• Try to encourage higher-order thinking or application of new knowledge, rather than learners reciting facts</li> <li>• Ensure you wait several seconds for someone to respond</li> </ul>
Brainstorming	<ul style="list-style-type: none"> <li>• Pose question to audience and invite multiple responses</li> <li>• Write responses so everyone can see them</li> </ul>
Buzz groups	<ul style="list-style-type: none"> <li>• Learners break into groups of 3-5</li> <li>• Give a problem to solve, question to consider, or ask them to discuss something that was not clear</li> <li>• Group nominate spokesperson to share their thoughts</li> </ul>
Think-Pair-Share	<ul style="list-style-type: none"> <li>• Pose a problem or question</li> <li>• Learners think about the question for about two minutes</li> <li>• Then pair up with another learner and share thoughts</li> <li>• You can have a few pairs share their thoughts</li> </ul>
Pause and reflect	<ul style="list-style-type: none"> <li>• Ask learners to spend two minutes re-examining the material just covered</li> <li>• Invite them to share their thoughts with a neighbor</li> </ul>
Show a video	<ul style="list-style-type: none"> <li>• Reinforce new knowledge with a video example</li> </ul>

key points, and providing closure to the topic<sup>1,6</sup>. You can have them reflect on an image, a quote, or how they will apply the new knowledge. Providing your contact information (if you so choose) can also be helpful. After you are done speaking, it is important to leave several minutes for questions from the audience, and you should actively invite them<sup>1</sup>. It is also recommended that you create a slide to leave up at the end, as opposed to ending the slide show with the dreary (and blank) “exit to end slide show”<sup>6</sup>.

### **Finalizing**

Once you have created your presentation, it is time to refine it. Practise! Deliver the lecture to yourself, but also to a small, trusted audience of valued colleagues. Time yourself delivering your lecture to ensure it fits within the time you are allotted. Practise speaking clearly and deliberately, implementing pauses between ideas. Keep in mind, though, that the time it takes to deliver your lecture on your own will likely be shorter than when you deliver it to your learners<sup>2</sup>. You can also pre-identify portions of the lecture that could be skipped over if you find yourself running out of time on the day<sup>1</sup>. Practising your lecture will also help you gain familiarity with your material so you are less nervous<sup>1,6</sup>. You should rehearse your lecture enough so that you can deliver it in a natural, conversational style; this is opposed to a rigid, flat, read speech (not unfamiliar to most readers). If needed, you can create notes to refer to while giving your lecture, either on a piece of paper or in the notes section of PowerPoint (below each slide), but avoid relying on them while you speak<sup>1</sup>. It is further suggested to have a complete hard copy (printed) of your entire lecture to overcome any potential technological failure.

### **Giving Your Lecture**

On the day of the lecture, ensure you arrive early enough to set up any visual aids and other equipment. This may include logging onto a virtual platform ahead of time, to ensure that you are familiar with

the format. As you begin, lead off with enthusiasm and maintain eye contact with the audience: this can make learning more effective<sup>1</sup>. Speak in a deliberate, conversational style, and try to read your learners’ reactions and cues to help tailor your lecture<sup>2,6</sup>. Lectures have generally focused on the lecturer delivering content to a passive listener. This, however, can impactfully change<sup>3</sup>. Use clear, simple language, and ensure your learners can hear you, using a microphone if available. Establish rapport by inviting them to actively participate in the lecture and to ask you for clarity if needed<sup>1,8</sup>. Finally, keep track of time and have a plan in place to truncate your lecture if needed<sup>1</sup>.

### **AFTER YOUR LECTURE**

The final component of giving a lecture is obtaining evaluations of the lecture after its conclusion<sup>1,2,8</sup>. Evaluations can serve to either ensure learners’ comprehension of the material, or to improve the lecture itself. Opinions on the teacher or lecture can be solicited from the learners in verbal format or through an evaluation form (Figures 3a & 3b). The “one minute paper” has also been utilized, which allows the learner to reflect on the content of the lecture (Figure 3c). Evaluations and papers can be collected and reviewed after the lecture and be used to inform adjustments<sup>2,8</sup>.

Evaluations of learners’ comprehension of the material, for example through examinations, may also give a glimpse into the effectiveness of the lecture. You may assign these if you wish, or they may already be in place if your lecture is part of a wider curriculum. Potential confounders may include learners who have prior knowledge of the material covered, or if the evaluation is far removed in time from the lecture learners may have acquired the knowledge elsewhere<sup>1,2</sup>.

Additional methods for evaluating your lecture are peer evaluation and reflection. For the former, you can ask a peer to observe all or

**Figure 3A: Please rate the lecture on the following items:**

	<b>Strongly agree</b>	<b>Slightly agree</b>	<b>Strongly disagree</b>	<b>Slightly disagree</b>
Clear				
Interesting				
Easy to take notes from				
Well organised				
Relevant to the course				

**Figure 3B: Please rate the lecturer on the following items:**

	<b>Strongly agree</b>	<b>Slightly agree</b>	<b>Strongly disagree</b>	<b>Slightly disagree</b>
Was enthusiastic				
Was clearly audible				
Seemed confident				
Gave clear instructions				
Encouraged participation				

**"One-minute" paper worksheet**

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Lecture title: \_\_\_\_\_

Directions: Take a moment to think about the lecture you have just attended, and then answer the following questions.

1. What was the most important thing you learned in today's lecture?  
\_\_\_\_\_

2. What question remains uppermost in your mind at the end of today's lecture?  
\_\_\_\_\_

3. What was the "muddiest point" in today's lecture?  
\_\_\_\_\_

**Figure 3A-C:** These present examples from Cantillon<sup>8</sup> of written evaluations of a lecture (A) and the lecturer (B), and of a "One minute paper" (C). In A & B, ordinal responses are selected. In C, the evaluation is less structured, and learners can write freely.

part of your lecture and provide feedback to you. Reflection is a self-directed evaluation in which you set aside some time think through your experience of giving the lecture. It may be helpful to write some thoughts down as soon as the lecture is over. For example, try to recall reactions you observed from your learners, questions they asked, or if your time management was effective. Decide what things you would change, and what you want to keep<sup>1,2</sup>.

## CONCLUSION

Even though medical professionals are rarely given the skills to execute an effective lecture, it can be accomplished with some preparation and forethought. We need to aim to apply the same fervor in becoming better clinicians to our approach to improve lecturing skills<sup>2</sup>. Make no mistake: implementing the recommendations presented here require time and dedication, but are easily achievable if you begin preparing well in advance. A "bad talk," on the other hand, characterized by transcribing numerous details into endless wordy slides, is relatively easy to prepare<sup>6</sup>. Moreover, a lecture that simply repeats facts (printed elsewhere) obviates the need for a lecturer; learners would do just as well off reading it for themselves<sup>2</sup>. The teacher's role in a lecture should be that of a guide – showing learners how to apply new knowledge and concepts through a focused delivery of a few key and applicable concepts at a time.

Student-focused learning and engagement occurs when lecturers actively create platforms, as well as opportunities (and cultural change) for sharing and participating.

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## Remote Learning: Opportunity in Necessity

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### Abstract

Remote learning is not a new concept. The first major correspondence program was established in the late 1800s at the University of Chicago in the United States, in which the teacher and learner were at different locations.

Remote learning, sometimes referred to as “Distance Learning”, “e-Learning”, or “Virtual Learning” has evolved rapidly with the advent of the internet and accelerated with the pandemic. Historically, learning has occurred through didactic methods, delivered through textbooks and in-person lectures. With travel and group meeting restrictions due to the COVID-19 pandemic, educators have been forced to search for novel solutions to continue robust academic training programs, continuing professional development, and international exchange programs.

For all the benefits of remote learning, there remain improvement opportunities. Learners and instructors alike have many logistics and resource demands, to enable meaningful engagement in remote learning. Making online content more accessible, innovative, and interactive through user-friendly tools, can future-proof education systems. An invaluable educational tool for all engaged in medical education and training, the use of remote learning will necessitate equity in access to technology and information.

This article will review the benefits and limitations of remote learning, highlighting its evolution, obstacles with logistics and future directions.

**Key words:** Education, Distance, Access to Information, Multimedia, Literacy, Open Access Publishing, Computer-Assisted Instruction, Pandemics, Cost Savings, Internet Access, Learning, Communications Media, Educational Personnel, Students, Social Networking, Videoconferencing, Software, Problem Solving.

### EVOLUTION OF TEACHING AND LEARNING

Historically teaching has occurred through didactic methods, delivered through textbooks and in-person lectures. A didactic or instructive method is a teaching method that adheres to a scientific approach or educational style and involves face-to-face interaction between educators and students. Didactic methods are criticized by many authors, for being teacher – centered and passive, contrary to current understanding of optimum adult learning. However, it is still used at many levels of education.<sup>1</sup> Traditional educational resources, such as textbooks and journals are heralded for reliability, with peer-review processes ensuring high-quality and relevant content.

There are several limitations to classic learning approaches. The time required for publication and distribution, especially for textbooks, delays dissemination of the most up-to-date information. New research often emerges within the time it takes for textbook publication. Expert opinion provided in

lectures can overshadow independent evaluation of evidence by audience members. Conferences often require costly registration fees and travel expenses. In-person lectures typically occur according to the organisers’ schedule rather than that of learners.

Distance education aimed to overcome these inadequacies. The first generation of distance education became known as correspondence learning with scholars receiving textbooks, study guides, assignments, and other study materials through the post.<sup>2</sup> The second generation developed in the 1950s used radio and television broadcasts to manage distribution of materials. More recently, audio and video teleconferencing have benefitted the provision of more effective distance education, through the third and subsequent generations of distance learning.<sup>3</sup>

The COVID-19 pandemic has severely limited clinical teaching, meetings and in-person lectures.

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With pandemic travel restrictions, many are searching for novel solutions to continue academic training programs, continued professional development, and international exchange programs and conferences. Simultaneously, the evolution of webinar technology and expanding access to teleconferencing applications, has allowed many programs to go virtual. Advancement of remote learning has become an opportunity born from necessity. At the end of this article, we have summarized some valuable practical tips for the anesthetists to deliver remote teaching courses.

### Defining Remote Learning

Many types of learning can occur remotely. With Electronic Learning, also called E-learning, the learner accesses course materials and training on a computer, making access more widespread and instant compared with correspondence or broadcasting learning. The outbreak of COVID-19 in 2020 created an emergency situation that forced institutions in many different countries to suddenly shift from a traditional teaching model into a remote one (Emergency Remote Teaching).<sup>4</sup>

Technology-supported e-learning can be online, offline, or both<sup>5</sup>, with the electronic content housed on CDs, DVDs, USB/memory cards or computer-based applications. Online Learning requires access to the internet, allowing learners to communicate with instructors and other students in real time. Depending on how the e-learning is created, learners may be able to download study materials, attend webinars, watch pre-recorded sessions, or complete assignments directly online and uploaded.<sup>6</sup>

An important tenant of remote learning is that of synchronicity (Table 1). Synchronous learning allows learners to engage in real-time with the material. Synchronous learning opportunities also facilitate remote discussions and collaboration with other learners with instructors and allow for instantaneous question and answer sessions.<sup>7</sup> Video conferencing allows learners expanded exposure to colleagues practicing in distant locations. Exchanges between differently-resourced practice settings leads to innovation sharing and creative problem-solving – key skills needed to overcome resource limitations and ensure patient safety.

During asynchronous learning, learners engage with educational materials independently.<sup>7</sup> Asynchronous learning eliminates the need for students to attend scheduled lectures or other learning experience arranged on others' plans. Static online resources allow learners to have repeated access to materials, convenient for their schedules, to use at their own pace, further consolidating learning and understanding. Many programs blend synchronous and asynchronous models for greatest impact.

### Benefits of Remote Learning

Remote learning has evolved rapidly with the advent of the internet and is accelerating within the pandemic.<sup>9-11</sup> Increased global internet coverage allows more timely and convenient access to information, decreasing previous limitations and barriers (Table 2).

In remote learning, the online platforms, software, and applications have evolved to meet end-user needs. Many successful platforms utilize multimedia approaches, including pictures and diagrams, video and audio resources, interactive quizzes, and virtual simulation. Many systems allow continuous monitoring of learner engagement as well as assessment of learning and retention. Whilst creating a new e-learning option -whether from existing sources or a bespoke curriculum - both instructors and learners have the opportunity for collaboration to design learning experiences to best fit the learners' needs within the local practice setting.

Smartphones have revolutionized distance education. Free web-based video conferencing apps include Skype, ooVoo, Tango, Hangouts, Viber, Video Chat, Mico and SOMA that can be used through smartphones enhancing learner/faculty interactions without the requirement of personal computers. Although smartphones are relatively new in education Tuncay<sup>12</sup>, in 2016 concluded that there was no significant difference between the students' exam results whether using paper or mobile phones.

Recent research showed the use of social media by both students and faculty members, has facilitated formal academic communication during the pandemic in developing countries. Students preferred social media as Facebook or YouTube for communication rather than

**Table 1:** Characteristics of Synchronous & Asynchronous Learning

Synchronous Learning	Asynchronous Learning
Learners take part in educational activities simultaneously with instructors and other learners.	Learners engage independently with materials online or downloaded at times convenient to their schedule.
<b>Advantages:</b> <ul style="list-style-type: none"> <li>Real-time interactions</li> <li>Learners can ask questions</li> <li>Participate in immediate discussions</li> <li>Learners and instructors receive instant feedback</li> </ul>	<b>Advantages:</b> <ul style="list-style-type: none"> <li>Flexibility - learners study on own time</li> <li>Self-paced learning</li> <li>Learners have repeated access to study material</li> </ul>
<b>Disadvantages:</b> <ul style="list-style-type: none"> <li>Less schedule flexibility</li> <li>Access barriers to the relevant technology</li> <li>Effectiveness limited by digital literacy</li> </ul>	<b>Disadvantages:</b> <ul style="list-style-type: none"> <li>Requires learner self-discipline</li> <li>Less swift interactions between instructors and students</li> <li>Learners are unable to clarify concepts with instructor or other learners in real-time</li> </ul>

Khan BH et al, in 2021, published a book discussing the eight dimensions of e-learning: (1) institutional, (2) pedagogical, (3) technological, (4) interface design, (5) evaluation, (6) management, (7) resource support, and (8) ethical.



other free online communication tools, e.g., ZOOM and Google Classroom. The students gained a positive learning experience from social media due to its ease of use and perceived usefulness.<sup>13</sup>

For example, anesthetists all over the globe can search for online courses in Anesthesia to find e-learning resources from a variety of providers. e.g. University expert in anesthesia, sedation and resuscitation(<https://www.healthcarestudies.com/University-Expert-In-Anesthesia-Sedation-And-Resuscitation/Spain/Alcal%C3%A1-Formaci%C3%B3n/>). While MEGA Online Anaesthesiology Course on Facebook is another example of remote learning via social media. Courses can be free at point of access or charged a competitive cost. YouTube hosts lectures, videos and courses about anesthesia, intensive care and resuscitation shared by organizations such as PROMPT Maternity Foundation, Saving Lives Academy, ABCs of Anaesthesia and ACLS Training Centre as well as institutions and individuals

Many journals are moving toward open-access publishing, making information available to readers at no cost whilst maintaining the standard of still being peer-reviewed. Online publishing has less physical costs compared with paper copies with a smaller carbon footprint. However some article processing charges and pay walls remain cost-prohibitive for researchers.

In a pandemic, remote learning facilitates infection prevention and control efforts as well. It allows social distancing and minimizes unnecessary in-person interactions especially when community prevalence is high. Remote teaching can allow continuing training for those who might not be able to attend face-to-face due to being clinically vulnerable.

## Limitations of Remote Learning

For all the benefits of remote learning, there remain opportunities for improvement. Distance learning has deprived students of the regular traditional community school environment with ample social opportunities, peer to peer support, face-to-face contact with staff, extracurricular sports and academic opportunities.<sup>14</sup> It is difficult to replicate the rich learning exchange that occurs through personal interactions with colleagues. Similarly, the tangible interaction while mastering both technical skills (e.g., intubation) or soft skills (e.g., closed-loop communication) are difficult to replicate using virtual simulations. Interactions can be maximized with the use of videoconferencing. There remains a requirement for full engagement of all participants. This can be helped with mandated 'camera on' agreements.

In some places limits on internet speeds, unstable connections, expensive data packages and uncertain electricity supply can hamper enthusiasm for engagement with remote learning.

Digital literacy involves the use of current technology to use and interpret online information, found through various electronic media.<sup>15</sup> It also includes an educator's ability to create and sustain online learning modules. Both educators and learners must have digital literacy with ongoing technical support to maximize impact and ensure effective learning with remote programs.

Misinformation and outdated information can be easily mistaken for fact. Although attempts to establish peer-review processes and quality indicators for online learning resources have been made, consensus for accepted guidelines is lacking.<sup>16-18</sup> Online authors and

**Table 2:** Benefits and Limitations of Remote Learning. Adapted from: Dahwan, S. Online Learning: A Panacea in the Time of COVID-19. Journal of Educational Technology Systems 2020, Vol. 49(1) 5–22, under the terms of the Creative Commons Attribution 4.0 License.<sup>21</sup>

Benefits	Limitations
<i>Convenience:</i> Flexibility for location and time	<i>Digital literacy:</i> Skill using technology varies widely and can lead to frustrations
<i>Expanded Audience:</i> Reaches a larger number of learners	<i>Quality of content:</i> Lack of consensus and guidelines for quality indicators of content
<i>Information Equity:</i> Improves equitable access to information, education, and experts	<i>Context specific:</i> Not all content is relevant to all settings and often needs adaptation
<i>Availability:</i> Wide availability of online content, platforms, and applications	<i>Misinformation:</i> Inconsistent use of peer-reviewed and evidence-based processes
<i>Collaboration:</i> Immediate instructor and learner feedback for course content flexibility	<i>Outdated information:</i> Online programs require frequent updates to stay current
<i>Engagement and Efficacy:</i> Ability to track learner participation and progress	<i>Technology Infrastructure:</i> Access to computers, internet, cameras, and software vary.
<i>Skills Demonstration:</i> Video demonstrations can reinforce hard and soft skills	<i>Cost:</i> Hardware, software and data packages can be costly
<i>Learner types:</i> Multimedia content for different learning styles	Require continuous monitoring and evaluation to ensure relevance of materials
<i>Cost-saving:</i> Open-access and free content without travel	Virtual experiences lacking in-person interactions and discussions feel less robust
<i>Infection Control and Prevention:</i> Decreased need for in-person participation	<i>Limited simulation:</i> Less robust for hands-on skill acquisition

editors may not be clearly identified, challenging learners to trust that provided resources are using evidence-based materials. One solution is to use publication dates and timestamps confirming what is the most current information published.

In order to overcome the above limitations, experts have suggested the following proposals:

1. Provide a reliable network infrastructure, especially the development of 5G.
2. Governments can provide more affordable devices such as tablets or computers.
3. The use of diverse modalities (telecourses, TV, radio, online courses) to provide accessible learning for students in remote areas.
4. Provide training to improve educators' and learners' technological skills.
5. Provide a structured educational plan with suitable materials.
6. Use interactive digital learning resources including video, animations and games.
7. Strategies to improve communication between teachers and students.
8. A blended approach is recommended where face-to-face lessons complement online lessons.
9. The use of artificial intelligence integrated with the pedagogical methodologies used by teachers.
10. More inclusive platforms and devices considering different web contents, to make digital learning resources more accessible.<sup>19</sup>

During the current pandemic, some countries such as New Zealand, has used a combined approach, using two television channels integrated with an Internet delivery and a hard-copy curriculum resource. While Queensland (Australia), had poor Internet connectivity, television has been used for learning.<sup>20</sup>

### Logistics for Remote Learning

For many, resource availability is a limiting factor. Optimized e-learning experiences are reliant on a dependable internet connection with adequate bandwidth. Faculty and users require access to a functioning computer or smartphone, compatible with the technology being used. Those with limited access may need to share computers, cameras, and workspace, while employing infection control measures. Some software such as telecommunication applications are subscription-based, placing potential financial barriers.

However, educators may obtain a free Learning Management System (LMS) such as Moodle.

Moodle (Modular Object Oriented Dynamic Learning Environment) is the most efficient and most commonly used open source LMS, used in 215 countries in 75 languages.<sup>22</sup>

Moodle seems to be attractive to educators for many reasons:

- It supports the Social Constructivist Pedagogy.

- It can be used for synchronous education.
- It requires a simple low technology internet search engine.
- It sends the lesson lists to the internet over the service provider.
- Thousands of lessons can be loaded within the Moodle LMS.
- Moodle incorporates multimedia products such as video and PowerPoint.

There are logistics associated with webinars (Table 3). A calendar is required for interactive sessions. Instructors must create registration links for the teleconferencing software, sending out invitations, and reminder emails. These new programs need be monitored and evaluated. Session preparation is a time-consuming endeavor taxed with the requirement for frequent updates. During sessions, instructors are tasked with screen sharing, advancing slides, and managing questions in the live discussion forum or "chat box".

### Learners' Feedback

In several studies, most learners reported they prefer online courses due to the greater convenience of time and location. Additionally, the integration of multiple media types serves various learning styles. Learners find it helpful to be able to easily communicate with other learners and course instructors.<sup>23</sup>

Still, learners do report some problems with synchronous learning environments including browser-related problems, necessity for software updates, hardware and equipment problems and disconnections. Some of these issues are solved by improving the connection speeds.<sup>23,24</sup>

In one study, 50% of learners cited clinical skills as the biggest gap in the remote learning curricula.<sup>11</sup> Students also felt a loss of motivation when clinical training opportunities were unavailable. Vallée A et al<sup>25</sup> conducted a systematic review and meta-analysis comparing blended to traditional learning in 2020. The pooled analysis showed significantly better knowledge outcomes for blended learning.

### Future Directions

Making online content accessible, innovative, and interactive through user-friendly tools, can prepare education systems for uncertainties such as pandemics, natural disasters, and other future disruptions.<sup>21, 24</sup> An invaluable educational tool for all stakeholders engaged in medical education and training, use of remote learning will require equity in access to technology and information. In addition to advocacy for more open-access journals and free educational materials shared by institutions of higher learning, education systems across the globe must also invest in professional development of educators to include the use of technology for improving digital literacy. Remote simulation is evolving to include iterative processes and virtual reality, augmenting hard and soft skills development.<sup>26</sup> Most importantly, remote learning must meet the needs of stakeholders from variably-resourced practice settings through support of technology infrastructure, and context relevant content.

**Table 3:** Considerations when setting up an online course. Practical advice for anesthetists in delivering remote teaching:

Prepare and master technology:	<ul style="list-style-type: none"> <li>A reliable computer, a strong internet connection, and the platform to meet your needs as Moodle for example. <a href="https://moodle.org/">https://moodle.org/</a></li> </ul>
Aim of the course	<ul style="list-style-type: none"> <li>Preparing for examinations such as Fellowship of Royal College of Anaesthetists (FRCA), <a href="https://rcoa.ac.uk/e-learning-anaesthesia">https://rcoa.ac.uk/e-learning-anaesthesia</a></li> <li>Enhancing safety in anesthesia practice</li> </ul>
Target audience:	<ul style="list-style-type: none"> <li>Junior registrars versus senior anesthetists</li> <li>Other members of the peri-operative teams</li> </ul>
Is a new online course required?	<ul style="list-style-type: none"> <li>Search for existing suitable online resources <a href="https://www.mmacc.uk/nw-anaesthesia/saved">https://www.mmacc.uk/nw-anaesthesia/saved</a></li> <li>Is a lecture series created during the pandemic by anesthetists covering FRCA exam topics</li> </ul>
Topic Choice	<p><b>e.g. Basic science:</b></p> <ul style="list-style-type: none"> <li>Monitoring, <a href="https://www.esaic.org/education/courses/basic-sciences-anaesthetic-course/">https://www.esaic.org/education/courses/basic-sciences-anaesthetic-course/</a></li> <li>Teaching airway skills</li> <li>Regional Anaesthesia <a href="https://www.maverickmeded.com/Courses/Regional-Anesthesia-Essentials">https://www.maverickmeded.com/Courses/Regional-Anesthesia-Essentials</a></li> </ul>
Course content creation	<p><b>Implementation of Interactive Elements:</b></p> <ul style="list-style-type: none"> <li>Welcome video</li> <li>Guest experts</li> <li>Questions &amp; answers</li> <li>Case-based discussions</li> <li>Learner led discussions</li> <li>Simulation</li> </ul>
Set the calendar and allocate contents	<ul style="list-style-type: none"> <li>Assignment due dates</li> <li>Share registration links</li> <li>Invite guest speakers</li> <li>Send reminder emails</li> </ul>
Ensuring quality control	<ul style="list-style-type: none"> <li>Clear authors and editors</li> <li>Reveal conflicts of interest</li> <li>Evidence-based resources</li> <li>Date/time stamped</li> </ul>
Candidate communication	<ul style="list-style-type: none"> <li>Motivate the candidates</li> <li>Encourages asking for help from peers and other educators</li> </ul>
Learner feedback	<ul style="list-style-type: none"> <li>Monitoring and evaluation of learner participation and progress</li> </ul>
Evaluation and Course Monitoring	<ul style="list-style-type: none"> <li>Participation</li> <li>Engagement</li> <li>Dissemination</li> </ul>
Relevance, Retention and learning	<ul style="list-style-type: none"> <li>Consider using the Kirkpatrick evaluation model 27 to ensure the effectiveness of training</li> </ul>
Ongoing Maintenance	<ul style="list-style-type: none"> <li>Practice change</li> <li>Maintenance</li> <li>Updating and Enhancement</li> </ul>

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## Simulation-based education – how to get started

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### Abstract

Simulation-based education (SBE) has a long history in medical education. SBE is now widely used to train individuals and teams in technical as well as social and cognitive skills. Much of the simulation literature is developed in well-resourced universities and hospitals with a dedicated simulation center, staff, consumables, and other assets. Looking at simulation from a global viewpoint, simulation centers are very hard to establish since the opportunity cost of investing in simulators, mannequins, equipment, a physical space and staff to run the center, is high. There also exists other barriers, for example time and training opportunities needed to develop expertise amongst simulation educators in the institution. Understanding that fidelity is not equal to benefit and that scenarios can be conducted in actual clinical settings, such as using in-situ simulation, rather than specialist simulation facilities, can help anesthesiologists begin to train using simulation without the need for significant financial investment. We provide practical tips for getting started with SBE and argue that the most important investment is in faculty development and engagement of the team. We also discuss the impact of the COVID-19 pandemic in necessitating the simulation world to be creative and develop new ways to train, for example through remote simulation.

**Key words:** simulation, SBE, patient safety, anesthesia education, education, medical education, low cost simulation, insitu simulation, faculty development

### INTRODUCTION

Although simulation-based education (SBE) has grown in its use in medical education over recent decades, its history can be traced back for centuries, for example using task trainers to practice skills. SBE has been adapted by anesthesia to incorporate opportunity for critical incident training as well as non-technical skills, partly pioneered by Dr. David Gaba at Stanford University, who developed techniques to use a mannequin in the operating room to train teams in handling critical situations that could develop in real life<sup>1</sup>. Inspired by human factors training in aviation, this led to the development of the anesthesia crisis resource management concept<sup>2</sup>, which has since been refined and spread to other specialties and settings<sup>3</sup>. Over the years, his team developed the first advanced anesthesia simulator but emphasized that simulation is an education technique and not a technology.

From its first clinical scenarios to the present day, using SBE in this way has revolutionized medical education, including in undergraduate, postgraduate, continuing

medical education and multidisciplinary learning. SBE is now widely used to train individuals and teams in technical skills (such as airway management) as well as social and cognitive skills<sup>4,5</sup>.

For the purpose of this paper, we define simulation as an educational activity intending to replicate a clinical scenario, partly by using a task-trainer, a mannequin or a simulator, or a patient or an actor. We propose that effective SBE requires:

- An intended focus (for example skill training, application of knowledge and skills, non-technical skills and/or assessment)
- A learning environment (a simulation center or a clinical setting)
- A method or way to recreate a real-life situation (for example a task trainer, a patient, a virtual simulator)
- Trained simulation facilitators

In this paper we intend to discuss each of these in turn.

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## What can SBE be used for?

(The intended focus)

SBE enables practice and analysis and evaluation of knowledge, skills and attitudes in real time, without putting patients at risk<sup>6</sup>. As a learning technique it has roots in experiential learning, and can be explained through Kolb's cycle<sup>7</sup> (figure 1). Applying this to SBE, participants have a concrete experience (a learning activity using SBE) followed by an opportunity for reflection (debriefing or feedback). Following this they are able to adapt existing or develop new concepts. They later develop these concepts further by testing them in new situations, either in real life or further SBE.

SBE can be used in multiple areas of anesthetic training (table one). Task trainers have been used for basic and advanced airway management, central line insertion, and regional anesthesia from spinal to specific nerve or plexus blocks<sup>7-9</sup>. Scenarios used to apply knowledge, practical skills and train in decision making (for example in management of the difficult airway), are now embedded in many specialist training programs<sup>10</sup>. It is also frequently used to train teams for example resuscitation, trauma, obstetric and pediatric teams. Simulation training is also important in teaching human factors such as leadership, communication, situational awareness and collaboration<sup>11</sup>. Additionally, SBE is used to train in the use of new technologies like anesthesia machines, infusion pumps or airway devices<sup>12</sup>.

SBE can also be used for assessing competencies and decision making in anesthesia, for example in objective structured clinical examinations (OSCEs).

Simulation is also used for organizational learning including analyzing systems to identify latent errors, removing threats and developing patient safety<sup>13</sup>, for example using translational or sequential simulation. In these types of simulation, patients or actors may be involved in the scenario and can contribute their feedback in addition to healthcare team members<sup>14</sup>. During the COVID-19 pandemic, the use of simulation has been reported on for preparing staff and analyzing techniques and workflow in organizations<sup>15</sup>.

## Where can SBE take place?

(The learning environment)

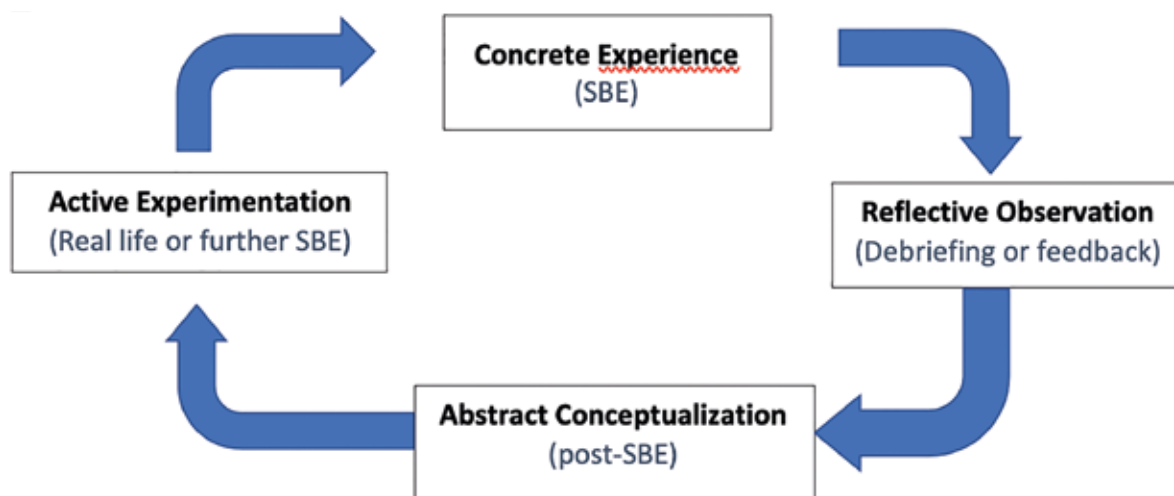
Much of the simulation literature comes from well-resourced universities and hospitals that have a dedicated simulation center, staff, consumables, and other assets<sup>16</sup>. However, considering this globally, simulation centers are very hard to establish due to economical, resource and staff challenges, even though we know that in many cases there is no difference in learning when comparing high-fidelity with low-fidelity equipment<sup>17</sup>. Because of high-cost believed to be associated with SBE, the reality in low- and middle-income countries (LMIC) is that simulation is seen as a luxury and not a necessity. If we know that simulation ensures safer practices<sup>18</sup>, we have to find a way to bring this to all those who practice anesthesiology<sup>19</sup>.

We argue that the focus should be on creating an appropriate simulation learning environment, not an expensive center equipped with high-fidelity equipment. By starting small scale and not requiring expensive equipment, you get to know the need of your learners and can develop training programs using low-tech tools and with low costs.

Scenarios can instead be run in clinical settings with the equipment being taken into departments and therefore training in the learners' own environment (in-situ)<sup>20</sup>. In-situ simulation has proven to be less expensive than having a dedicated simulation center, realistic since it runs in the actual clinical setting, and can be used to analyze not only individual and team performance, but also the systems where clinical situations take place<sup>13,21,22</sup>.

Another way to start to implement SBE in a cost-effective manner is to start with practical skill training, for example using task trainers, or scenario training using low-tech equipment.

National roll-out of specific courses, where simulation equipment and instructors are taken to places that do not have a simulation center thereby enabling those staff to participate, has also been used successfully<sup>23,24</sup>. A good example of this concept is the SAFE® anesthesia courses (<https://safe-anaesthesia.org>). These have the



**Figure 1:** Kolb's cycle of experiential learning and its representation in simulation.

advantage that with one investment in the equipment, many people in multiple hospitals can be trained. Although this enables a wide reach, a disadvantage is that after the course is over, simulation education culture is unlikely to continue at that center without further visits.

Another important strategy to improve cost-effectiveness is to use SBE only for training that would benefit from this teaching technique, for example practical skills, teamworking and human factors training. Training requirements that can be taught effectively using other less resource-intensive means should be taught instead using those activities, leaving the resources and simulation teaching capacity for learning objectives that are best taught through SBE.

### **How can we recreate a real-life situation?**

(The ways or forms)

In agreement with other authors, we find that it is beneficial to use low-tech equipment whenever possible, because this is likely to achieve the same learning objectives without the high-cost, limited session time, or problems with technology distracting from the learning opportunity<sup>25</sup>. A trained simulation facilitator and low-cost methods can compensate for the signs and symptoms that a low-tech simulator cannot provide.

Simulation societies such as the Society for Simulation in Healthcare (SSH), the Latin American Federation for Simulation in Healthcare (FLASIC) and the Society in Europe for Simulation Applied to Medicine (SESAM) are using workshops and online publications to promote innovation and creativity, and to help people interested in bringing simulation to their centers to develop models and ways to perform simulation at a lower cost with more achievable goals. This helps bring what was once a rare and innovative teaching tool into modern medical education in a variety of settings. This, in combination with technologies such as 3D-printing, locally produced models, the use of various materials such as resins, foams and silicones, mobile and web applications to mimic patient monitors, and the use of colleagues and friends as actors, have enabled simulation to come closer to the people<sup>26</sup>.

### **The question of fidelity**

The importance of fidelity has been widely explored<sup>25</sup>. In order to better understand the potential that exists when using low-cost tools, it is necessary to understand “realism” as a concept, since simulation by definition is the representation of a real situation.

Perception of reality happens in participants’ minds, so is a subjective experience. Fidelity in simulation, in contrast, is referred to as the similarity of simulation with real life. Therefore, realism happens in the participants’ minds, and fidelity in the real world.

According to Peter Dieckmann we can think of realism in three modes: the physical, the semantic and the phenomenal<sup>27</sup>. Physical realism is referred to as the similarities that the simulated object has in relation to the real world, for example in a scenario you can use an actual laryngoscope in order to intubate with a real endotracheal tube increasing realism. Despite this however, the plastic mannequin, the dryness of the mouth and the feeling of the laryngoscopy might not be as in real life, therefore limiting physical realism.

Semantic realism is referred as “the portions of the world that are facts only by human agreement” similar to the idea that when A occurs, it will be followed by B<sup>27</sup>. So, for example “if the patient bleeds then blood pressure will decrease” or another example “if I give propofol, then the patient will fall asleep”. The more experience the learner has, the more they might demand of semantic realism<sup>27</sup>.

Phenomenal realism includes emotions, beliefs and self-awareness. Studies have reported a similar state of emotion during a simulated scenario compared with real life<sup>28</sup>. Living the experience of a simulated scenario generates emotions because of the scenario as well as due to being observed and experiencing a complex clinical situation to solve. Finally, phenomenal realism also concerns the understanding of the phenomena, meaning the participant relates the educational experience to one that will be useful in clinical settings.

These concepts suggest that physical likeness to real life is not the only factor involved in learning from simulation. Surgeons have known this for a long time now, using basic boxes with cameras and tasks that physically do not look like an organ but that with deliberate practice, help the learner gain an understanding of which skills are needed to perform a laparoscopic procedure<sup>29</sup>. Following this, the next level of training can be conducted on more advanced surgical simulators. Similar to this, in anesthesia simple airway models can be used for learning how to handle the fiberoptic for example<sup>30</sup>, which can then be followed by practical skills training on more advanced simulators and later on, scenario-based team training. These illustrate examples of training in the basic skills first using relatively low-fidelity, and thereafter higher fidelity options as available.

Fidelity is context-bound and if both facilitators and learners buy in into the scenario in mutual agreement, there is unlikely to be a need for replicating the exact physical characteristics of the real world to achieve the learning objectives<sup>25</sup>.

Although we believe that low-fidelity simulation does not limit learning, it may be that the more real the simulation is perceived, the more engaging the learners find the session. Knowing that learner’s enjoy realism and that this often comes with increased cost, in situ simulation (for example in the actual operating room) meets multiple needs. Depending on the learning objectives of the scenario and skills to be taught, low-fidelity can be used, for example a full-size or smaller mannequin, a task trainer such as an intubation head (figure 1c) using pillows, a clinical gown and surgical drapes to give the form of a patient, or even a colleague acting. Although fidelity can be low in these methods, the use of the real clinical environment often means realism and engagement may be high.

One risk of in situ simulation documented in the literature is that of expired or unreal medications being taken into the clinical environment for the scenario, then later being mistakenly used after the training on a real patient. It is essential that efforts to check the clinical environment is safe for patient use again after the training are undertaken, and we would recommend never taking training drugs into the clinical environment in order to avoid this risk<sup>23,27</sup>.

Information given to the learner about the patient, for example a patient chart or from an embedded simulation participant (for

example other faculty or actors) can also help fidelity. A low-cost monitor using a tablet, a smartphone and apps that you can download from the common app stores is also useful, for example the SimMon® app (<https://simmon-app.com/>). We can also increase fidelity by using low cost methods to represent clinical signs, for example bleeding or rashes ([www.opensourcesim.com](http://www.opensourcesim.com)).



### **The development of low-tech equipment and the combination with simple guidelines**

In many LMIC, basic simulation-based training has been successfully introduced. One example is the Helping Babies Breathe (HBB) project (figure two), with the aim of saving newborn lives. Firstly, a simple guideline to be used to assess the condition of the newborn baby was developed followed by a simple newborn task trainer to train basic skills such as assessment of breathing and heart rate, mask ventilation and suction of the airway. One cause of the success of this project, is that the cost of the training equipment is relatively low.

In a cascade model, local facilitators were trained to use the simulator and training tools to teach other colleagues. In a pre-post design large-scale study in Tanzania with observations of more than 6000 deliveries, a 48% reduction in neonatal mortality was demonstrated within the first 24 hours<sup>30</sup>. Factors contributing to this implementation being successful include involvement of all levels of leadership and the multidisciplinary team including government, hospital leaders, midwives and the doctors' association. Last but not the least, the availability and ease of procuring the low-cost equipment was essential<sup>30</sup>.

The HBB concept is now available in 77 countries and it has been followed by Helping Mothers Survive, where learners learn safe delivery techniques, removal of the placenta and injection of medications to stop excessive bleeding. Several other programs have been developed based on low-tech solutions directed towards the learners need with successful results also<sup>23</sup>, suggesting again that high-fidelity and cost are not requirements for learning.

### **Competent Facilitators and Staff**

As mentioned previously, skilled facilitators are the most important element in SBE. Our recommendation is that this is more valuable than high-tech equipment. A good facilitator can establish a safe learning environment and guide the learners through the scenario by providing the necessary information, especially the signs and symptoms that the simulator cannot give. The facilitator should lead the debriefing session addressing the learning objectives, making room for all learners to join the discussion, and end the session with an application phase where learners can set their own goals and future learning objectives for other scenarios and their clinical practice. In addition, a trained facilitator is important to ensure that debriefing and feedback takes place in a safe learning environment and that psychological safety is maintained.

In most centers, facilitator training courses are run over at least 3-days enabling time to develop experience and get feedback from more experienced facilitators, but combinations of shorter courses and mentoring is also possible. The facilitators are often motivated learners who enjoy and can see the benefit of discussion with peers and reflection for learning.

The World Federation of Societies of Anesthesiologists endorses two courses that teach the basics of simulation. Vital Anesthesia Simulation Training (<https://vastcourse.org/>) is a short course designed to initiate simulation in LMIC centers and has a train-the-trainers component. Inspire Through Clinical Teaching (<https://inspirecourse.com/>) is another course that teaches practical teaching skills and includes a full day on simulation-based medical education.

### **Simulation in the pandemic**

Because of concerns of infection transmission to healthcare workers during training, remote methods of simulation training have grown during the COVID-19 pandemic, for example “tele-simulation”<sup>31</sup>.

Even though tele-simulation is not new, it has gained presence this last year. In this modality, participants, simulation operators and facilitators are located remotely, interacting on a web communication platform such as zoom®. Some examples of how tele-simulation is performed are:

- Live feed from a simulation center - In some cases, actors can be present in a simulation center interacting virtually with the learners who manage the situation remotely.
- Screening a vital signs monitor - During the virtual session a monitor is shown on the screen and a scenario is presented by a facilitator. Learners will share what they are thinking and suggest actions.
- Use of specific virtual simulation platforms - Simulation companies have developed robust platforms that integrate a virtual patient, a monitor and even an anesthesia machine, for learners to experience diagnosis and decision making.

Even though it is not the same as face-to-face simulation training where learners can interact with the mannequin in a physical space and teams can learn together, both increase in knowledge and participant engagement has been demonstrated in tele-simulation<sup>32</sup>. Even though some discussion can be had about whether this is truly SBE or not, we believe this is a promising educational technique that could be engaging and used well during the pandemic and after, for example by bringing this education technique to remote areas.

Another model for remote simulation has asked learners to practice a skill, such as intubation or proper donning, and then video record it and upload it to a specific website where experienced staff provide feedback. After receiving this feedback learners practiced again and



sent back another video for review. Using this model, studies have demonstrated that learners acquired competence. Although this has also been introduced because of COVID-19, it may have a future use in order to bring simulation into more remote settings<sup>33</sup>.

Facilitator training courses have also changed during the pandemic. Virtual training and mentorship of facilitators has been successfully used, for example the EUSIM course (<https://eusim.org/>) or the Harvard Center for Medical Simulation online instructor training course (<https://harvardmedsim.org/course-type/online-instructor-training/>).

## Conclusion

SBE has proven to be useful in anesthesia practice. Even though sometimes it is seen as a luxury, there can be affordable ways to bring it to places where capacity and funding might be scarce. Understanding that physical fidelity and expensive mannequins are not always needed to achieve learning objectives, using low-cost simulators, using actors or standardized patients, and running simulations in-situ can be some of the ways to cost-effectively bring SBE to clinics and hospitals around the globe.

**Table 1:** Uses of simulation with examples relevant to anesthesia

Use	Examples in anesthesia
Skill training	Direct laryngoscopy, fiberoptic bronchoscopy, central line insertion
Knowledge application and decision making	Knowledge concepts applied to a critical situation in the operating theatre such as anaphylaxis
Human Factors training	Leadership, communication, situational awareness
Learning new technologies	Use of new infusion pumps or a new video laryngoscope
Assessment	Either formative assessment during training or summative assessment such as towards certification
Organizational learning	Identifying latent errors in a hospital operating room
Sequential simulation	Developing patient pathways in healthcare

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## Introduction to Debriefing

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### Abstract

Debriefing is a unique type of conversation that guides reflection, analysis, and ultimately learning after a practical experience. During a debriefing, participants and instructors share their experiences and observations of the event, discuss what they did or did not do and, mostly importantly, why, and develop plans to apply lessons learnt to their future practice. A successful debriefing requires active engagement, an environment of mutual respect, and a focus on learning. This article is an introduction to the why, how and when of debriefing. It will discuss what makes debriefing unique from other types of teaching that happens in medicine and medical education, how to create the right environment for a successful debrief, and when to apply debriefing tools in clinical practice and education.

**Key words:** Medical education; interdisciplinary; feedback; learners; learning; conversation

### INTRODUCTION

Reflecting on an experience is the link between having that experience and the ability to learn from it<sup>1</sup>. Debriefing guides that reflection. Debriefing is a structured conversation that allows someone to discuss a meaningful experience<sup>2</sup>. Debriefing relies on active conversation between the learner and instructor or among a group of learners. Participants of a debriefing reflect on what happened during the experience, how they felt and acted, discuss what went well and what did not, determine why they acted the way they did, and consolidate knowledge and skills that they can apply in future situations<sup>3,4</sup>. This article will review why, how, and when to debrief: the rationale for debriefing, components of a structured debrief, and clinical and educational events where debriefing can be helpful in promoting learning, improving clinical care and patient outcomes.

#### Why Debrief

Debriefing has its roots in the military and aviation industry in which, like medicine, teams work together in potentially critical situations. Many of the features of debriefing in health sciences and health sciences education come directly from these two fields: holding debriefings as close in time to the event as possible, involving all team members regardless of hierarchy, creating a non-punitive environment that focuses on learning, and application to future events<sup>5,6</sup>. The skills that are often discussed during a debriefing

(leadership, decision making, communication, resource utilization, situation awareness, collectively referred to as Crisis Resource Management skills or non-technical skills or teamwork skills) are derived from the aviation industry's crew resource management skills<sup>5,6</sup>.

There is evidence that when debriefing is used in both clinical and simulation settings, there is improvement in technical skills and non-technical skills, individual performance and team performance, and patient outcomes<sup>4,7,8,9,10</sup>. Debriefing is widely used in simulation curriculum in medical schools and postgraduate medical education training programs. Many hospitals and departments hold debriefings after critical events. Both the European Resuscitation Council and the American Heart Association recommend debriefing after a resuscitation event<sup>11</sup>. There is growing evidence that, when used as part of a simulation program, debriefing is beneficial to the education of surgical and obstetrical residents in low- and middle-income countries<sup>26,27</sup>.

#### How to Debrief

Debriefing is a special type of social interaction between you and your participants and amongst the participants. Like any type of social encounter, you need to consider the environment you are in and the one you are creating, the participants you will

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be interacting with, and also how you will be spending your time together.

The debriefing environment includes both the physical and psychological environment (Table 1). Ideally you should find a private space with few distractions where all participants can sit down and both see and hear each other<sup>12</sup>. In our institution we use a conference room close to the operating room area. This may not always be possible at your site. Be creative. Find an empty operating room or patient room and close the door. If there aren't enough chairs for everyone then stand in a circle. Ask colleagues (not involved in the debriefing) to answer pages or phone calls during the debriefing. Don't let a lack of the "ideal" environment stop you from debriefing.

The psychological environment you create is even more important than the physical environment in which you find yourself. In order for a debriefing to be effective, your participants need to feel psychologically safe to share their observations, reflections, thoughts, and ideas. Confidentiality is important for the learners and the instructors. For simulation sessions we ask the participants not to discuss the content of the scenarios as we often reuse scenarios for future learners. For all debriefings we ask participants not to share what was discussed. In return, we tell them that we will not be sharing anything about performance during the simulation scenario or questions or comments shared during the debriefing with department heads, supervisors, or program directors. Only include people in the debriefing who were involved in the clinical or simulated event<sup>12</sup>.

Assume the best of your participants. At our institution we have signs posted on the walls of our debriefing rooms that share our basic assumption, adapted from the Center for Medical Simulation in Boston, Massachusetts<sup>13</sup>: "We believe that every participant at the University of Ottawa Skills and Simulation Centre is intelligent, capable, cares about doing their best, and wants to improve". Approach your learners with the same attitude. Include a similar statement when you start your debriefing.

Focus on learning. A debriefing is not an evaluation, a performance review, nor is it meant to be punitive<sup>12</sup>. Remember that participants are there to learn from you and learn from each other. Be open to learning from your participants as well. This is especially true during interprofessional and interdisciplinary debriefings where participants have a lot to learn from other team members about their different points of view, experience, and roles during a crisis.

Participant engagement is critical to a successful debriefing. Unlike a lecture, or what we typically think of as feedback, debriefing is a

conversation between instructor and the participant(s) or amongst the participants themselves. The participants are not passive<sup>8</sup>. Debriefing relies on their observations, reflection and analysis. All team members, regardless of their role or level of training, who were involved in the clinical or educational event should be included in the debriefing<sup>12</sup>. Everyone should be given the opportunity to speak and ask questions. There are examples of peer-led debriefing where participants are able to debrief themselves with little or no input from an instructor<sup>24,25</sup>. They may be guided by a list of written questions. This often works best if members of the team have some training or previous experience with debriefing.

The content of your debriefing should focus on knowledge, skills, and behaviours that are clinically relevant. One of the biggest challenges I have observed is instructors who try to address every performance gap that they observe. This is especially challenging when there are multiple instructors, each with their own agenda, trying to discuss what is most important from their own perspective. It is also a challenge when participants come from different professions or specialties. Debriefings have a limited duration and there is only so much that participants can learn during any teaching session<sup>12</sup>. Spend your time discussing two or three objectives in detail. Don't expect to discuss everything that happened. Your learners may want to discuss different topics than you during the debriefing; try to address some of your objectives and some of theirs. At our institution, many instructors will focus on learning objectives related to team work skills instead of medical knowledge or technical skills. This allows us to engage the entire team in conversation rather than learners from specific specialties or professions. We send resources regarding the medical expert objectives after the session by email.

It is important to focus the discussion on how the team worked together, made decisions, used their resources, and communicated rather than the outcome that was achieved. Sometimes a team demonstrates excellent medical knowledge and teamwork but the patient has a poor outcome. Sometimes, despite poor teamwork, the patient has a good outcome. The goal of debriefing is to examine the processes that were used by individuals and the team and to reinforce what was done well and improve what can be improved<sup>12</sup>.

Your goal as a debriefer is to close performance gaps<sup>15</sup>. Participants may act in ways you don't expect them to. This difference between their actual performance and the performance you expect and want, is the performance gap. The goal of debriefing is not just to correct the actions, it is to uncover the thought processes (or frames) that led to the actions that you observed. Correcting frames will lead to more consistent and effective learning and behaviour change than

**Table 1:** Creating the Debriefing Environment

The Debriefing Environment	
Private and quiet	Confidential
Eliminate distractions	Respectful
Allows everyone to see and hear each other	Appropriately inclusive of all team members
	Assume the best of your participants
	Subgaleal space
	Learning focused

correcting actions alone. By teaching participants better ways of approaching and working through problems, they will be able to apply what they have learnt to a wide variety of situations. Similarly, you should spend time during the debriefing discussing what thought processes led to desirable actions and provide reinforcement.

There are multiple debriefing models described in the literature. They all have the same basic structure (Table 2): pre-brief (for a planned experience such as simulation or clinical teaching), reactions, description, analysis, and summary<sup>16</sup>.

**Table 2:** Different phases of a structured debriefing. While the duration of each component will vary depending on the type of event taking place, the number of learners, and the duration of the event, the analysis phase is the main component of a debriefing and most of your time should be spent in the analysis phase.

<b>Pre-Briefing</b>
<b>Reactions Phase</b>
<b>Description</b>
<b>Analysis Phase</b>
<b>Summary</b>

Pre-briefing should be done for all planned simulation activities and clinical teaching where a debriefing is planned. A pre-briefing engages the participant by preparing them for and orienting them to the experience they are going to have. It is the first step in creating a psychologically safe environment during the debriefing. Hughes and Hughes<sup>17</sup> describe the four basic components of a pre-briefing: reviewing the session goals and objectives, establishing a contract with the learner where they agree to treat the scenario as if it was real (necessary for simulation events), describing logistics and ground rules, pledging to respect the learner. Table 3 outlines a suggested script that can be used during a pre-brief.

The reactions phase is the first phase of the post event debriefing. It often occurs as participants are walking towards or gathering

**Table 3:** Suggested pre-briefing script

<b>Suggested pre-briefing script</b>
(Introductions). Thank you for joining us today for your simulation session. The goal today is for us to practice and discuss our team working skills by working through either common or important crisis situations that can occur in the operating room. We know that everyone here is intelligent, capable and wants to improve and we are all here to learn from each other today. We will not be discussing your performance outside of this room and we ask that you also do not discuss the events or discussion we have here today. We have done our best to make the clinical situation and environment as realistic as possible but we know that things will be different from a real clinical situation. Please do your best to treat the situation, patient, equipment, and people you are working with as if this was a real clinical situation. Today we will be running one scenario for 10-15 minutes and then we will spend 30-45 minutes discussing it together. Please ensure your pagers and cell phones are turned off for the duration of the session. Does anyone have any questions?

in the debriefing room. When a participant experiences a real or simulated event, it will have an impact on them<sup>18</sup>. They may have strong negative or positive feelings about what happened. The reactions phase allows participants to share or vent these feelings to the instructor and to each other. Make sure everyone has the opportunity to speak. As an instructor, the reactions phase can tell you whether the participant thinks they did a good or poor job and how they are feeling about their performance: are they confident, angry, excited, sad, withdrawn? It can tell you the level of insight the participant has on the experience and their performance: are their emotions what you expect or are they unexpected? It can tell you what the learner is focused on and what they will want to speak about during the debriefing. Pay attention to the participant's facial expressions, tone of voice, body language, and words and adjust your debriefing accordingly. Table 4 contains suggestions for how to start the reactions phase.

The description phase brings all the participants onto the same page so there is no confusion about the facts of the case and the events that occurred<sup>16</sup>. Participants may come from different clinical backgrounds or different levels of training. They may not have been present for the entire event being discussed. They may not have a global picture of everything that happened because they were focused on a particular situation or task. You may choose to provide the description yourself or have participants describe the main issues and events from their perspective. See Table 5 for suggestions on how to summarize or how to ask learners to summarize the scenario. The description phase is important because learners may not be able to focus on discussions about non-technical skills, crisis resource management, or teamwork until they know if they "made the right diagnosis", "managed the case correctly" or figured out "what the case was about".

The analysis phase is crucial for learning to occur during and after a debriefing and this is where you should spend most of your time<sup>5,16,18</sup>. I recommend spending 75% of your time in the analysis phase. This is where the learners have time to reflect on their actions, ask questions, analyze their frames, discuss their performance gaps, and come up with solutions to close them<sup>1,2,5,16,18</sup>. There are many different strategies that can be used to guide this reflection, analysis, and discussion. In their PEARLS Debriefing Script, Eppich et al describe how to choose which strategy (self-assessment, instructor led teaching, or facilitated discussion) will be most effective for your participants based on the type of performance gap, the insight of the participants, and the time available<sup>16</sup>.

**Table 4:** Examples of phrases that can be used to start the reactions phase

<b>Suggested reactions phase opening</b>
How are you feeling right now?
Would anyone like to share how they are feeling?
What is your reaction to what just happened?
Would anyone like to share their initial reactions?

**Table 5:** Examples of phrases that can be used to start the description phase

<b>Suggested description phase opening</b>
This was a case of a patient with an anticipated difficult airway deteriorating and requiring urgent airway management. The goal was to see how you assessed and managed the patient applying the difficult airway algorithm and eventually securing the airway using a surgical airway.
Can you please summarize the important medical issues and events in 1-2 sentences?

Whichever technique is used, it is important to keep in mind the principles of a safe debriefing environment, respect for your learners, respect for your own knowledge and expertise, and the importance of asking genuine questions and paying attention to the answers. Rudolph et al<sup>14</sup> describe the use of “good judgement” to create psychological safety in a debriefing. As a debriefer, instructor, teacher, or expert in your field, you have knowledge, experience, and perspective that your participants may not. Your judgements are valuable and should be shared during the debriefing. However, judgements should be made without shaming, blaming or criticizing. Share your observations and thoughts about performance in a way that respects the participant’s experience and perspective. Don’t assume you know why they performed in a certain way. Instead, be genuinely curious about what led to their actions and try to understand why they did what they did.

The “plus/delta” technique asks learners to create a list of things they did well (plus) and things they would change or improve (delta)<sup>3,19</sup>. Plus/delta relies on participants to speak up, reflect on their own performance and that of their team, and be willing to recognize things that well and things that did not. Presenting this as a written, two-column exercise encourages participants to be balanced and not to focus only on the good or poor aspects of their performance. This technique can be used to generate a list of potential topics to discuss during the analysis phase. As an instructor, you may not necessarily

agree with the participants’ assessment of what belongs in each column. Your perspective and opinion should be shared, respectfully, and used to generate further discussion of the topic<sup>14</sup>.

Direct feedback or instructor-led teaching can be used if there is limited time or for performance gaps that are technical or knowledge based<sup>16</sup>. Ideally, more time will be spent using other techniques that allow participants to engage, reflect, and create their own insights. However, some learners need more guidance or direction from the instructor in order for the conversation to move forward.

A facilitated discussion gives the participants and the instructor a deeper understanding of why certain actions were taken, barriers to applying knowledge, the pros and cons of the decisions that were made, or any other learning objective that is important and relevant to both the instructor and participant<sup>16</sup>. It requires a participant who is engaged, willing to reflect on their performance and their frames, and analyze their behaviours. It also requires an instructor who has paid attention to what was done, is able to respectfully share their “good judgement” and ask genuinely curious questions<sup>14,15,16</sup>. Table 6 contains examples of phrases you can use to facilitate discussion.

Regardless of which technique you use, the analysis phase should focus on objectives that are clinically relevant and important to both you and the participant. End the analysis phase by asking the learners if there are any other issues they wish to discuss.

**Table 6:** Examples of phrases that can be used in the analysis phase to guide a facilitated discussion

<b>Facilitated Discussion</b>
I saw you wait for bloodwork results before treating hyperkalemia even though you noticed EKG changes. That seems like an unnecessary delay. Help me understand why you waited for bloodwork before starting treatment of hyperkalemia.
You decided to give medications for intubation yourself instead of delegating that task to the nurse. It seemed like you had a lot going on at that time and in my view, you were overloaded with tasks. What are the pros and cons of giving medications yourself vs delegating that task to someone else?

**Table 7:** Example of a phrase that can be used to start the summary phase

<b>Facilitated Discussion</b>
Let’s wrap up by each sharing one thing you did well today that you will continue doing in your clinical practice and one thing you learnt that you will apply the next time you encounter a similar situation.



**Table 8:** from Ahmed M, et al. A SHARP Improvement in Performance Feedback in the OR19

The debriefing concludes with the summary phase. Learners summarize 1-2 take home points that are important to them. The summary phase has multiple important roles. First, summarizing helps consolidate the learning points for the learner themselves. It also gives you, as an instructor, feedback about whether the learners achieved the objectives you wanted them to from the event and from the debriefing. Finally, the summary phase is a good reminder from both the instructor and the participant that learning does not end when the debriefing ends. Learners should continue to reflect on their experience and the discussion. They should look for ways to apply what they learnt to their future practice, thus continuing the cycle of experiential learning<sup>1</sup>. Table 7 contains suggested phrases you can use to guide the summary phase.

### When to Debrief

The debriefing conversation and tools can be applied to simulation sessions, clinical teaching, or after critical events.

Several systematic reviews and meta-analyses have established the importance of debriefing when conducting simulation<sup>4,8,12,20</sup>. Without debriefing after simulation, there is no learning. Simulation is a time and resource intensive teaching modality that requires additional training and, often, equipment. A full review of simulation is addressed in another article in this journal. Although we often think of debriefing in the context of simulation, it can be used more broadly in education and clinical practice.

Teaching tools, such as the SHARP tool (Table 8) and the BID technique (Table 9), have been developed that use a debriefing structure and debriefing strategies<sup>19,21</sup>. They are designed to be used even in busy clinical and teaching practices, taking 5-10 minutes to complete. Start the day/case/clinic/shift/patient encounter by setting expectations, identifying objectives (your objectives and your learner's), and creating an atmosphere of mutual respect: "the pre-brief". Hold the debriefing as soon after the session as possible<sup>12</sup>. Include a reactions phase by asking the learner how things went or how they are feeling. Try self-assessment strategies by asking the learner what they did well and what they could do differently. Have a facilitated discussion by sharing your opinion and good judgement and by asking questions. Use directed feedback to reinforce or correct their knowledge or technical skills. Finally, summarize by asking the learner what their plan is to close their performance gap or apply what they learnt during this session. Unlike what we traditionally think of as feedback, using a debriefing approach engages the learner in the conversation, analysis, and creation of a learning plan.

Structured debriefing tools, such as the DISCERN tool, have been created that require little debriefing expertise or experience and many institutions have created their own versions to use following critical events<sup>22,23</sup>. A psychologically safe environment, a focus on learning rather than blaming, and an attitude of respect for all team members are extremely important when debriefing a team that has recently managed a critical event, especially if there was a poor patient outcome. To make these tools easy to use by those without formal debriefing training, many use a plus/delta strategy. The authors of these tools also suggest that any ideas raised in the summary that could be applied on a system level to reduce error and improve patient outcome, be anonymized and shared with hospital leadership.

**Table 9:** from Roberts NK, et al. The Briefing, Intraoperative Teaching, Debriefing Model for Teaching in the Operating Room<sup>21</sup>

Stage	Step	Script
Briefing	Set learning objectives for encounter	"What would you like to focus on?" OR "Today I want you to focus on..."
Intraoperative Teaching	Teaching during the encounter	Focused on stated objectives
Debriefing	Reflection	"How do you think you did? Why?"
	Rules	"What did you learn for next time?"
	Reinforcement	"You did well at..."
	Correction	"Next time, do this..."

## Conclusion

Debriefing is a well-established tool for promoting learning after a simulation session. There is growing evidence that when used in other areas of healthcare, such as teaching and after critical events, individual performance, teamwork, and even patient outcomes improve. Debriefing is rooted in an educational theory that requires learners to engage, reflect, analyze, and demonstrate insight and a willingness to apply what they've learnt to their future clinical work. The debriefer must be able to create a psychologically safe environment, adapt to the learners' needs and goals, and be willing to share their observations and opinions honestly and respectfully. When both sides are able to fulfill their responsibilities, it leads to a unique and rich discussion where everyone involved learns and improves.

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## **Feedback in Medical Education is a Journey; Pack More than a Sandwich**

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### **Abstract**

The exchange of feedback between learner and teacher is a critical component of medical education. Effective feedback allows for sustained performance improvement over the continuum of training. Despite the importance of feedback in the development and growth of medical learners, the skillful provision and delivery of feedback remains a daunting task for most medical educators. Medical educators are often poorly trained to deliver effective feedback and suffer from a lack of education in feedback theory. Additionally, educators must also recognize and remove barriers to effective feedback exchange. Institutional culture and learner expectations further complicate the feedback conversation. This review seeks to provide a brief background on feedback theory in the medical education environment. Furthermore, characteristics of ideal feedback, barriers to feedback delivery, and tips and techniques for more effective feedback exchange are discussed. The role of the learning environment culture on feedback exchange is also explored. Effective feedback exchange in medical education remains a complex and difficult goal in the clinical environment. Nonetheless, the content of this review article may help improve feedback exchange in many clinical learning environments.

**Key words:** medical education methods; medical education/trends; teaching methods; teaching trends; learning; feedback

### **INTRODUCTION**

Learning is a complex process that can be facilitated by the setting of goals and objectives, a period of teaching and practice, and then an assessment of performance with attention to improvement. The provision of regular feedback is one method to provide formative assessment. Feedback as a systematic approach of assessing results compared to desired outcomes, originated in engineering in the 1940s and then expanded into many other fields including medical education<sup>1</sup>. The role of feedback in graduate medical education was defined by Ende in his landmark article in 1983 as “information describing students’ or house officers’ performance in a given activity that is intended to guide their future performance in that same or in a related activity”<sup>2</sup>. The purpose of feedback is to help learners reflect on their actions with a goal of improving future performance. Learners often wish to get feedback that can aid in self-reflection and improve their performance<sup>3,4</sup>. However, many learners feel that they are provided insufficient constructive feedback<sup>5,6</sup>. Furthermore, educators often lack sufficient training to formulate and deliver effective feedback<sup>7,8</sup>. This review will seek to define feedback in medical education, identify the

characteristics of effective feedback, discuss barriers to and provide tips for giving effective feedback.

#### **Feedback vs. evaluation**

Prior to an in-depth discussion of feedback, it is important to make clear the distinction between feedback and evaluation. Feedback is formative; it is information that is meant to be used to influence future performance at the completion of an observed performance. Evaluation is summative and seeks to provide an assessment of performance after a series of performances within a lengthier time span. In other words, feedback is an assessment done for the purpose of learning while evaluation is an assessment of what has been learned. Brand et al. have gone so far as to use the analogy; feedback is to evaluation as driving lesson is to driving test<sup>9</sup>.

#### **Characteristics of effective feedback**

Feedback quality and character are important determinants of impact and acceptance. Feedback should contain discrete information regarding specific observed facets of a performance, center on actionable behaviors, and followed by an action plan to help the

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learner improve. The content should be objective and free of any reference to personal characteristics, non-observed behaviors, or past events that were not a shared experience. (see Table 1) For instance, telling a learner “You are not good at intubations. You’re not a good fit for anesthesiology.” is unlikely to be helpful feedback as it is non-specific, judgmental, overly broad, and likely to be taken as a personal attack. It would be better to share direct observations and suggestions on performance improvement. A more effective feedback statement might be “The intubation looked like it was difficult, did you consider raising the patient’s bed to obtain a better view?” Such feedback allows the learner to share their insight into their performance and provides a catalyst for a fruitful discussion. Did the learner believe the intubation was difficult? If so, did they appreciate that the bed height may have played a role in their difficulty?

The timing of feedback delivery is another key consideration of effective feedback exchange. Ideally, the session should be a conversation between the learner and teacher; not a one-sided lecture. Feedback delivered immediately after the observed performance may be most effective. However, the teacher must balance the risks and benefits of immediate vs. delayed feedback given the learner’s ability and clinical situation. Immediate feedback is often necessary when teaching clinical procedures, especially when patient care may be compromised. In that case, the learner should be redirected in order to prevent any harm from being done to the patient, but in a way that does not humiliate the learner in front of others. (see Table 2)

### Barriers to effective feedback

Effective feedback exchange may prove difficult in medical education for many reasons<sup>10</sup>. Several common barriers to effective feedback exchange are described below.

#### *Time limitations*

The pace and acuity of modern medical care and its attendant administrative burden leave little time for the thoughtful discussion and observation required for feedback exchange. The fast-pace and time pressure of the perioperative environment limit opportunities for in-the-moment feedback exchange. A fading memory of events may make feedback exchange less effective at day’s end. The use of mini feedback sessions throughout the day may result in better recall of events and a more natural dialogue with opportunities to implement practice change on the fly.

#### *The Dilemma of negative feedback*

Feedback can be perceived to be positive or negative by a recipient. Positive feedback will make the recipient feel good and reinforce behaviors of a successful performance, but it will not address areas of deficiency.

Negative feedback has the potential to identify and address performance deficiencies, but it is important to consider the barriers to the acceptance of such feedback. Negative feedback can cause significant distress on the part of the learner who, when faced with information that is damaging to their self-esteem, may dismiss the feedback as useless, critical, or controlling<sup>11</sup>. Studies have shown negative or corrective feedback is better accepted when learners feel the source is credible<sup>12-15</sup>. Credibility can be established by spending time to build rapport with the learner, having a transparent process for obtaining information used in providing feedback, and by the content and characteristics of the feedback itself<sup>14</sup>. The effect of negative feedback can be paralyzing and long lasting<sup>16</sup>. Therefore it should be given in a constructive and non-punitive manner with respect and an earnest intention to foster learning and improvement. Delivering negative feedback by lecturing, or worse, berating the learner, is only likely to cause the learner to become defensive or withdrawn and is unlikely to produce any results.

#### *Resistant recipient*

Effective feedback is not solely dependent on the skill of the deliverer. The learner’s mindset is also an important determinant<sup>17</sup>. A “growth” mindset centering on a desire to improve and learn from mistakes is more likely to result in acceptance of feedback. A learner with a “fixed” mindset may prioritize the appearance of a good performance over anything that might be perceived as a deficiency or a mistake. The “fixed” learner may consider negative feedback as a defeat rather than a tool to improve their skills. An individual who perceives feedback to be a negative experience may not effectively process any of the information provided regardless of the content or delivery method<sup>18</sup>.

A learner’s fixed mindset is not the only reason a learner may fail to accept feedback. It is cognitively difficult to accept feedback that is discordant with our own opinion of self<sup>11</sup>. Therefore when challenged with negative feedback, some feedback recipients may be dismissive and or adopt a defensive or aggressive position against the feedback deliverer<sup>16</sup>. Conversely some learners who take feedback poorly may become upset and withdrawn rather than aggressive or defensive. Fear of appearing “weak” or “stupid” can lead a learner to avoid opportunities for feedback<sup>18,19</sup>. An antagonistic relationship between feedback deliverer and recipient is counterproductive to learning. A learner who displays a “fixed” mindset orientation in a feedback discussion may be encouraged to adopt a more “growth” centered perspective if successfully engaged by the teacher. This can be done by assuring the learner that feedback is provided to drive improvement; it is not intended to make them feel badly nor is it an indictment of their skills or character.

**Table 1:** Characteristics of ideal feedback

Specific: Use concrete and specific examples
Timely: Give close or near the event for maximal impact on performance improvement
Observed: Use firsthand observations; avoid using interpretations or inferred actions
Collaborative: Shared focus on improvement goals with exchange of ideas
Actionable: identifies discrete behaviors that the recipient can change or improve for the future.

**Table 2:** Tips for delivering effective feedback.

Build rapport and invest in a relationship with the learner
Time and location should be agreed upon by both parties
Seek learner's self-assessment and engagement in the conversation
Performance measured against well-defined goals that are transparent and readily available to all
Use specific examples based off first-hand data or decisions and actions
Use precise, neutral, non-judgmental language
Create an action plan by providing a scaffold for future improvement
Create a culture of feedback by making it a frequent and expected part of the learning process

The teacher may also reach out by sharing their own self-reflection of performance. The foundation for a career-long commitment to self-reflection and practice improvement can be laid during training by helping the learner understand how to constructively process negative feedback.

Occasionally, feedback recipients may refuse to accept the validity of negative feedback. They may feel that “everyone is out to get them” and dismiss the feedback as punitive and arbitrary<sup>18</sup>. It may be helpful for the feedback deliverer to step back in such situations and engage the learner in self-reflection. For example, take the case of the learner who is repeatedly told that they need to be more proactive in emerging patients from general anesthesia. The learner may respond by stating their belief that they are performing well in that domain, and other factors are responsible for the delay. Arguing your viewpoint with the learner is unlikely to be constructive. It may be better to ask the learner to consider the alternative to their belief. You might volunteer, “I understand how you feel, but have you considered the possibility that there may be things you could do differently to facilitate a more timely emergence?” If the learner reflects on the feedback, they may realize there are things they could improve for the future. In cases where patient harm or inappropriate care is likely to continue, it may be more prudent to pursue correction via more formal and systematic methods as available to training program directors and hospital leadership.

#### *Learning environment/culture*

Feedback in medical education has evolved from a unidirectional concept focused on the skill and training of the facilitator, to an understanding of the need for a more nuanced and bidirectional process<sup>20,21</sup>. The educational environment itself can facilitate or inhibit feedback. In the hierarchical world of medicine, the perceived divide between learner and teacher can also be a hindrance to effective feedback exchange<sup>22</sup>. Telio et al, emphasize feedback is affected by the relationship between participants. Borrowing from the concept of a “therapeutic alliance” in psychotherapy, the authors suggest that an “educational alliance” approach may provide an ideal environment for effective feedback<sup>23</sup>.

Institutional beliefs can further complicate matters if faculty members feel that the excellence of the institution and its trainees makes constructive feedback impolite, or feedback that threatens trainee self-esteem should be avoided<sup>24</sup>. On the other hand, the feedback facilitator may be overly concerned that “negative” feedback may

result in retaliation by the recipient, which may directly discourage faculty from giving any feedback at all<sup>25</sup>. Faculty development programs in feedback delivery may not be universal, and uncertainty regarding best practices for effective feedback delivery remains<sup>7</sup>. Faculty members may have trained in environments where feedback took the form of public shaming. Despite the counterproductive nature of antagonistic or abusive feedback, some still consider it an appropriate approach. It is unlikely that any message, even a justified one, is optimally received when there is an undertone of disrespect for the learner.

Departmental cultural norms for feedback exchange can greatly impact the success and ease of daily feedback exchange. If feedback is expected, and the norm, then its absence may become as uncomfortable as giving feedback in a setting where it is neither expected or commonplace. It is very difficult to change institutional culture. Faculty development programs can be helpful, but learner's attitudes and expectations cannot be ignored. Although wholesale cultural change would be ideal, it is more likely that effective change may be driven by individuals working to foster feedback exchange on an individual level. If such practices become widespread within a department, then the desired cultural change will follow.

#### **Feedback Techniques**

Many techniques have been described to assist the delivery of high-quality feedback. Despite exhaustive attempts at identifying a one best strategy for feedback delivery, the complex nature of feedback interactions limits the universal appeal of any one strategy.

#### *The feedback sandwich method*

The feedback sandwich technique has a long history in both medical education and the business world<sup>26</sup>. It is designed to assist in the delivery of feedback by lessening its perception as negative. The two “buns” of the sandwich are positive statements surrounding a middle “meat” that could be perceived as negative. This method has been subject to a great deal of criticism due to its contrived, uni-directional, nature and lack of focus on the constructive and formative facets of feedback. Positive comments may have little constructive value and come off as patronizing. Additionally, the positive bookend statements may lessen the impact of the actionable feedback in the “meat” of the sandwich<sup>27</sup>. Parkes suggests that although the feedback sandwich may affect the recipient's perceptions it has little effect on future performance improvement<sup>28</sup>.

### *Multisource Feedback or 360 Evaluation*

Recently a newer technique for providing medical trainees feedback known as the multisource feedback (MSF), or 360° evaluation, has gained popularity<sup>29</sup>. This method was widely used in business before transitioning into medicine. The MSF model combines feedback from both self-assessment as well as a variety of other members that function closely on a team such as peers, supervisors, nursing staff, patients, etc. This method gives learners a broader perspective, but potentially lacks the specificity required to facilitate or guide practice change.

### *The Ask-Tell-Ask method*

The “Ask-Tell-Ask” (ATA) feedback method is constructed in three parts, with the first and last parts being learner-driven<sup>30</sup>. The recipient is “asked” to reflect on their performance and provide a self-assessment. The feedback deliverer then “tells” the recipient their observations of what went well and what might be improved. The final step of the ATA method requires the feedback deliverer to “ask” the recipient to clarify their understanding of the feedback and create a plan for future improvement. In contrast to the feedback sandwich, the ATA method allows the feedback recipient to impact the nature of the feedback given and incorporates planning for future improvement. As a result, feedback may be better received using the ATA method if the delivery of feedback aligns with a recipient’s self-assessed area for improvement.

### *The Pendleton model*

The Pendleton model provides a structured method for feedback between a learner and a teacher by emphasizing learner reflection on their performance with input and guidance from the feedback facilitator<sup>31</sup>. The learner identifies something positive regarding their performance. The feedback facilitator discusses their impression and confirms aspects of the performance that were successful. The learner then identifies areas of the performance that could have been done better. The feedback concludes with the facilitator confirming areas of the performance that could be improved. The Pendleton method shares some similarities with the plus-delta approach to debriefing popularized in medical simulation which utilizes two categories of learner-identified facets of a performance<sup>32</sup>. The plus category consists of things that were done well, whereas the delta category contains things that could be done differently in the future. Both techniques encourage and facilitate reflection on the part of the learner, which may be very productive in facilitating meaningful feedback. At times, it may be more appropriate for the feedback facilitator to exercise restraint and allow the learner to provide their own feedback via self-reflection. This may be especially true if the events discussed were stressful and the learner would benefit from an opportunity to decompress. As with the feedback sandwich and the ATA method, the structure of the Pendleton method may prove artificial and impede the discussion of the more valuable areas for improvement if the learner lacks insight or does not participate fully<sup>33</sup>.

### *The R2C2 method*

The R2C2 feedback method builds upon a reflective model of feedback delivery. The model was created by Sargeant et al in 2015 and defined building relationships (R), exploring reactions (R),

**Box 1:** Box reproduced, with permission from publisher, from Lockyer J, Armson H, Könings KD, Lee-Krueger RCW, des Ordon AR, Ramani S, Trier J, Zetkolic MG, Sargeant J. In-the-Moment Feedback and Coaching: Improving R2C2 for a New Context. *J Grad Med Educ* 2020 Feb; **12(1)**: 27-35.

### **BOX 1: Sample Facilitative Phrases Used in Each Phase of R2C2 in the Moment**

#### **Phase 1: Build Relationships**

- *First meeting:* This is the first time we have worked together. To help learners progress efficiently, I like to observe one thing learners are doing and have a feedback and coaching discussion about the experience. How does that sound and what would be useful to you?
- *For following up with continuing learners:* During our last discussion you identified that you would be working on [x]. how has that been going for you?
- *For both a first meeting and a continuing learner:* What do you want to achieve today? What skills are you working on? What can I observe?

#### **Phase 2: Explore Reactions and Reflections**

- *Gain learner perspective:* How was that experience for you? What went well? Were there challenges for you? Did anything surprise you?
- *Provide preceptor perspective:* When I watched you, I observed [x]. I wondered what made you decide to do that?
- *Enable learner to reflect on and react to preceptor’s comments:* What are you thinking about hearing my observations?

#### **Phase 3: Confirm Content**

- Is there anything we discussed that isn’t clear?
- Do you agree with what I have said?
- Now that we have asked about [x], what is your goal?
- To summarize, I hear you say that you want to work of [x], is that correct?

#### **Phase 4: Coach for Change and Co-Create an Action Plan**

- *Set a goal:* Now that we have established some directions for learning, what specific goal requires the most attention right now?
- *Establish plans:* How will you achieve this goal? What might get in your way? What resources will you need? Who will help you? When will you begin to implement this plan?
- *Determine a follow-up plan:* Let’s talk about how we will follow up. Who will you follow up with? What will this require? What is your timeline? How long might it take for you and others to see results? How will you know when you have achieved your goal?

exploring the content (C), and coaching for change (C) as the four phases of the R2C2 abbreviation<sup>34</sup>. The first phase of the R2C2 method is the establishment of a relationship between feedback participants. A greater understanding of the feedback recipient's background and motivations can provide a safer and more effective feedback environment. An established relationship also helps the facilitator understand what feedback may be most helpful for the recipient prior to the observed activities. The second phase centers on the observation of the recipient's reaction to the feedback. Facilitators are encouraged to ask open nonjudgmental questions when exploring reactions to feedback. Phase three of the R2C2 method moves from the recipient's reaction to the feedback to the assessment of the recipient's understanding of the feedback provided. The facilitator must guide the recipient to explore strengths and weaknesses identified in their discussions. The facilitator should identify a few areas of importance to the recipient to address in the future. The fourth and final phase requires the facilitator to coach the recipient for change. Identification of future goals with a plan to accomplish them is the most critical characteristic of this phase. Although the R2C2 model seeks to overcome many barriers to effective feedback, it requires considerable skill and time to allow for discussion and reflection which makes it more suited for summative evaluation than brief clinical feedback. Despite this potential limitation, the R2C2 model has been adapted for use for in-the-moment feedback and coaching<sup>35</sup> (see Box).

## CONCLUSION

Feedback in medical education is critical to driving performance improvement. Although research has provided evidence to suggest the most effective feedback content and practices, the provision of effective feedback remains challenging in most clinical environments. Historically the burden of effective feedback has been placed on the educator, but further research has led to the understanding that efforts to exchange effective feedback must consider many factors. The shift of feedback from a unilateral transfer of information to a dialogue between educator and learner is an important development in medical education; the relationship and shared goal of performance improvement between the educator and learner is key. Similarly, advances in the understanding of how feedback recipients process information and may benefit from facilitated reflection inform better feedback practices and avenues for future research. Although feedback models and best practice recommendations may elevate feedback quality in medical education, one size may not fit all. The learning environment must set feedback exchange as a valued aspect of medical education. Medical educators must leverage the collective wisdom of the available literature with their own intuition when delivering feedback to their learners.

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## Mentoring in Medical Education

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### Abstract

Mentorship focuses on career and psychosocial support in a relationship where a mentor and mentee work together using open discussion, reflection, problem-solving, and testing of new ideas. Benefits include development and growth of confidence in non-technical skills, for example leadership, teamwork and leading change, support with career planning, and personal growth. Mentors also benefit through professional development opportunities, learning to facilitate a developmental discussion, and satisfaction of supporting colleagues often more junior than themselves.

Multiple mentoring models exist each with their own benefits, including formal and informal programs, group and peer-mentoring, and electronic mentoring. Ethical issues of relevance to mentoring include ensuring psychological safety, issues of professionalism and power imbalance, issues of access, and recognition of gender-based, cultural and other differentials.

Despite being infrequent in anaesthesia, especially outside academic contexts, mentoring is increasingly recognised in medical education as an effective means of providing personal and professional support, facilitating development and broadening networks. In view of the increasing workplace stresses anaesthetists are currently exposed to, we argue for broader implementation of mentoring in anaesthesia departments and education, exploring benefits, methods for reducing risks, as well as practical tips for both mentors and mentees to make the most of this developmental opportunity.

**Key words:** mentoring; education; medical, mentor; mentee

### What is mentorship?

This short review paper is intended to provide an overview of mentorship in medical education, its importance and effective use as a development opportunity. Although few issues are specific to anaesthesia, it is intended primarily for anaesthesia providers interested in engaging in new mentorship relationships, either as mentee or mentor.

For the purpose of this paper, we define mentorship as a longitudinal relationship occurring in academic and professional contexts<sup>1</sup> with the primary goal of supporting the career and psychosocial development of a mentee through dialogue that aims to increase self-awareness, insight and reflection<sup>2</sup>. Trust, engagement, respect and empathy are essential features of the relationship. In this context, psychosocial development relates to how the individual interacts with social factors, for example managing relationships within the team, recognising and dealing with issues

of stress and burnout, and challenges to work-life balance.

Other professional relationships often overlap with mentorship (Table 1). Although each role has distinguishing features, a mentor may use elements from multiple roles in mentoring<sup>3</sup> and some mentorship programs have been deliberately designed to blend elements from multiple roles<sup>4</sup>. For example, coaching is a fundamentally different process to mentorship, but mentors may include elements of coaching (e.g. asking questions to challenge assumptions without giving the answers).

Mentorship often involves a senior and junior colleague (the mentor and the mentee respectively), described as a dyad. Alternatively, mentorship may occur within a triad (e.g. one mentee with two mentors each with different experience) or larger group. Mullen and

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**Table 1:** Different kind of professional relationships throughout career development in medicine

<b>Mentor</b>	<ul style="list-style-type: none"> <li>• May be formal or informal</li> <li>• Mentor is often chosen for having more knowledge or experience in a given domain than the mentee, and often a role model</li> <li>• May offer advice and guidance, or share their own experiences, or help the mentee reflect on their experiences</li> <li>• May ask open-ended, closed or leading questions as part of dialogue. Often gives advice.</li> <li>• The primary goal of the relationship is to further the goals of the mentee, but often significant benefits are available for the mentor in terms of their own development</li> <li>• May help deal with past, present or future situations</li> <li>• Psychological safety is a core element in the relationship</li> <li>• Likely a long-term relationship (years)</li> </ul>
<b>Coach</b>	<ul style="list-style-type: none"> <li>• Generally a formal role</li> <li>• Often a professional paid-for service, by someone with specific training in coaching, sought by the person being coached</li> <li>• Looks at the present to help guide future performance</li> <li>• Asks open-ended, not leading questions</li> <li>• Coach does not give advice but asks questions that challenge assumptions and prompt reflection</li> <li>• Can be someone entirely outside of the industry/area of expertise of the person being coached. Benefit does not stem from being a role model.</li> <li>• Psychological safety is a core element in the relationship</li> </ul>
<b>Sponsor</b>	<ul style="list-style-type: none"> <li>• Usually an informal role where the sponsor acts as an advocate for their protégé (a junior worker who the sponsor sees as having lots of potential)</li> <li>• Sponsor has a position of authority or influence in an organisation or field</li> <li>• Sponsor can create opportunities that the protégé may not be able to access on their own</li> <li>• Relationship may be transactional - if the protégé fails to “deliver”, it may reflect poorly on the sponsor</li> </ul>
<b>Advisor</b>	<ul style="list-style-type: none"> <li>• Usually a formal role</li> <li>• The advisor should have more knowledge or experience in a given domain than the advisee</li> <li>• Primarily offers advice and guidance</li> </ul>
<b>Counsellor</b>	<ul style="list-style-type: none"> <li>• Usually formal role - reactionary intervention to support an individual in managing a current problem or a past experience</li> <li>• May ask leading questions and open-ended questions</li> <li>• Non-judgmental, may give advice</li> </ul>
<b>Supervisor</b>	<ul style="list-style-type: none"> <li>• A formal role</li> <li>• Has a position of authority over the person being supervised</li> <li>• Relationship is characterised by being accountable to the supervisor who has some role in assessing the performance of the person being supervised</li> <li>• Often a direct educational role in supervision, whether clinical or non-clinical</li> <li>• Need for accountability may take priority over psychological safety</li> <li>• There may be a conflict between the need for openness and honesty about the struggles an individual may be experiencing and the need to pass training or performance targets</li> </ul>

Klimaitis<sup>1</sup> have categorised mentorship into 9 models: formal, informal, diverse, electronic, co-mentoring and collaborative, group, peer, multilevel and cultural (Table 2). Furthermore, the structure of mentorship conversations varies, ranging from those that are unplanned to planned meetings with identified expectations and goals. Topics discussed may include clinical development, teaching, quality improvement and research projects, career aspirations, networking opportunities and dealing with psychosocial issues (e.g. conflict management, teamwork and relationships).

Mentorship is a socially constructed phenomenon. It creates a space for individuals to develop a relationship and share dialogue. How the individuals involved view their position and experience the relationship, varies with many factors and is continually changing, so individuals each gain differently from mentorship. Despite this, research suggests common themes in the benefits for mentees from successful mentorship including enjoyment<sup>5</sup>, higher job satisfaction and faster career progression<sup>6</sup>.



**Table 2:** Nine mentoring models (adapted from Mullen and Klimaitis, 2021<sup>1</sup>)

<b>Formal</b>	<ul style="list-style-type: none"> <li>Planned and structured, e.g. mentoring new consultants as they transition into their role</li> <li>Mentor may be assigned to mentee</li> <li>Commonly part of an institutional program or backed by organisational leadership, therefore more likely than informal mentoring to have structures, training and guidance in place</li> </ul>
<b>Informal</b>	<ul style="list-style-type: none"> <li>Established by the mentee and the mentor themselves, rather than the organisation- a strength as it means buy-in from both</li> <li>Some mentees may struggle to find informal mentors, especially women and under-represented minorities in medicine</li> </ul>
<b>Diverse</b>	<ul style="list-style-type: none"> <li>Pairs individuals with demographic diversity to help understanding of each other's lived experiences, recognition of institutional and other barriers, and understanding the role of power relationships and situational contexts</li> </ul>
<b>Electronic</b>	<ul style="list-style-type: none"> <li>Activities occur by email, social media, technology-communication platforms and other online methods</li> <li>Communication can be synchronous, for example using a video-call, or asynchronous, for example using email</li> <li>Requires sufficient technology resources and internet by all parties, otherwise access becomes a limiting factor</li> <li>Particularly pertinent during a pandemic</li> </ul>
<b>Co-mentoring and collaborative</b>	<ul style="list-style-type: none"> <li>Mutually beneficial, dynamic relationship directly supporting both parties in their development, as though parties have the role of both mentor and mentee</li> </ul>
<b>Peer</b>	<ul style="list-style-type: none"> <li>Mentors and mentees are similar in age, experience or knowledge, particularly popular in the undergraduate setting</li> <li>Mentors and mentees can support each other, similar to co-mentoring</li> <li>Mentees may be able to relate better to mentors at the same position in a hierarchy and mitigates some ethical challenges relating to seniority and power</li> <li>Some programmes have used a "facilitated-peer" or "vertical" mentoring model to support junior mentors with more senior faculty</li> </ul>
<b>Group</b>	<ul style="list-style-type: none"> <li>A group of three or more people established with the objective of supporting each other's growth</li> <li>Often a senior figure in attendance taking the mentor role, although this is not a requirement</li> <li>Group benefits from the multiple perspectives in the room and development of the team</li> </ul>
<b>Multi-level</b>	<ul style="list-style-type: none"> <li>Large institutional programs where leaders and staff decide the changes required in the institution and then multiple mentoring networks are implemented in horizontal and vertical directions towards this</li> <li>Systems level change often the target</li> </ul>
<b>Cultural</b>	<ul style="list-style-type: none"> <li>Shared democratic values and experiences of discriminatory behaviour and exclusion form the basis of the mentoring, aiming for wider social change rather than focusing on the growth of the individuals involved</li> </ul>

In medical training and practice, mentoring programs most commonly focus on non-clinical or non-technical skills<sup>2</sup>, for example, teamworking, leadership, and skills for driving system-level change<sup>4</sup>. Therefore, it is widely believed that mentees developing these skills also benefits organisations.

### Mentorship in anaesthesia

There are specific challenges concerning an anaesthetist's role that may be well supported by mentorship. Anaesthetists often practice in highly stressful situations managing high-risk patients in complex work environments<sup>7</sup>, and have been reported to be a high risk for stress, burnout and depression<sup>8,9</sup>. These concerns have increased during the current COVID-19 pandemic. Mentorship has been suggested to play an important role providing anaesthetists with increased professional support structures, thereby increasing the ability to deal with these issues<sup>7</sup>. Anaesthetists practicing in low- and middle-income countries (LMIC) are often professionally isolated, resulting from the low density of anaesthesia providers (also a challenge for finding mentors), and anaesthesia often has a lower professional status than other specialties. The professional

support and networking opportunities mentoring brings could be particularly valuable in these contexts, however there is a lack of research concerning mentorship in anaesthesia and where this exists, research commonly focuses on programs in high-income countries and in academic departments.

A study using semi-structured interviews to investigate mentor and mentee outcomes in a formal, institutional post-graduate mentoring program in anaesthesia in Canada, found that residents valued the psychosocial support and nurturing of a mentoring program, in particular residents in their junior years and at periods of transition<sup>10</sup>. Other mentoring programs have also claimed that mentorship may be useful at career transition points, for example starting as a new consultant.

Another Canadian study<sup>11</sup> found 79% of mentored anaesthetic residents reported mentoring was important to success as an anaesthetist, and 86% of respondents reported they benefitted from mentoring, most commonly citing building confidence, development of clinical and teaching skills, and achieving personal goals as outcomes. As with other papers<sup>6</sup>, the quality of the mentoring

relationship emerged as an important theme, and mentees reported that having a choice of mentor and matching individuals based on common interests could improve the relationship.

Correspondingly, a study in the USA exploring anaesthetists' perceptions of the usefulness of mentoring in a formal academic mentoring program, found 71% of respondents reported mentoring was either "important" or "very important", but interestingly this proportion did not increase over the course of the program<sup>12</sup>. It may be that participants expected mentoring to be valuable prior to taking part and therefore their opinion did not change, or that as the authors argued, a change in perception would require a longer study period.

### **Academic mentoring**

Mentorship has potentially been more common in academic settings, compared to fully clinical career pathways or within teaching and educational leadership<sup>6</sup>. There may be particular needs within academic anaesthesia that can be met through mentorship. In academic medicine, junior team members face the pressures of entering into an unfamiliar academic world where performance demands, for example publications and grants, are high<sup>13</sup>. Therefore, academic medicine is one context where the role of mentor often overlaps with the role of advisor or supervisor by supporting the development of research ideas and skills, as well as the career and psychosocial development more familiar to mentoring. This can include learning to manage institutional pressures experienced, setting achievable goals, and developing strategies for balancing academic, clinical and personal lives. By viewing their mentor as a role model, mentoring is also suggested to reduce the risk of ethical malpractice in research- a known risk of workplace pressures to meet output requirements in academic environments<sup>13</sup>.

Makerere University College of Health Sciences, Uganda, reported on a long-standing academic mentoring program supporting post-graduate doctors in specialist training as well as junior academic faculty<sup>14</sup>. The authors raise the importance of contextual factors to mentoring programs in LMIC, including powerful hierarchical differences in the workplace<sup>14</sup>. In this study, the personal characteristics of the mentor were very important to the mentee, suggested by the authors to be of greater importance in a highly hierarchical context, and therefore ensuring mentoring was a relationship of mutual trust and respect was comparably more important<sup>14</sup>. Mentor respondents also supported this finding by stating that mentees need to feel free of intimidation in the mentoring relationship, enabling them to speak openly and feel empowered in order for personal development to be achieved.

A study exploring mentoring views of junior and senior physicians at a tertiary health institution in South-Eastern Nigeria reported one-third of participants were involved in a mentoring relationship with the majority describing this as informal mentoring<sup>15</sup>. Interestingly, when defining a mentoring relationship, respondents more commonly cited training, supervising, advising, guiding and counselling, teaching, coaching and assessment roles rather than mentoring being about personal and professional relationships. This contrasted responses regarding the benefits of mentoring, which instead focused on professional and personal growth<sup>15</sup>. Similar

findings were reported in the Ugandan study, and both papers argued that in a LMIC setting, fewer senior staff means mentors often have multiple professional roles and separating these out becomes difficult<sup>14,15</sup>. We suggest that whilst this cannot be avoided, mentors need to be especially aware of the impact other roles (for example supervisor or assessor) have on the mentoring relationship, and find ways to ensure mentees have the safety needed to speak openly about their difficulties.

### **Mentoring during a pandemic**

The psychological and emotional support provided by mentoring is potentially even more valuable during the current pandemic. Whilst entire medical teams are under unprecedented stress with novel workplace challenges, it may be difficult for individuals to talk openly about their fears, their wellbeing, and their need for emotional support. Team members may be less available for open discussion in view of increased clinical and leadership demands, and concerns about speaking openly, risking assessment or career progression.

Mentorship, provided by someone who is not a direct colleague but understands the situation and can empathise and actively listen, creates a sense of connection<sup>16</sup> and increases support during this pandemic where existing structures may be less accessible or under new strain.

Electronic mentoring offers many advantages in the context of a pandemic<sup>3</sup>. Here communication can occur synchronously, for example using videoconferencing or calling, or asynchronously using e-mail or social media and communication platforms, for example WhatsApp. Social media platforms have been argued to be an effective means of networking by expanding the mentors available and creating an environment with a more flattened hierarchy and a degree of anonymity, and therefore a safer environment for individuals to approach potential mentors<sup>17</sup>. Additionally, social media campaigns working to address stereotypes in medicine (for example #ILookLikeASurgeon and #BlackMenInMedicine) may themselves increase networking, leading to mentoring relationships<sup>17</sup>.

Electronic mentoring may also have specific advantages at this time: arranging meetings is more flexible and both mentors and mentees may feel more comfortable talking openly in a one-to-one online interaction which they can participate in from their home, in contrast to academic and workplace environments where often the junior party feels like a guest, perpetuating hierarchical imbalance<sup>18</sup>. Individuals working at smaller or more rural institutions, who traditionally have less access to mentorship and professional networking opportunities, may now be able to join distance programs. Despite this some challenges exist, in particular the lack of reliable internet connectivity can mean some individuals may not be able to access this opportunity.

### **Ethical implications of a mentoring relationship**

As discussed, the nature of social relationships leads mentorship to be experienced differently by all those involved. Often this is a strength, showing the adaptability of relationships to evolve to meet the needs of individuals, but there is also the risk of failing to benefit or of experiencing negative consequences. Some of these risks can be ameliorated by considering the ethical implications of

mentorship. The following are ethical issues to remain aware of, and considerations to reduce their existence within a mentorship relationship or program.

#### *Inadequate psychological safety*

Psychological safety is an individual believing they can speak honestly and openly about their thoughts, fears and experiences, without negative repercussions<sup>19</sup>. It is essential that mentees feel this level of safety in order to engage fully in the mentoring process.

Creating a confidential environment is essential for building trust and for psychological safety. In cases of group mentoring, all members of the group need to agree to this in order to create a safe environment. Some programs deliberately match mentees with mentors external to their organisation or speciality to add to confidentiality and psychological safety<sup>4</sup>, and enable an external perspective which may help the mentee take a wider view of their situation.

#### *Professionalism and power imbalance*

Unprofessional behaviour in the mentoring literature includes breaching professional boundaries, bullying, racism, sexism and claiming credit for the mentee's work<sup>20,21</sup>. It has been suggested that severe professionalism breaches can commonly be traced back to earlier, more minor acts of unprofessional behaviour, therefore recognising and acting early is essential<sup>21</sup>.

Issues of differences in power can limit the engagement of mentees, reduce trust, and there have been reports of power imbalance in mentoring leading to both bullying and sexual harassment<sup>21</sup>. Even in peer mentorship, where there is little difference in seniority between individuals involved, power can still exist. Accordingly, there is consensus that in all mentoring relationships, the mentor must be aware of the vulnerabilities of the mentee<sup>3</sup>.

Having a professional code of conduct for mentors and mentees setting out expectations, combined with appropriate oversight and monitoring of mentoring programs by host institutions, can help reduce both the risks of unprofessional behaviour and power differentials. This helps reduce negative outcomes from mentoring for the individuals involved, and also helps to role model the organisation's expectations of professionalism.

#### *Gender-based and cultural differentials*

It has been reported that under-represented groups may lack the role models and contextual support needed to excel, and that this need can be partly met by mentoring<sup>22</sup>. Ensuring under-represented groups receive mentorship is also argued to improve inclusivity and diversity in the workplace, improve understanding among the workforce of the challenges encountered by minority groups, and increase productivity<sup>23</sup>. Despite mentees wanting programs to consider needs associated with gender or cultural background, they are often not consulted or offered this during matching<sup>11</sup>. There have also been multiple reports of mentors selecting a mentee that they feel they can identify with, with gender and cultural backgrounds being commonly cited<sup>24,25</sup>. This therefore creates an unconscious bias where juniors who are similar to senior staff demographically, are more likely to receive mentor support. As mentorship supports career advancement and achievement of promotions<sup>5</sup>, diversification

at senior level is limited unless mentoring programs specifically address issues of equity.

A systematic review of mentorship for women in academic medicine in the USA reported that mentoring programs were consistently viewed as beneficial by participants and that gender concordance between mentors and mentees did not appear to impact outcomes<sup>26</sup>. However, some studies find that mentees from underrepresented backgrounds prefer matching based on demographics, stating that a shared sense of history and the increased ability to see yourself in a similar role to your mentor is valuable<sup>27</sup>.

Farkas et al<sup>26</sup> found that some programs focusing on the mentoring of females specifically focused on achieving faculty recruitment, retention, promotion and scholarship, and used these as outcome markers, suggesting some mentoring programs focusing on underrepresented groups may blend mentoring with sponsorship (Table 1), especially in working towards improved diversity at leadership level in organisations.

A study of residents interested in pursuing a career in academic medicine in the USA found participants from racial minority groups did not report less access to mentorship but did report barriers that they believed affected their potential gains from the relationship, for example a shortage of female or ethnic minority mentors<sup>27</sup>.

Ensuring diversity is taken into consideration in mentoring programs requires actively seeking mentors from under-represented groups (which can be challenging as often fewer in number<sup>26</sup>), ensuring mentors are trained and supported in recognising issues of equity, and openly asking prospective mentees about their needs associated with gender and culture during the matching process. Group mentoring, peer or near-peer mentoring may be particularly beneficial here by enabling mentees to hear experiences of other people they identify as similar to themselves, in addition to the experiences of their mentors.

#### **Entering into a mentoring relationship**

Some top tips for developing a mentoring relationship are listed in Table 3 and explained in more detail here.

#### *Finding mentorship*

Local formal programs are most likely to have trained mentors who have the time and capacity to fulfil the role and are also more likely to have the support structures needed, for example codes of conduct and formal guidance for mentors and mentees. Informal mentorship, where the individuals involved start the relationship without an organised program, is also useful, especially in the case of mentees who already have a colleague or other professional they see as a role model and find it easy to talk to. In these cases, mentees should have the confidence to approach a conversation with a prospective mentor about developing a mentoring relationship, often seen by potential mentors as a compliment and often will appreciate being identified as someone who could be valuable in this capacity.

It is important that all parties enter into this voluntarily. We suggest that programs where mentees can choose their mentor are particularly advantageous as this autonomy and opportunity for ensuring a shared interest has been shown to lead to improved engagement and more authentic conversations<sup>14</sup>.

**Table 3:** Tips and advice for mentors and mentees

Mentors	Mentees
<ul style="list-style-type: none"> <li>• Have an initial discussion about the goals for the mentorship relationship, what you intend to achieve, what areas you will focus on and if you have specific aims for the relationship</li> <li>• Be clear about what you expect of each other including the time commitment and how you will communicate</li> </ul>	
<ul style="list-style-type: none"> <li>• Be available, check in frequently and assign dedicated time to developing the mentorship relationship</li> <li>• Ensure a safe space for discussions where the mentee knows that what is discussed will be confidential</li> <li>• Learn do to active listening</li> <li>• Set boundaries</li> <li>• Be non-judgmental and offer honest feedback</li> <li>• Share your own ideas and experiences</li> <li>• Empower the mentee</li> </ul>	<ul style="list-style-type: none"> <li>• Don't be afraid to ask someone if they would consider being your mentor and to "formalise" a relationship even outside of a formal mentorship program</li> <li>• You may need to find multiple mentors for multiple goals of domains of activity</li> <li>• Good mentorship relationships are often mentee driven – be active and don't wait for your mentor to schedule meetings</li> <li>• Make sure the mentoring discussions focus on what you would like to get out of the relationship</li> </ul>

*Being a successful mentor*

It is important mentors are approachable, open-minded and non-judgemental throughout the relationship. It is useful if mentors ensure there is opportunity at the start for individuals involved to discuss goals and expectations for the relationship, as well as preferred methods of communication. Most common issues surrounding motivation and commitment arise from poorly defined goals and expectations, a lack of guidelines, and a lack of ongoing support from mentoring programs. Mentors and mentees aligning expectations, goals and boundaries can help with this, often via a written mentoring agreement.

Mentors should continually set the tone for open, blameless discussion and consider how to encourage dialogue and reflection from the mentee without falling back on telling them what they think the answers to the challenges are. Active listening (Table 4) is a useful skill in doing this, leading to more meaningful developmental conversations.

It is also important to be aware that mentorship also has value for the personal and professional development of the mentor. Mentors gain personal satisfaction from supporting mentees, develop communication skills including active listening and gain experience of developing trusted relationships in the workplace<sup>28</sup>. Facilitating another person in their self-reflection and development of their ideas is a valuable skill in medical education and can be developed through

mentoring. Mentorship also offers mentors the opportunity to reflect on their own practice and career, in distilling the lessons they have learnt to support another individual<sup>28</sup>. Mentorship increases professional networking and sharing of new ideas<sup>3</sup> for the mentor, opening doors for more longer-term collaboration. Undertaking a mentoring role can also be a stepping stone to other educational leadership positions and for career advancement<sup>29</sup>. Appropriate training, access to other professional development opportunities, and recognition of mentors' contributions by their organisation, for example at appraisal, and protected time to participate and organisational mentorship awards, all support mentors in gaining from this relationship.

**CONCLUSION**

Literature about how mentoring exists in anaesthesia and its benefits is lacking, especially outside of academic anaesthesia and high-income country contexts. However, available evidence shows that mentorship is a powerful tool for career and psychosocial development, under-used in anaesthesia, and may be particularly useful for dealing with the challenges of being an anaesthetist in an LMIC. This is especially the case in view of evidence of high levels of stress and burnout among the anaesthesia workforce, as well as increasing workplace challenges including this pandemic.

**Table 4:** Active listening

		Example phrases
Mirroring	Repeating what has been said to encourage more talking	"So what I hear you saying is.."
Clarifying	Checking understanding	"What exactly do you mean by that?" "I think what you are saying is..."
Summarising	Repeating the main points discussed	"Let me see if I have it all..."
Validating	Showing understanding of the issues and their importance	"I can see that this is important" "That resonates with me because..."
Empathising	Showing understanding of the feelings experienced	"I can see why you feel so strongly about that"

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## **Anesthesia curriculum design for the global setting**

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### **Abstract**

A stepwise process for curriculum design is presented. This begins with considering the context, resources and skills required for program graduates. The stepwise approach requires identification of broad outcomes to be achieved, selecting and organizing content, choosing active teaching methods, developing assessment tools and considering a plan for program evaluation. The authors share experience with the Rwandan anesthesia curriculum as an illustrative example of a multi-year curriculum and the Vital Anaesthesia Simulation Training (VAST) Course as an example of curriculum development for a short course.

**Key words:** curriculum design; medical education; spiral curriculum

*“Medical education is not about the transmission of information but about the transformation of the learner”<sup>1</sup>*

### **INTRODUCTION**

The Lancet Commission on Global Surgery highlighted disparities in the numbers of trained healthcare providers between low- and middle-income (LMICs) and high-income countries (HICs), setting a goal of 20 surgery, anesthesia and obstetric specialists per 100,000 population by 2030<sup>2</sup>. The WFSA Global Anesthesia Workforce Survey details these discrepancies as they apply to anesthesia. The survey identified the wealthiest countries as having an average of 17.96 physician anesthesia providers (PAP) per 100,000 population while 77 countries reported a PAP density of <5 per 100,000 and 43 countries reported a PAP density of <1 per 100,000<sup>3</sup>. Effective educational initiatives are essential to developing leaders and teachers who can build the anesthesia workforce<sup>4</sup>. The purpose of this article is to outline principles of robust curriculum design that apply to developing a single teaching session, a short course or a full anesthesia academic curriculum. We share our experience with the Rwandan anesthesia curriculum and development of the Vital Anaesthesia Simulation Training (VAST) Course<sup>5,6</sup> as illustrative examples. The authors have been associated with the Rwandan anesthesia residency training program as the co-designer of the curriculum (PL, with input from Rwandan anesthesia educators), a learner and later a

teacher (GN) and a teacher and the founder of VAST (AM).

There was only one anesthesiologist in Rwanda following the Genocide against the Tutsi in 1994. In 2006, a partnership was established with the Canadian Anesthesiologists' Society International Education Foundation (CASIEF)<sup>7</sup> to send volunteer North American anesthesiologists, for a month at a time, to teach in Rwanda. The intention from the start was to educate residents to become future teachers and leaders in anesthesia with the goal of self-sufficiency by the end of the program.

In the early years of the program, there was a topic list for visiting volunteer teachers but no comprehensive curriculum. Anesthesia residents were educated in medical school through a traditional passive approach that relied on lectures and observation. The basic science background, particularly in physiology and pharmacology, was inadequate and residents struggled to apply book learning into clinical practice. Additionally, there were shortages of equipment and medications needed for safe conduct of anesthesia and few local role models and teachers. Cognizant of these issues, the need was apparent for a comprehensive curriculum for anesthesia resident education that would prepare future leaders, educators and clinicians. This required a deep exploration of principles of curriculum design.

The VAST Course arose from recognition that safe anesthesia care requires well-functioning perioperative teams. This 3-day course uses immersive, low-cost

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simulation, focusing on safe anaesthesia and resuscitation for obstetrics, paediatrics, trauma, general surgery, and pre- and post-operative care. In addition to role play in 15 simulated scenarios, there are case-based discussions and skills stations covering non-technical skills e.g., situation awareness, team working, trauma primary survey, difficult airway management, neonatal resuscitation, pain management, and complex decision-making.

The following discussion provides an overview of curriculum, outlines a stepwise approach to curriculum design and discusses the Rwandan anesthesia curriculum as an example. Appendix 1 demonstrates application of these principles to the VAST Course.

### Curriculum overview

A curriculum describes the planned learning experiences of an educational institution<sup>8</sup>. It is much more than a syllabus. A properly designed curriculum guides teachers, learners and administrators in offering transformative experiences so that learners achieve the desired outcomes of a program. A curriculum encompasses everything from what learners must be able to do after the course of study (learning outcomes) to identifying how well the stated goals have been achieved (program evaluation). In between, it specifies what is taught, how it is taught, who teaches and how learning is assessed. The best curricula are never considered “final”, rather they are strengthened by being reassessed and refined.

Anesthesia training includes both mentorship in clinical practice and formal academic curricula. Some programs have clearly specified clinical rotations (e.g., regional anesthesia, pediatric anesthesia) while others are less structured. In both cases, learning experiences will be “opportunistic”, meaning that encounters with patients having various pathology cannot be predicted. A well-designed academic curriculum complements opportunistic clinical learning by providing standardized learning experiences in core topics and exposure to areas that are less common but important. For example, malignant hyperthermia is rarely encountered clinically but recognition and management of the condition can be well taught through academic curricula.

### Stepwise approach to curriculum design

Many models for curriculum design exist<sup>8-10</sup> but they usually agree on core elements (Figure 1). The following discussion describes the curriculum design process as applied to training of anesthesia providers. Principles outlined are equally relevant to design of a short 2-hour teaching session or an entire specialty training program, to design of de novo curriculum or to modification of existing programs. While written here in a linear manner, the actual curriculum design process is iterative by working back-and-forth through these stages.

#### *Build the curriculum design/renewal team*

The ideal curriculum design team includes educators, learners and administrators who are enthusiastic about medical education. Build a team of keen, engaged people who are committed to medical education.

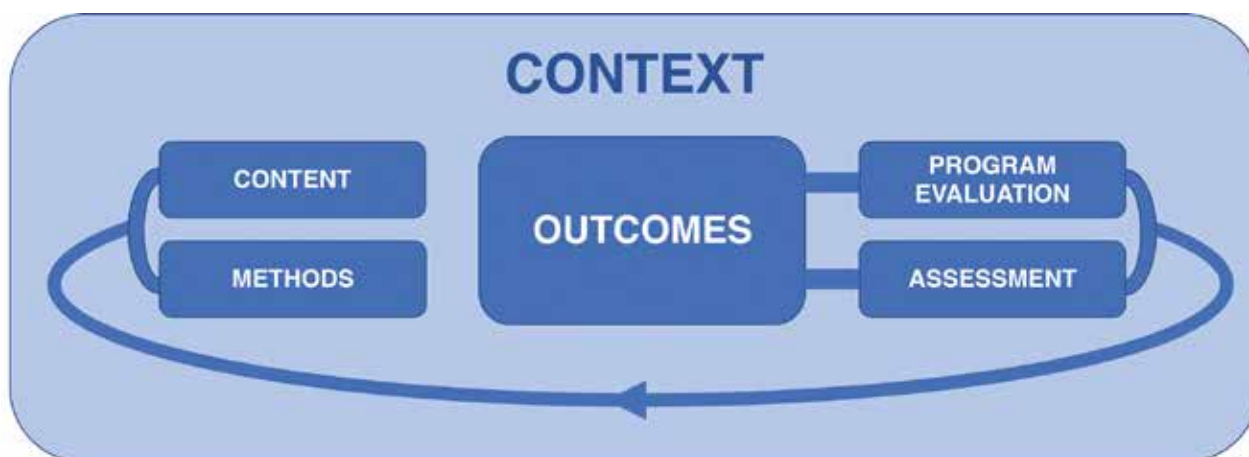
#### *Consider the context*

An anesthesia provider working in a remote district hospital with minimal resources will need a different skill set than a practitioner in a well-resourced tertiary care centre. While many requirements for each setting are common (e.g., all need airway management skills), graduate anesthesia providers must meet the needs of their own patients, learners and society. Contemplate the skills that are required to practice safely and effectively by considering the likely end destination where graduates of the program will practice.

Consideration of the context also requires reflecting on the available resources. Some questions to ask early on are:

- Who are the teachers?
- What resources and equipment are already available?
- Is there a simulation lab or space for a basic one?
- What avenues are there for sourcing additional resources?

Prior to embarking on curriculum design, the team should carefully assess their circumstances, requirements and resources, as these contextual factors influence all aspects of the curriculum.



**Figure 1:** Key components of curriculum design. This visually represents to the key features of curriculum design. All aspects are embedded in and informed by a particular learning context. Broad outcomes are at the centre, as achieving these is the purpose of the curriculum. Content and teaching methods are designed with these outcomes in mind. Assessment measures learners’ progression to achieving the stated goals. Program evaluation occurs on a continuous basis. Learner assessment and program evaluation inform the ongoing refinement of the curriculum.

### *Identify broad outcomes*

Having reflected on the context, the next step is to identify what learners will be required to do by the end of training. A curriculum is designed by keeping the end goals in mind. Broad outcomes are higher level goals rather than specific knowledge, skills and attitudes (learning objectives). For example, an anesthesia provider in a remote district hospital must be able to recognize and manage obstetric emergencies. Knowing this is an essential outcome, the curriculum should be designed to achieve this goal.

A recent trend in healthcare training is competency-based medical education (CBME)<sup>11</sup>. This involves describing what a learner can be entrusted to do by the end of training (entrustable professional activities)<sup>12</sup> and the competencies to be achieved at each level of training (milestones). CBME is labour intensive as it requires frequent assessment and feedback for learners to identify where they are on their trajectory of achieving the stated goals. While CBME has potential advantages, it is not the only way to arrange a curriculum. Even when CBME is not employed, best practice is to begin by considering broad outcomes to be obtained by the end of training and to design the remaining elements to ensure these goals are achieved<sup>9</sup>.

### *Select and sequence content*

Having identified broad outcomes, the next step is to select content needed to achieve those goals. Content overload is a common pitfall, as inevitably the volume of material exceeds what is realistic and manageable. Rather than attempting to include everything known on a topic, the focus should be on selecting the core knowledge, skills and attitudes the graduate practitioner will require to ensure that broad outcomes are accomplished.

The concept of “spiral curriculum”<sup>13</sup> is useful in sequencing content. In a spiral curriculum, topics are revisited throughout the program but each time with increasing depth to enrich understanding. In the example of “recognize and manage obstetric emergencies”, early anesthesia trainees may learn about physiology of healthy pregnancy and various diseases of pregnancy. Later they may learn details of the clinical presentation and treatment of conditions such as severe pre-eclampsia. Still later they may be required to demonstrate management of a sick pre-eclamptic patient in simulation or clinical practice.

When possible, look for existing content that is suitable for the local needs. The World Federation of Societies of Anaesthesiologists (WFSA) website<sup>14</sup> has a host of resources and links to established courses. The Anesthesia Tutorial of the Week has well-developed content intended for worldwide use. Other short courses, such as SAFE Obstetric, SAFE Pediatrics, Essential Pain Management and VAST, have been well-designed and tested. Including these international courses in anesthesia training is a strength. If considering a more longitudinal curriculum, the VAST Foundation Year is a one-year simulation-based curriculum for first year anesthesia. This curriculum is available for teachers who have trained as VAST facilitators and expands upon the foundations established in the VAST Course. Finally, select textbooks that are appropriate for the needs and not overly complex. Morgan and Mikhail’s Clinical Anesthesiology<sup>15</sup> is a clearly written fundamental anesthesia textbook.

### *Match teaching methods with desired outcomes*

Select teaching methods to promote transfer of learning<sup>16</sup> from the context in which learning occurs (e.g., classroom, simulation lab) to the context in which learning is applied (patient care). Transfer of learning is most effective when circumstances for learning resemble circumstances where new learning is implemented. If trainees have only read about pre-eclampsia in a book, it is more difficult to treat real patients with this condition than for trainees who have rehearsed management of pre-eclampsia in simulation. Effective transfer of learning does not require teaching methods to be complex but rather that they be thoughtfully selected to achieve the desired outcomes. For example, if a desired outcome is safe selection for and performance of spinal anesthesia, teaching methods could include preparation reading with guiding questions, watching a video, hands on practice with a part-task trainer and, finally, supervised mentorship in clinical practice. Learning is facilitated by active methods where the learners are engaged, and experiences are vivid. Problem solving, case-based discussions, skills labs and simulation promote greater retention of learning than passive lectures. Anesthesia providers work with surgeons, nurses, colleagues, and trainees. Consider incorporation of inter-professional education, to help prepare anesthesia trainees for effective team function in future practice.

In selecting teaching methods, also consider the teachers:

- Can they be freed up from clinical service to be available for formal teaching?
- Are teachers able to establish a safe and supportive learning environment or are they accustomed to “shame-based” teaching methods?
- Is faculty development needed?
- How will teachers be oriented to teaching topics?
- Is teaching valued and rewarded by the institution?

It is essential to advocate for protected time for teachers to ensure the formal curriculum can be implemented.

### *Choose appropriate assessment methods*

Assessment, along with meaningful feedback, is vitally important for helping learners reflect on behaviour and develop strategies for improvement. Assessment is a means for programs to determine how well learners are progressing on the trajectory to achieving the desired outcomes. Having a variety of assessment tools allows selection of those that most closely align with the required knowledge, skills and attitudes. For example, if recall of basic knowledge is being assessed, a written examination would suffice. If teamwork is being assessed, a 360 evaluation where various team members (nurses, surgeons, colleagues, mentors) provide anonymous feedback would be suitable. If complex synthesis of knowledge and behaviours is being assessed, an Objective Structured Clinical Examination (OSCE) or standardized simulation scenario may be best suited. The CanMEDS Assessment Tools Handbook provides a comprehensive survey of assessment tools and where they are best used<sup>17</sup>.



### Consider how the curriculum will be evaluated

Just as assessment and feedback help learners improve, program evaluation looks at the degree to which the program achieves the broad outcomes of the curriculum. As with assessment tools, optimal evaluation uses a variety of methods. The Kirkpatrick model<sup>18</sup> includes four levels from basic to most robust: reactions (learner, teacher and administrator impressions of the program), learning (exam scores for groups of learners), behaviour (workplace performance assessments for groups of learners) and results (impact of the program on patient outcomes). As much as possible, programs should endeavour to capture data from all four categories, recognizing the demonstration of results on patient care is difficult.

### Collaborate with other similar programs

Curriculum design can be complex and laborious. There is no need to “reinvent the wheel”. Collaboration and resource sharing amongst programs in similar contexts should be highly encouraged.

### Development of the Rwandan anesthesia curriculum

The Rwandan anesthesia curriculum (Figure 2) was developed in 2012 by Rwandan and CASIEF partners. The initial focus was on academic sessions, which could be controlled, rather than the clinical setting, which is more complex. The academic curriculum has improved significantly with the establishment of a simulation and skills centre in 2013<sup>19</sup>.

The Rwandan curriculum identifies broad outcomes and includes specific learning objectives for each session. Spiral design is used

so that topics are revisited with increasing depth, starting with Foundations and later in Core. There is one full academic day each week where active teaching methods are employed. Prior to each session, learners are assigned preparation reading and asked to submit answers to guiding questions. This allows teachers to gauge understanding and primes residents for deeper learning. Reading is from selected textbooks<sup>15,20</sup> and articles shared by teachers. Classroom time may include collaborative problems solving, case-based discussions, videos, debates, games, quizzes, oral exams, skills stations and simulation. To build teaching skills, a resident teacher leads the session each week, with mentorship by the visiting or local teacher. Resident teachers are given feedback to help improve teaching skills. Each academic day also includes resident-led problem rounds to discuss management of clinical challenges.

To address challenges in clinical practice and the shortage of local teachers, selected residents have been offered clinical electives at Dalhousie University in Canada for periods of 3-6 months. The goal of this program is to strengthen clinical skill and to expose residents to Canadian practices of teamworking and patient care. Since 2010, 11 residents have participated in this program which was unfortunately paused due to the global pandemic.

### Successes

Anesthesia was previously considered one of the least attractive specialties to medical students and the program struggled to recruit candidates. That is no longer the case; it is now a highly desirable program able to recruit excellent medical graduates.

Year 1: Foundations									
Academic curriculum	Anesthesia fundamentals		Preoperative assessment			Pharmacology			
Academic curriculum	Equipment			Physiology					
VAST Foundation Year	Introduction to simulation & preoperative assessment	Theatre preparation	Airway management	Induction of anaesthesia	Essential pain management	Obstetrical anesthesia & neonatal resuscitation			Pediatric anesthesia
VAST Foundation Year	Pediatric anesthesia (cont.)	Trauma & burns	Recovery	Cardiac arrest management	Sepsis	Ethics	Invasive monitoring	Teaching & Learning Course	
Year 2: Core									
Academic curriculum	Cardiovascular				Respiratory			Neurologic	
Academic curriculum	Neurologic (cont.)	Renal			Hepatic		Gastrointestinal & metabolic	Endocrine	
Simulation and skills	There is a bank of simulated scenarios for use. Specialty skills workshops depend on visiting/local faculty (e.g., regional anesthesia, airway techniques, POCUS)								
Case presentation	Assigned topics that correspond to the Core subject taught that day								
Year 3: Core									
Academic curriculum	Hematologic & Musculoskeletal		Infectious disease & Immunologic		Pediatric		Obstetric	Critical care	
Academic curriculum	Critical care (cont.)	Recovery & Perioperative	Regional & pain			Trauma & burns	Airway		
Simulation and skills	There is a bank of simulated scenarios for use. Specialty skills workshops depend on visiting/local faculty (e.g., regional anesthesia, airway techniques, POCUS)								
Case presentation	Assigned topics that correspond to the Core subject taught that day								
Year 4									
Teaching & research	Senior residents are involved in teaching junior residents and preparing their final research dissertations in addition to clinical duties								

**Figure 2:** Overview of Rwandan anesthesia academic curriculum. This overview of the curriculum shows the topics with allotted time approximately indicated by the size of the box where the smallest box represents two weeks. Year 1, Foundations, includes: the academic curriculum, which focuses on anesthesia fundamentals, pharmacology, physiology and equipment and the VAST Foundation Year, a simulation-based curriculum. Years 2 and 3 continues with the academic curriculum, exploring body systems and their interaction with anesthesia. Across each year, relevant skills workshops, simulations and resident led case presentations occur. Year 4 is less structured but includes time for residents to complete their research projects and teach junior learners.

Where once there were 0-2 applicants per year, recent intake has been 15 candidates per year.

Program graduates are increasingly capable of bridging the gap between “book knowledge” and clinical practice. Additionally, residents demonstrate improved confidence and capability at effective teaching. Residents are involved in teaching colleagues, non-physician anesthesia providers, updating the curriculum and teaching at international courses endorsed by the WFSA.

### Challenges

The overwhelming challenge to achieving the CASIEF vision of autonomy has been the shortage of local teachers due to the attraction of work outside Rwanda<sup>21</sup>. Migration of skilled anesthesiologists is a massive loss to the people of Rwanda and demoralizing for colleagues and learners who remain. The Rwandan Ministry of Health is endeavouring to address the root causes of migration, but it is difficult to compete with well-paying non-governmental organizations and high-income countries. As a result of migration, high clinical demands and the attraction of private work within Rwanda, a scarcity of available teachers remains. For local teachers, an additional barrier may be significant travel required between the work and teaching locations. Retention of anesthesiologists is slowly improving but government, academic and clinical leaders need to strive for better working conditions and salaries that encourage anesthesiologists to remain in Rwanda to practice and teach.

Language has been another challenge for the Rwandan anesthesia program as most of the early learners were educated in French. In 2009, the official language of instruction was changed to English. In the early years of the CASIEF-Rwanda program, communication between Anglophone volunteer teachers and learners was difficult. This is gradually improving as the younger generation is more comfortable with English.

While assessment tools were included in the initial curriculum, comprehensive program evaluation was not. This weakness has led to an unstructured approach to ongoing curriculum renewal. Despite this limitation, significant informal learning from the curriculum has occurred.

### CONCLUSION

Curriculum design does not need to be complex, but it should include the core elements previously described. Each training program is situated in its own unique context and reflection on the local needs helps to ensure the curriculum is designed so that graduates have the knowledge, skills and attitudes required for that particular setting. Begin with the end in mind so that broad outcomes are defined for the curriculum and the remaining elements are coordinated to ensure these outcomes are met. Select content carefully to achieve the learning goals while avoiding content overload. Sequence content to ensure topics are revisited with increasing depth. A range of active teaching techniques is ideal. Simulation is an especially strong modality as vivid, experiential learning in simulation fosters transfer of learning to clinical practice. Assessment and feedback help teachers and learners gauge progress. Evaluation is often overlooked – as it was in Rwanda –

but necessary for continuous refinement of the curriculum.

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**Appendix 1:** Stepwise approach to the VAST Course curriculum design

<b>STEP</b>	<b>PROCESS UNDERTAKEN</b>
Build the curriculum design team	Co-authors of VAST collaborated with the colleagues from the WFSA, the Scottish Center for Simulation and Clinical Human Factors <sup>22</sup> and partners from diverse contexts to identify needs and steer VAST's direction. Anesthesia trainees from Canada and Rwanda were actively engaged in course development.
Consider the context	VAST needed to be easily delivered, without reliance on a simulation centre, and clinically relevant in contexts ranging from remote hospitals in resource-limited settings to tertiary care hospitals.
Identify broad outcomes	Course graduates need to provide safe anaesthesia and peri-operative care for the most common clinical challenges and essential surgery (Bellwether procedures <sup>23</sup> ) seen in first-level hospitals. This requires both safe clinical practices and effective non-technical skills <sup>24</sup> .
Select and sequence content	Clinical content was selected to focus on the main case mix seen at district hospitals in resource-limited settings. In addition to the Bellwether procedures, content includes pediatric and obstetric emergencies, trauma, pain management and ethical decision making. Recognizing the key role non-technical skills play in effective team function for patient safety, non-technical skills are embedded throughout. Spiral design <sup>13</sup> is used so that scenario "patients" are first introduced in case discussions before appearing in simulated scenarios that follow stages of their hospital stay.
Match teaching methods to desired outcomes	Since a key learning outcome is practice of non-technical skills, the predominant teaching method is immersive simulated scenarios followed by reflective debriefing. Course participants are optimally prepared to manage scenarios by pre-course reading with guiding questions, introduction of systematic frameworks, case-based discussions and skills stations that cover core clinical content and technical skills.
Choose assessment methods	The VAST Course is designed to promote behaviour change amongst healthcare providers, rather than to assess performance according to standard benchmarks. Assessment happens in self-reflection during scenario debriefing and in commitment-to-change discussions at the end of the course, whereby participants consider their learning and contemplate practice changes they plan to make post-course. For research purposes, the impact of VAST on performance has been assessed <sup>6</sup> using the Anaesthetists' Non-Technical Skills framework <sup>24</sup> .
Consider curriculum evaluation	End-of-day evaluations are collected from participants and facilitators to gain information on aspects of the course that have gone well and to identify areas for improvement. This feedback is integrated into an ongoing process of iterative refinement of VAST's teaching methods and content.
Collaborate with other programs	During development, course authors collaborated with the leads of existing programs such as Essential Pain Management, Safer Anaesthesia from Education, Helping Babies Breathe and Primary Trauma Care to build a curriculum that integrates consistent clinical content from these programs with the goal of complementing and reinforcing learning across courses. Likewise, in developing simulation methodology, VAST's design principles and debriefing framework were adapted from an established model used at the Scottish Centre for Simulation and Clinical Human Factors.

## The Practice of Assessment

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### Abstract

Assessment is a central feature of teaching and the curriculum. The most important part of assessment is the correct interpretation and use of the information for its intended purpose. There should be a strong emphasis on using frequent and timely formative assessment to optimize individual progress, as inevitably assessments will influence students' learning strategies. There are a multitude of different assessment approaches that will need to be aligned with the desired learning objectives as a useful way to encourage trainees to attend to the most important outcomes. Consider the complementarity of different methods at your disposal to leverage the strengths and compensate for the individual weaknesses which will influence validity in your own setting. Despite the educators' best intentions, problems can develop when they attempt to assess trainees and challenges should be anticipated. A properly constructed system of assessment can, over time and using multiple methods and judges, provide greater validity and coverage of a curriculum.

**Key words:** educational assessment; competence; performance evaluation; programmatic assessment

### INTRODUCTION

Assessment plays a major role in how students learn, their motivation to learn, and how teachers instruct. It may seem easy for clinician-teachers to determine whether a trainee has met the criteria to complete an educational experience ("I know it when I see it"). After all, we have been exposed to assessment since the age of childhood and are implicitly expected to understand the basics of assessment by the time we take on teaching responsibilities. The reality is that many clinician-teachers and the trainees themselves may soon realize their understanding of assessment is insufficient, especially when it comes to understanding the overall purpose and underlying principles of assessment. The following article will provide a broad overview of the fundamentals of assessment which will be relevant to both the trainee and faculty given that both effective receivership and delivery is integral to achieving the overall goals of assessment.

### Principles of Assessment

Assessment can be defined as "the process of collecting, synthesizing and interpreting information to aid decision-making"<sup>1</sup>. Assessment defined in this way appears to be a simple process, until you are faced with the challenge of making it work in practice. There are three important principles everyone should know before entering a conversation about assessment.

### Purposeful

Firstly, in choosing or designing assessment tools, it is critical to articulate the purpose of the assessment. Though the terms are often used interchangeably, 'assessment' can refer to either formative or summative depending on the intended purpose. Classically, formative assessment occurs during an educational experience, and summative occurs at the end of an educational experience.

**Table 1:** Purposes of Assessment

<b>Assessment for learning</b>	Formative, low stakes, often informal and opportunistic by nature and is intended to stimulate learning
<b>Assessment of learning</b>	Summative, medium or high stakes and intended to respond to the need for accountability

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Assessment of learning is the traditional summative assessment which is familiar to all of us. This may take the form of a grade or formal report card which sums up the learners' attainment of the objectives of the curriculum. It often requires coherent, high quality test material, a systematic standard-setting process, and secure administration. On the other hand, assessment for learning is formative and informs both the learner and teacher about the learners' progress towards attaining the objectives of the curriculum and provides insights to guide further learning. It is important to recognize that both summative and formative assessment indicate the purpose of assessment, not the method. A distinction should be made between assessments that are suitable only for formative use and those that have sufficient psychometric rigor (validity-coherence, reproducibility-consistency) for summative use. This distinction is especially important when developing high-stakes assessments (i.e., licensing and certification examinations).

### Goal Oriented

Achieving competence (e.g., independent professional practice) is a longitudinal process that requires a sampling of knowledge, skills, and attitudes across all the domains required of professional practice. One of the most broadly used frameworks for the assessment of competence is Miller's Pyramid. Miller's model provides a framework for understanding the hierarchical progression from "knows" to "knows how" to "shows how" to "does". Miller's ideas strive to define education by its outputs and not by its inputs. It argues that to truly know whether our learners are achieving what we want them to achieve we should assess them in the setting that we expect them to be delivered<sup>2</sup>. It is important to appreciate that the assessment arising

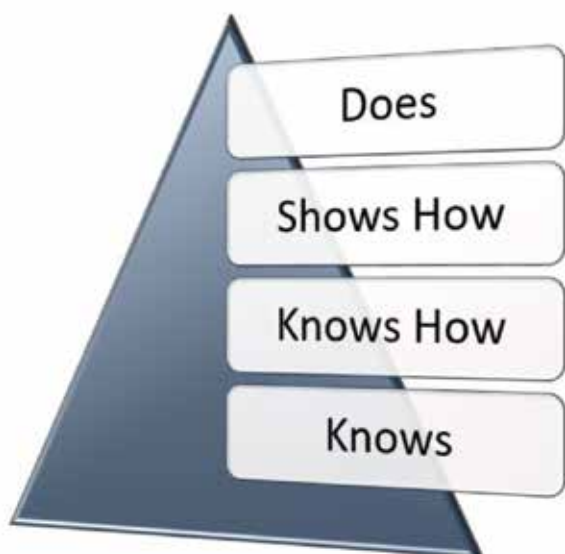
from each individual domain helps generate a small window into the overall understanding of how a learner is progressing from "knows" to "does" over the course of a training program.

### Validated

All assessments should aim to facilitate acceptable and defensible decisions about the individual being assessed. To make these decisions, evidence needs to be evaluated to understand the strengths and weaknesses of the assessment in question. There are many ways to judge the quality of an assessment. Historically, there was emphasis on the measurement properties of the test alone (reliability and validity). Reliability is a measure of the reproducibility of the scores of an assessment, so that the outcome is the same if the assessment is repeated over time. Validity is not an inherent property of the test itself, but rather refers to the use of a test for a particular purpose. Messick and later Kane have proposed the most widely cited frameworks on validity. They evaluate the fundamental claims, assumptions, and inferences linking assessment scores with their intended interpretations and uses<sup>3,4</sup>. Cees van der Vleuten expanded the list of qualities, pushing beyond the traditional measurement characteristics to include issues related to the test's effect, acceptability, feasibility, and impact on future learning<sup>5</sup>. More recently Cook has proposed a more practical approach to validation of Kane's argument which serves as a desirable concise review of modern validity<sup>6</sup>. All of the aforementioned validity criteria were reaffirmed and added to an international consensus statement of the 2010<sup>7</sup>, and 2018 Ottawa Conference<sup>8</sup> which resulted in the following criteria and framework for good assessment outlined in table 2.

**Table 2:** International Consensus for Good Assessment

Criteria for Individual Assessment	Framework for a System of Assessment
<p><b>1. Validity or coherence</b> There is a body of evidence that is coherent ('hangs together') and that supports the use of the results of an assessment for a particular purpose.</p> <p><b>2. Reproducibility or consistency</b> The results of the assessment would be the same if repeated under similar circumstances.</p> <p><b>3. Equivalence</b> The same assessment yields equivalent scores or decisions when administered across different institutions or cycles of testing.</p> <p><b>4. Feasibility</b> The assessment is practical, realistic and sensible, given the circumstances and context.</p> <p><b>5. Educational effect</b> The assessment motivates those who take it to prepare in a fashion that has educational benefit.</p> <p><b>6. Catalytic effect</b> The assessment provides results and feedback in a fashion that creates, enhances, and supports education; it drives future learning forward.</p> <p><b>7. Acceptability</b> Stakeholders find the assessment process and results to be credible.</p>	<p><b>1. Coherent</b> The system of assessment is composed of multiple, coordinated individual assessments and independent performances that are orderly and aligned around the same purposes.</p> <p><b>2. Continuous</b> The system of assessment is ongoing and individual results contribute cumulatively to the system purposes.</p> <p><b>3. Comprehensive</b> The system of assessment is inclusive and effective, consisting of components that are formative, diagnostic, and/or summative as appropriate to its purposes.</p> <p><b>4. Feasible</b> The system of assessment and its components are practical, realistic, efficient, and sensible, given the purposes, stakeholders, and context.</p> <p><b>5. Purposes driven</b> The assessment system supports the purposes for which it was created.</p> <p><b>6. Acceptable</b> Stakeholders in the system find the assessment process and results to be credible and evidence-based.</p> <p><b>7. Transparent and free from bias</b> Stakeholders understand the workings of the system and its unintended consequences are minimized.</p>



**Figure 1:** Miller’s model of competence (adapted from Miller: *Academic Medicine* 65(9 suppl): S63–7, 1990.).

### Types of Assessment

We will now look at the different methods of assessment available to assess clinical skills and behaviors in academic or workplace settings. We will discuss how and why they are used (e.g., formative versus summative), and some of the practical aspects (e.g. environmental and resource constraints) to be considered for educators wishing to make use of them. In the process of selecting or designing an assessment approach, instructors should consider the following questions.

1. What are the learning objectives that the assessment seeks to evaluate?
2. What are the skills and abilities that students need to do well?
3. Have students and faculty been adequately prepared to meet assessment expectations?
4. How will this assessment be utilized to enhance the student learning process?

### Written Examinations

Multiple-choice questions (MCQs) are commonly used for assessment because they can provide a large sampling of examination items and from a testing perspective can be efficient since selected-response items take relatively little time to correct. Having a group of experts contribute to test creation provides different perspectives allowing broad representation, the elimination of non-contributory questions and the ability to have the final questions validated by the group<sup>9</sup>. Modified essay and short answer questions have the advantage of assessing clinical reasoning but are less common given the disadvantages of question marking and standardization. Though time consuming, a blueprint for item construct can minimize gaps in assessment content through appropriate sampling of all objectives. This blueprint should be shared well in advance of the examination with anyone being assessed. If using a “pass-fail” summative approach valuable assessment data is discarded along the way; including the information about the answers not chosen by the learner, the

specific questions that were answered correctly versus those answered incorrectly, and even percentage correct. Progress testing for formative use is a method wherein you can sample the content of your curriculum in an ongoing continuous fashion by administering progressive tests prepared from a single large item bank itemized according to the blueprint of content areas. Students are given the results of the test to help identify knowledge gaps, and on repeat testing over the course of their training will hopefully demonstrate continued progress in their overall knowledge over time.

### Structured Clinical Exams

The oral exam is a “knows how” traditional form of assessment in which one or more examiners deliver questions to a candidate to attempt to assess the candidate’s knowledge of a subject, depth of understanding and to test clinical reasoning skills. They have been criticized for lacking structure and standardization, having poor inter-rater reliability, and potential examiner bias<sup>10</sup>. The structured oral examination (SOE) and objective structured clinical exam (OSCE) now exists to remove some of the traditional bias through use of standardized scoring rubrics and multiple scenarios or examiners<sup>11</sup>. To improve the validity a minimum of 10 stations is necessary to achieve a reasonable reliability for summative examinations<sup>12</sup>. The observing faculty member uses either a checklist of specific behaviors or a global rating form to evaluate the student’s performance. To limit any subjectivity in this regard the criteria for answers provided in a scoring rubric will ensure clear guidelines on what is and not an acceptable answer. Faculty development for examiners on the appropriate usage of these rubrics should be provided to develop a shared mental model. The advantages of using this assessment approach is the sampling of competencies or procedures which are normally difficult to assess under conditions with high fidelity and patient safety. Important practical points to consider when administering and setting up an OSCE are that it’s both time and resource heavy. Costs do vary significantly and can be mitigated with employing lower fidelity approaches, and volunteerism.

### Workplace Based Assessment

The ability to “show how” can be accomplished through simulation but can also be accomplished with limited resources using work-based assessments (WBA). WBA allow for demonstration and observation of performance in the workplace. Faculty are asked to record their assessment of students on a checklist or rating scale. It is especially helpful if the rater includes narrative comments with their ratings. Direct Observation of Procedural Skills (DOPS), involves the direct observation and scoring of performance on a rating scale. Physicians-in-training are given the list of procedures for which they will need to be assessed in advance. For a resident anesthesiologist, typical procedures might include endotracheal intubation or arterial cannulation. The sequence of WBA is outlined in table 3 and typically involves a 15-minute, direct observation and a 5-minute, structured feedback session. The mini-clinical examination (mini-CEX) is another version of work-based assessment for faculty to assess physicians-in-training as they interact with patients. Research in the use of WBA suggests mini-CEX assessments are similar to simulation-based assessments but with higher fidelity and lower cost<sup>13</sup>.

**Table 3:** Process for any work-based assessment (WBA)

1. Direct Observation
2. Learner Self-Evaluation
3. Structured, faculty-driven written and verbal feedback
4. Development of an action plan for improvement
5. Follow-up with frequent WBA [with different faculty assessors]

Direct observation and timely communication can be powerful sources of feedback to students. If the ratings are used for formative purposes the feedback generated can be used to improve performance on subsequent attempts. If the ratings are used solely for summative purposes the student may be encouraged to hide their weaknesses and limit any benefits gathered through the feedback process. The other major issue in the assessment of students by faculty is the lack of reliability of the faculty assessor. The scores may be biased by the different standards and understanding by individuals completing the ratings<sup>14</sup>.

### Portfolios

A portfolio might serve to organize assessment data into readily accessible fashion for review at regular periodic coaching meetings. Multiple assessment data points may be used to build a developmental portfolio in which students and their coaches can follow the student's progress from novice to expert. It is important to specify what to include in portfolios as doctors will naturally present their best work, and the evaluation of it will not be useful for quality assurance. In addition, if there is a desire to compare doctors or to provide them with feedback about their relative performance, then all portfolios must contain the same data collected in a similar fashion<sup>15</sup>. Otherwise, there is no basis for legitimate comparison or benchmarking.

### Programmatic Assessment

A program of assessment is used to collect and combine information from various assessment sources to inform about the strengths and weaknesses of each individual learner. This helps mitigate limitations in a single assessment as the weaknesses or deficiencies of some instruments can be compensated by the strengths of other instruments. Multiple sampling through various assessments leads to a diverse spectrum of complementary measurement tools to better understand competence as a whole<sup>16</sup>. When reviewing a student using programmatic assessment, individual data points, garnered from individual assessments, are maximized for learning and feedback value. Whereas high-stakes decisions on a learner's competency are based on the aggregation of many data points. Thus, no high-stakes decisions are made without a detailed collection of information that is supported by thorough measures to ensure their reliability. Programmatic assessment considers assessment to be as important as the curriculum itself, thus requiring intense planning and review.

### Challenges in Assessment

Despite the educators' best intentions, problems can develop when they attempt to assess trainees. It is generally acknowledged that assessment drives learning; however, assessment can have unintended consequences for both the trainee and the program. Some of the

common problems you may encounter are discussed below and outlined in Table 4.

#### 1. *Incoherent Approach*

If the assessment process is not integrated into the curriculum, it may produce data that are not meaningful or that inappropriately skew the direction of the curriculum. Devising and operating an assessment system using a comprehensive blueprint that maps learning objectives to multiple assessment tools ensures the program is robust and there are no gaps in the assessment process. A key principle of the approach is that individual data points are maximized for learning and feedback value whereas high stake decisions are based on an aggregation of many data points. Thus, each assessment point is optimized for learning using meaningful feedback but the key decisions about progress on the program are never taken on single assessment points but only on an aggregation of points. Data collected early in the curriculum and at the midpoint can provide feedback about learners in trouble to both educators and the learners in question. A formal system for addressing failures can prevent the creation of ad hoc solutions, along with their potential challenges.

#### 2. *Insufficient Data*

An assessment system should generate a meaningful amount of data. To aid busy faculty and learners, data acquisition processes should be simple and automated. Learners should be encouraged to seek out feedback, and mandatory activities that require assessment data should be implemented. Many assessment programs pursue objectivity over subjectivity as it is easier to summarize and compare objective information but choosing to ignore the details of well-gathered subjective evaluations discards the great value of this subjective information. Using quantitative and qualitative data in combination can bring greater meaning to learner assessment. Do not assume that quantitative data are more reliable, valid, or useful than qualitative data.

#### 3. *Biased Assessment*

This is perhaps one of the most challenging pitfalls of assessment. The problem is complex and related to the amount of time required to provide precise data; the inherent biases in our assessment, and the reluctance of supervisors to provide necessary "negative" assessments because of the emotional, personal, and professional repercussions that assessments may have. All tools are only as good as the people who are using them. The best way to accurately assess learners is not found in a holy grail assessment tool, but rather to have a wide range of faculty members use multiple efficient tools to assess a learners' performance in several different context. This approach, in combination with faculty development sessions and the use of well-defined scoring rubrics with criterion referencing, may provide a foundation for improving the reliability and validity of assessment data.

#### 4. *Evaluation Fatigue*

The administrative setup required to manage a robust and defensible system must be planned and supported, with due regard for costs. The issue of having sound educationally based systems and high quality needs to be balanced against time and financial costs. Not everything

**Table 4:** Challenges in Assessment

1. Incoherent Approach
2. Insufficient Data
3. Biased Assessment
4. Overburdened Practices

that can be measured, needs to be measured. Many assessments are highly predictive of each other and of subsequent similar assessments. Consequently, designing the system of assessment with the aim to limit redundancies or assessments of low educational yield should reduce the resources needed to run them and make assessment more feasible.

## CONCLUSION

Assessment is a central feature of teaching and when done well is a powerful catalyst for learning. Ideally, any assessment should enhance a student's capacity for learning and engagement with the curriculum. Assessment should therefore aim to reinforce students' intrinsic motivation to learn and to inspire them to set higher standards for themselves. However, this doesn't always happen in practice as it is heavily dependent on the form of assessment and whether timely comprehensive feedback is given. These elements are in sharp contradistinction from established practice where assessment measures are often applied in isolation or at least in an uncoordinated fashion. These uncoordinated measures are often combined to reach an overall decision based on weights dictated by tradition. A system of assessment explicitly blends single assessments to achieve the different purposes (e.g., formative versus summative; high vs. low stake) for a variety of stakeholders (e.g., students, faculty, patients, regulatory bodies). Those involved in educating, training, and certifying anesthesiologists should build in a systematic approach to assessment with evidence to support the validity and reliability of their approach. The advanced skills of a specialist can often be difficult to evaluate, finding effective assessment methods, especially systems of assessment that can eventually lead to more capable practitioners is necessary to effect long-term improvements in practice.

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## **The Constancy of Change – Adapting Anesthesia Medical Student Education in the time of COVID**

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### **Abstract**

2020 will always be remembered as an unprecedented year with the Coronavirus 2019 (COVID-19) pandemic creating chaos and disruption in healthcare systems worldwide and in particular that of medical education in Anaesthesiology. We share our experience of the university affiliated with the largest medical school in Singapore in mitigating the disruption on medical student education in Anaesthesiology amidst the pandemic.

In Singapore, medical education is coordinated by the Ministry of Health, medical schools and the Academy of Medicine. With COVID19, undergraduate anaesthesia education was severely disrupted. Planned training programs had to adapt to a videoconferencing platform, small group teachings or E learning modules. Alterations to assessments and training had to be implemented. Constant changes and updates became the norm, adding to the stress amongst the medical students as they continued with the pursuit of training and education.

As the world braces itself for a more virulent strain of the COVID-19 virus and the challenges of mass vaccination programs, the only constant in life is that of change. The task of educating the next generation of anesthesiologists and airway skills of doctors, likewise, needs to adapt and evolve to ensure quality and competencies of our specialty.

**Key words:** medical education, Covid-19

### **INTRODUCTION**

Since January 2020, COVID-19 has infected more than 135 million people worldwide with more than 5 million lives lost worldwide as of November 2021. The pandemic has disrupted lives, overwhelming healthcare systems across the world with several nations instituting lockdown measures, social distancing, mandatory mask wearing and border controls. The pandemic is reminiscent of the severe acute respiratory syndrome (SARS) outbreak in Singapore in 2003, where 238 were infected with 33 deaths<sup>1</sup>. On a national level, a contingency plan for dealing with pandemics has been put in place and when it became evident that COVID-19 would be a prolonged battle, these measures were immediately stepped up. A major goal was to ensure continuity of healthcare services while protecting healthcare professionals (HCPs). Non-critical administrative and training functions were halted and medical education for Anaesthesiology was severely curtailed.

The first COVID-19 case in Singapore was detected on 23 January 2020, about a month after the report of a cluster of severe pneumonia cases in Wuhan,

China. By 7 February 2020, Singapore had 33 cases and the pandemic alert was raised to the highest at Disease Outbreak Response System Condition (DORSCON)-Orange. By April 2020, more clusters of new infections were found with an exponential rise in the number of infections particularly in foreign worker dormitories. The country went into lockdown mode. In June 2020, staged measures were taken to lift the nationwide lockdown, after the nationwide community-acquired infections started to steadily decline. Since then, the country has then transitioned into a period of “new normalcy”, where wearing masks and enforcing social distancing rules in the community were mandatory. Since then, large gatherings of people of more than 100 persons for social functions continue to be prohibited, however, the country is revisiting the possibility of relaxing these measures with the introduction of rapid COVID-19 test kits, and a nationwide vaccination program. As of now, in Singapore, the total number of COVID-19 cases has exceeded the 260,000 mark with 690 deaths as of November 2021<sup>2</sup>.

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Training of our future Anesthesiologists at the undergraduate level is carried out on a national level with both University Medical schools, Academy of Medicine and individual department level undergraduate education directors. The implications of the COVID-19 era have brought about unique challenges in the education of our medical students. Therefore, we aim to describe our experience in the undergraduate anesthesia education of the university affiliated with the largest medical school in Singapore in the upcoming sections.

## **IMPACT OF COVID-19 ON MEDICAL STUDENT EDUCATION IN ANESTHESIOLOGY**

The COVID-19 pandemic has undeniably affected education in all areas of medicine including anesthesia worldwide<sup>3</sup>. Anesthesiology has traditionally been a “hands-on” discipline, with heavy emphasis on practical skills such as bag-mask ventilation and airway management, which are crucial foundations to anesthetic practice and acute care management in the wards. These skills were previously heavily emphasized to students, and made a cornerstone of their curriculum, with students having to achieve minimal competency in basic airway management skills including bag mask ventilation, preoperative assessment, and exposure to cases using airway management techniques such as intubation and laryngeal mask insertion and removal, prior to their successful graduation from the 2-week anesthesia clinical posting module.

### ***Balancing Anesthesia Education and Medical Student Safety Amidst the Pandemic***

In view of the procedural nature of our practice, COVID-19 has especially impacted anesthesia medical student education in a unique way. Safety restrictions were placed by the university to prevent the risk of infection transmission to students. These restrictions included excluding all medical students from “high risk” areas including the Operating Theatre, Emergency department and Intensive Care Units. Students were therefore only allowed to undertake learning activities within the University Campus, but not allowed to enter hospitals at all for the most part of 2020, until restrictions have been gradually relaxed in the last quarter of 2020. However, as these clinical placements were held within the 4th year of the 5 year medical school undergraduate program, students who were interested were potentially able to have additional allowances to re-do an anesthesia clinical posting once restrictions were relaxed.

In addition to the above, medical student clinical postings were also spread out over 7 different hospitals in Singapore. To avoid the risk of cross-institutional infection, students were not allowed to cross over between hospitals, and required a 2 week wash out period before being allowed to participate in clinical postings in another hospital. Overseas students were also not allowed to participate in clinical electives due to global travel restrictions with the COVID-19 crisis.

The government had also placed limitations on the number of people who could gather, once the nationwide “Circuit Breaker” was lifted. This was initially limited to 5 people, and recently relaxed to 8 in the later part of 2020, and re-tightened to 2 people in June 2021. In view of this, repeated small group tutorial sessions had to be arranged to cater for the entire cohort of 300 medical students who were scheduled to rotate through the anesthesia department yearly.

Students who were interested to schedule additional face-to-face teaching sessions had to take the initiative to source for their own small group tutors to take them through tutorial sessions of less than five people, in accordance with legal requirements. This took a toll on the department manpower. In addition increased resources and tutors were required to facilitate these multiple sessions.

### ***Transitioning to a Web-based Anesthesia E-learning Model***

The government limitations placed upon medical student gathering and limitations in patient interactions meant that an alternative approach to ensure continuity of student training in the areas of acute care medicine was urgently required. Similar to our colleagues around the world, our institution transitioned to a largely internet-based and simulation-based model, with one week of in-person simulation training, small group tutorials, followed by a second week of online-based simulated anesthesiology clinical module in a virtual classroom environment<sup>4</sup>; as opposed to the traditional 3 days of foundational lectures and simulations followed by 6 full days of clinical exposure where students would join anesthesiologists in the operating theatre and actively participate in the clinical management of cases.

This posed multiple problems in ensuring continuity of medical education for students, as airway management was unable to be taught at all for a whole year, due to the restrictions placed by the university to preserve student safety. In addition, not being able to observe practicing anesthesiologists in the operating theatre limited the student’s ability to learn from role-modelling in the areas of patient interaction and observing non-technical skills essential to anesthetic practice. We aimed to mitigate this through using airway management mannequins during in-person simulation sessions which were used to teach students basic airway management skills such as bag-mask ventilation, intubation and laryngeal mask airway insertion. Although this would have nonetheless imparted some basic airway management skills to the students, the mannequins are unlikely to be entirely representative of real-life airway management on a patient. Furthermore, the absence of real-life patient interactions meant that students were not able to cultivate the communication and physical examination skills which are necessary in daily clinical practice<sup>5</sup>.

During the transition to a web-based anesthesia E-learning model, several potential technical challenges were also faced – these include inefficiency of video streaming, audio-visual connections, log-in issues, and heterogenous internet speed amongst participants which is consistent with that reported in existing literature<sup>6</sup>. Fortunately, despite the aforementioned limitations, the transition to online teaching was relatively seamless, as most students already had high-speed internet access, and the school had imposed log-in securities such as a mandatory password request prior to log-in for all lectures. Each student was also sponsored an I-Pad by our university on enrolment, which was put to good use during this period.

The new emphasis on web-based learning posed additional benefits to students. These include flexibility of location and hence increased convenience of attending lectures, which has similarly been reported in other settings<sup>7</sup>. The transition to digital learning may also aid to prepare medical students to face a world where the role of digital

health services is ever expanding. To maximise class participation in these internet-based modules, every student was required to have their video on during online teaching mediated by video-conferencing software such as Zoom. Lecturers were thus able to actively call on students to participate in various aspects of the lessons. This has been similarly reported in other centers, where online distance learning models employed during COVID involve both asynchronous components in the form of recorded videos, and synchronous components involving live interactions between staff and students<sup>8</sup>.

### ***Impact on Assessment of Competency in Anesthesia***

It is undisputed that worldwide, medical student examinations have been irrevocably affected by the COVID-19 pandemic, with some centres postponing or cancelling examinations entirely<sup>9</sup>. In our institution, acute medicine competency has traditionally been assessed via written assessments, Objective Structured Clinical Assessment (OSCE), and day-to-day assessments of Directly Observed Procedural (DOPS) such as airway management and vascular cannulation. In view of the restrictions placed upon student and patient interactions, components such as the OSCE and DOPS were unable to be included as part of the formal assessment. Instead, students were assessed using a written examination, involving multiple choice and short answer questions, leaving the practical and hands-on component entirely unassessed. In order to mitigate this, we used airway mannequins as a surrogate for assessing airway management techniques. However, we acknowledge that despite the use of high-fidelity mannequins, although students were able to obtain tactile practice and repetition necessary in the development of most procedural skills, the experienced gleaned may not be entirely reflective of the real patient airway anatomy and hence true clinical experience; this is consistent with that reported in current literature<sup>10</sup>.

Other institutions have reported deploying assessment tools such as the Open Book Examinations, in an effort to improve deep thinking, prevent rote memorization and improve analytical skills<sup>11,12</sup>. While this seems highly useful in the setting of the pandemic where remote examinations may need to be conducted and it is difficult to ensure closed-book regulations are adhered to, this was not employed within our institution and may not be as relevant to the practice of anesthesia due to the heavy emphasis on hands-on procedural skills. Future work should be considered to evaluate the usefulness of such innovations within the practice of anesthesia.

These implications are especially relevant to the assessment of competency in anesthesia, where adequate hands-on skills are vital to ensuring safe and competent clinical practice, as they transition to becoming a new doctor.

### **CONCLUSION**

In summary, COVID-19 has brought about an unprecedented era of change in education and training within anesthesia undergraduate education. It has challenged the foundations of clinical medical education, urging for boundaries to be pushed, with the exploration

of new techniques and modalities of continuing education amongst future doctors. However, despite these efforts, a training gap in hands on patient experience, soft skills and patient interaction skills may still be inevitable, and may impact upon their practice as future doctors. Further study is needed to evaluate the impact of these new modalities on student performance, clinical aptitude and ultimately, recruitment into the specialty due to the paucity of clinical exposure. With the current relapsing and remitting nature of COVID-19 and the emergence of new variants, consistent efforts need to be underway to ensure the sustained delivery of quality medical education, while maintaining the safety of staff and students. Given the phased reopening of our community and scaling back on safe distancing measures, we are optimistic that in-person clinical education and patient experience amongst students will be able to continue, albeit at a scaled back capacity compared with the pre-pandemic era. Our experience has demonstrated that adaptability and innovation are to ensure education is continually sustained in a world where change is the only constant.

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## The Role of Anaesthesiologists in the COVID-19 Pandemic: Practical lessons from Groote Schuur Experience

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### Abstract

Clinicians worldwide have been called to action against COVID-19, requiring development of effective systems to respond to the surge of pandemic cases. Anaesthesiologists are equipped to fulfil many roles in the operating room, critical care and retrieval settings. However, it was anticipated that the case load could overwhelm our existing referral structures, and put staff and patients at increased risk. We describe, using the "4S" components of surge capacity development, how systems, staff, space and stuff were utilised to create a COVID Anaesthesia, Intubation and Retrieval (CAIR) Team at Groote Schuur Hospital, Cape Town, South Africa. The primary aims of the team are to provide safe anaesthesia for patients with known or suspected COVID-19, and perform intubation and transfer in COVID wards or high care areas to intensive care units. Concurrently, promotion of strict infection control practices and risk mitigation through the use of a dedicated group of low-risk, highly trained individuals was achieved. Staff support systems, protocols for streamlined patient management, reallocation of spaces within the hospital, the capital and disposable equipment required for the service, and use of continual audit and iterative improvement are discussed in this article.

**Key words:** airway management, anaesthesia, COVID-19, critical care, intubation, health systems, personal protective equipment

### INTRODUCTION

The first case of SARS-CoV-2 infection in South Africa was confirmed on 5 March 2020. By October, when the wave of infections was waning, there had been over 700 000 cases and 17 000 deaths, and the healthcare system within the country was under severe pressure<sup>1,2</sup>. As the country suffers from a second wave, this has doubled to 1.4 million cases, 40 000 fatalities, and an overburdened medical community which is showing increasing signs of operating under severe strain<sup>3</sup>. While the COVID-19 pandemic has had a dramatic short-term impact on the entire world, there will continue to be devastating consequences for low- to middle-income countries (LMIC) well into the foreseeable future. Global inequality has been highlighted by the fact that, while developed nations are already embarking on widespread vaccination programs to slow or halt the pandemic, access to vaccines may be greatly delayed in LMICs. Long-lasting effects will include negative health and economic influences over individual lives and livelihoods that will spread far more widely than the virus itself. The unique challenges facing developing

countries - stress on health systems and resources, baseline poor health care access, and suboptimal health status of the population - leaves LMICs in a vulnerable state<sup>4</sup>. It is thus incumbent upon us to create, test, share and collaborate on solutions to mitigate the impacts in less-resourced regions.

Clinicians worldwide have been called to action against COVID-19. There has been a need to develop effective systems to distribute and organise staff and equipment in spaces that promote the best possible outcomes. Central to this is the need for dynamic integration of multiple aspects: changing risks, shifting workloads and evolving needs; and to foster collaboration between disciplines and clinicians who may not traditionally work together<sup>5</sup>. Anaesthesiologists can fulfil niche roles that help other areas of the hospital function optimally. As perioperative medicine practitioners, anaesthesiologists are trained in acute-phase critical care cross-over skills such as advanced airway management, ventilation of the critically ill, haemodynamic monitoring and control, point-of-

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care imaging and bedside interventions. The specialty is therefore well equipped to contribute outside of the operating room during a pandemic. Furthermore, in many LMICs, anaesthesiologists also function as the primary clinicians for patients in the intensive care unit (ICU).

Based on reports from China and Europe emerging early in the pandemic, it was anticipated that there would be a rapid surge of patients who would require intubation, ventilation and transfer from emergency departments and COVID ward areas. This would rapidly overwhelm our traditional referral systems. There were established concerns over the increased exposure to transmission of SARS-CoV-2 during critical interventions such as intubation, cardiopulmonary resuscitation, suctioning, bronchoscopy and tracheostomy<sup>6</sup>. Historical data from the earlier SARS epidemic suggest that airway management is amongst the highest-risk procedures<sup>7</sup>. In order to address the surge requirements and mitigate the increased risks to staff, a new structure was created within the University of Cape Town (UCT) Department of Anaesthesia and Perioperative Medicine to address the previously described “4S” components of surge capacity: Staff, Systems, Space, and Stuff. These concepts evolved from the proceedings of a 2006 Academic Emergency Medicine Consensus

Conference on the science of surge capacity<sup>8</sup>. In addition to this, daily review and debriefing took place to allow timely troubleshooting and integration of lessons learnt through trial and error back into service improvement. Core to this iterative improvement process was a fifth “S”: collecting qualitative data and statistics on performance.

We describe below the processes, successes and failures of the COVID-19 Anaesthesia, Intubation and Retrieval (CAIR) Team at Groote Schuur Hospital (GSH), Cape Town, South Africa. Groote Schuur is a 991 bed tertiary/quaternary academic hospital. During the peak of the first wave, approximately a third of this capacity was dedicated solely to COVID patients, and ICU capacity trebled over baseline levels. At the time of submission, the GSH had treated 6399 COVID admissions. The UCT Department of Anaesthesia and Perioperative Medicine spreads its team of approximately 150 clinicians and support staff for anaesthesia, critical care and pain management between Groote Schuur and several smaller hospitals (Red Cross Children’s, New Somerset, Mowbray Maternity Hospital and other specialised units).

The primary aims of the CAIR Team are to provide safe anaesthesia services for patients with known or suspected COVID-19, and



**Figure 1:** CAIR Team members in PPE performing a COVID-19 intubation. (Photo: Barry Christianson, @thestreetsza)

to perform safe intubation and transfer of patients with severe COVID pneumonia from the wards and high care areas to an ICU. Concurrently, we aim to promote and maintain strict infection prevention and control (IPC) through unwavering use of correct personal protective equipment (PPE) and decontamination practices, while shifting the overall risk of transmission of the disease from higher risk colleagues within the Department to a dedicated group of low-risk, highly trained individuals.

## STAFF

When the Department embarked on developing a COVID-19 strategy, the first priority was to optimise the use of its staff members' expertise to maximise surge care capacity while minimising risk to both hospital staff, and patients themselves. Three important areas were identified in which the anaesthesiology skillset could be optimally beneficial during the pandemic surge: Ongoing anaesthetic support of a reduced but crucial emergency and urgent theatre service, increasing the capacity in the intensive care units, and bridging the gap between COVID units and intensive care by providing expedient airway management and safe transfer of critically ill patients. Integrated with this strategy was the timely identification of staff members at increased risk of poor outcome should they contract COVID-19, who could be diverted either to the non-COVID theatre service or into administrative or other non-clinical services.

The COVID-19 Anaesthesia, Intubation and Retrieval (CAIR) Team was established in March 2020 on a voluntary basis, and comprised anaesthesia medical officers, registrars and specialists within the GSH Department of Anaesthesia and Perioperative Medicine. Approximately 16 team members at a time (on a rotational basis, divided evenly between trainee and consultant levels) were redeployed from their routine and emergency anaesthesia duties to provide 24-hour emergency COVID intubation and retrieval services. This team also provided anaesthetic services for known COVID-19 patients and suspected cases (Persons Under Investigation; PUIs) in a dedicated theatre area. A similar number of staff were redeployed to increase ICU capacity. The reallocation of such a significant proportion of the Department left the remaining personnel to maintain urgent and emergency theatre duties, as well as covering the numerous regular on-call rosters. This placed additional workload and strain on all members of the Department. However, a camaraderie in dealing with "...the mutual conquest of difficulties..." did improve morale, and colleagues were motivated to step up into new roles. The greatest challenge was to prevent burnout due to the greatly increased frequency and intensity of the triple on-call duties. One strategy which brought fresh enthusiasm and helped to reduce emotional and physical burnout over the following six months was rotation between the theatre pool, CAIR Team and ICU on a 6-8 weekly rotation. In addition, daily rosters were dynamically adjusted to optimise rest during less busy periods.

The first objective of the CAIR Team was to ensure staff safety. This was initiated with the development of training tools and educational resources to upskill COVID-19 frontline workers in the correct use of PPE and IPC procedures, and is described further below.

During the initial national lockdown period in March 2020, PPE training, theatre simulations, and intubation/retrieval training was provided for GSH anaesthesiologists, surgeons, physicians and nurses, as well as other hospital and clinic doctors from around the City of Cape Town before they embarked on care of COVID-19 patients.

The high COVID-19 clinical workload required that team members felt valued, morale remained high, and that difficult clinical situations were addressed promptly to reduce burnout. An important strategy was daily morning "huddles," in which CAIR Team members were encouraged to openly voice feelings, concerns, and suggestions for improvement in operational procedures. This was supplemented by regular formal group debriefing sessions with hospital-provided clinical psychiatrists and psychologists (particularly after difficult cases or poor patient outcomes), and provision was made for individual sessions where needed. Rapid and effective communication within the team was crucial, as the members could at any time be spread across distant areas of the hospital, managing "activations" as they occurred. Open communication, regular rotation and optimal flexible daily role allocation were facilitated by the use of a Google Drive spreadsheet accessible to all members, and a dedicated WhatsApp messaging group.

## SYSTEMS

Systems were established on both national and provincial levels to address the COVID-19 pandemic in South Africa. This included an early and strict national lock-down which afforded valuable preparation time, and local provision of additional field hospital capacity. These efforts at a managerial level should be recognised as necessary and complementary to changes in our clinical practice. On a hospital level, multidisciplinary leadership coordinated downscaling of non-essential clinical services in order to support the expansion of COVID-19 testing, triage, wards and ICU capacity. There was timely reallocation of staff and resources to newly established COVID areas<sup>5</sup>. As described above, while supporting this expansion by deploying additional staff to critical care, the Department of Anaesthesia also recognised the need for a framework to cope with the surge of patients needing intubation and transfer to ICU. De-escalation of elective surgical services created staff capacity to form the CAIR Team.

Prior to the initial pandemic wave, the focus fell upon upskilling staff to respond safely. Training included safe donning and doffing of PPE with minimal contamination, anaesthesia of COVID-19 patients with good IPC practices (particularly managing aerosol-generating procedures such as intubation and extubation), and an approach to emergency intubations using a 'Hot' (contaminated) and 'Not-Hot' (non-contaminated) area approach. A number of protocols and instructional videos were developed by our team, and endorsed by the South Africa Society of Anaesthesiologists (SASA) for distribution on the Society's dedicated COVID-19 website (<https://sasaCOVID19.com/>), smartphone app, and via YouTube<sup>10</sup>. These resources have been published as an open-access online resource. They provide far-reaching assistance to anaesthesiologists and other medical colleagues in both the public and private sectors throughout South Africa and further abroad.

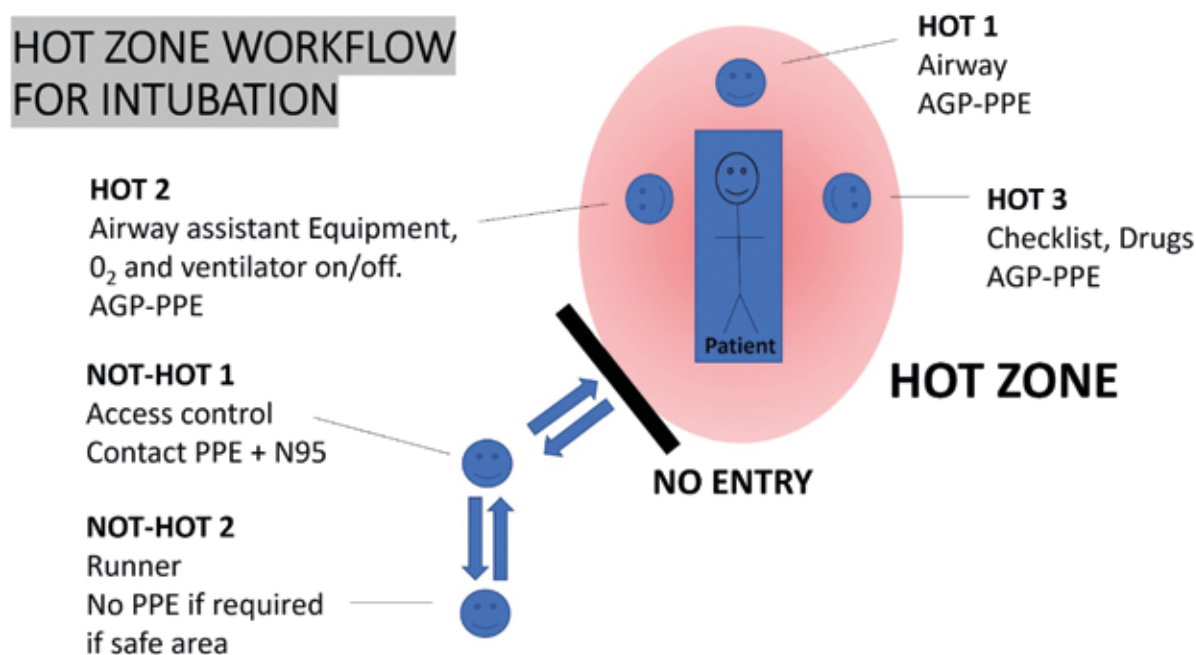
The anaesthesia and intubation team model developed for our setting drew on early reports from the first wave in China and Europe, as well as expert opinion within the international anaesthesia and airway community. A contemporaneous collection of resources collated at that time is available online<sup>11</sup>. Emphasis was placed on a team approach that balanced resource constraints (including staff) with patient and staff safety. Based on a standard theatre team (anaesthesiologist, anaesthetic nurse, surgeon, scrub and floor nurses) or a retrieval team of three supplemented by two ward staff, our approach has five interdisciplinary roles: “HOT-1”: Airway management, “HOT-2”: Airway assistant, “HOT-3”: Overall team leader, reads checklist, ensures situational awareness and administers drugs, “NOT-HOT-1”: Gatekeeper; transitions between the ‘hot’ (contaminated) area and the ‘not-hot’ (non-contaminated) area by passing any additional equipment to the hot team, and “NOT-HOT-2”: Runner who stays non-contaminated and facilitates additional equipment/drug provision, outside communication, note-keeping and transport. (Figure 2) This workflow can be adapted to either theatre or ward environment<sup>12</sup>.

We deliberately leveraged in situ simulation training to include practitioners of all disciplines in all roles (physicians and nurses in the wards, nurses and surgeons in theatre) to emphasise the importance of role allocation and strengthen the performance of ad hoc teams that could form anywhere in the hospital using the same model. Thereby, a collaborative environment was fostered and interdisciplinary relationships grew as the pandemic progressed<sup>5</sup>. Furthermore, while in this training and iterative performance improvement phase, we tested through simulation a variety of proposed mechanisms to address SARS-CoV-2 transmission, and were able to integrate these results with other teams and experts worldwide<sup>13-15</sup>.

A standardized system/checklist was designed to ensure smooth and safe performance from the point of team activation until either extubation (for a theatre case) or hand-over in ICU (for an intubation and transfer)<sup>12</sup>. This included buddy checks and a challenge-response phase immediately preceding and during the intubation, to ensure all steps were followed. Training was undertaken using this checklist from the outset, including CAIR Team members and all other staff, with interactive improvements made to the system from feedback, clinical experience, critical events and debriefing. These systems developed in the early phase of the pandemic ensured protocolised airway expertise and support to our non-anaesthetic colleagues, established a high standard of care, minimised transmission rates during high-risk intubation and other aerosol generating procedures, and provided safe transfer of the most critically ill patients at the most precarious period in their journey<sup>16</sup>. They have also mitigated risk for our own staff: through uncompromising use of PPE and IPC practices, no CAIR Team member contracted COVID-19 during the first wave<sup>15</sup>. Anecdotally, this focus on good IPC systems seems to have had a legacy. With shifting workload though the second pandemic wave, staffing a dedicated CAIR Team was not possible, but the ingrained practices appear to have provided protection: only one former member of the team was diagnosed with COVID in the time between the second wave and commencement of vaccination programs.

### SPACE

Essential to our service was the repurposing of existing working space to prepare, store, clean, process and sterilise equipment, decontaminate personnel, provide theoretical, part-task and simulation training, hold team meetings and debriefings, perform



**Figure 2:** Workflow for COVID-19 Intubation

data capture, and rest. Fortunately, the layout of our Department and theatre areas could be adapted to meet these needs. Various areas were reallocated, whilst being mindful of the potential for transmission through interaction of the staff. An access-controlled airway skills laboratory with multiple power points for charging equipment was converted into the CAIR Team equipment hub, where disposables and cleaned equipment could be securely stored. Access control is important during the pandemic due to widespread PPE shortages and theft. The thromboelastogram (TEG) laboratory with an existing basin and tap, was adapted to create an area where contaminated equipment could be processed before returning it to the hub. Theatre de-escalation allowed one of the existing on-call rooms to be allocated to the CAIR Team, and a second room was converted from a research office to provide sleeping space to on-call staff. The Department fortunately has pre-existing shower facilities, with regular provision of fresh scrubs and laundry.

Initial training and simulation took place within our existing teaching venues. Project Team Care, a resuscitation training unit within the Department, pivoted their activities to COVID and in coordination with the CAIR Team, provided training for all staff in safe PPE use on a ward-by-ward basis. At the later stages of the first wave, this training was also rolled out to medical students before they returned to the clinical platform. With the rapidly increasing need for operating theatre capacity for COVID-19 patients and PUIs, combined with a dramatic decrease in trauma admissions during the initial hard lockdown in March, the underutilised Trauma Theatre Complex was repurposed as a dedicated COVID-19 area. Initially, this was used as a theatre simulation environment with donning and doffing areas, and a clean theatre area equipped with a high-fidelity mannequin. While the Department's own anaesthesia and theatre nursing staff were trained first, this soon expanded to include a wide spectrum of practitioners from the trauma unit, physicians, surgeons and even staff from surrounding public and private hospitals.

As the pandemic progressed, all confirmed SARS-CoV-2 positive and PUI cases were operated on exclusively in the Trauma (now COVID) Theatres, limiting exposure to staff in the main theatre complex. In order to further protect the main theatre staff, screening questionnaire documents developed by SASA were used for every patient being prepared for surgery. The dedicated COVID-19 Theatres became integral to meeting the increasing need for open tracheostomies resulting from prolonged ventilation of COVID-19 patients in ICU. In addition, some of the logistical burden was reduced by performing as many tracheostomies as possible percutaneously in the ICUs, in collaboration with surgeons from the UCT/GSH Division of Otolaryngology.

## STUFF

Particularly in resource-constrained settings, provision of a high-quality and safe COVID anaesthesia, intubation and critical care retrieval service is not possible without adequate consumable and capital equipment. The CAIR Team was fortunate to have excellent existing relationships with outside medical equipment companies, our own clinical technologists, medical and hospital management, IPC and laundry teams. This was supplemented by emergency

COVID-19 funding from the government healthcare system and through donations by private individuals and companies.

In keeping with the primary goal of staff safety, the first “stuff” supply lines secured were for PPE. Guidelines formulated by members of our team based on the WHO and CDC publications and international experience were adopted by SASA and promulgated to the rest of the country, where they were adapted or adopted by other institutions. A list of appropriate PPE for different clinical situations is shown in Table 1. Recognizing the risk of global shortages at an early stage, the use of reusable PPE was incorporated. This included elastomeric respirators and non-sterile surgical gowns in the place of disposable gowns. Reducing the reliance on single-use items and using scrubs and gowns which could be washed in the hospital laundry averted an acute shortage for the team. This strategy has proven effective; ongoing work in the field suggests that higher levels of PPE are associated with reduced rates of healthcare worker infection<sup>15</sup>. Even with the use of reusable PPE, the complete lack of infections within the CAIR Team is somewhat of an outlier, which may be a reflection on our rigorous training and integration of PPE into a global IPC strategy.

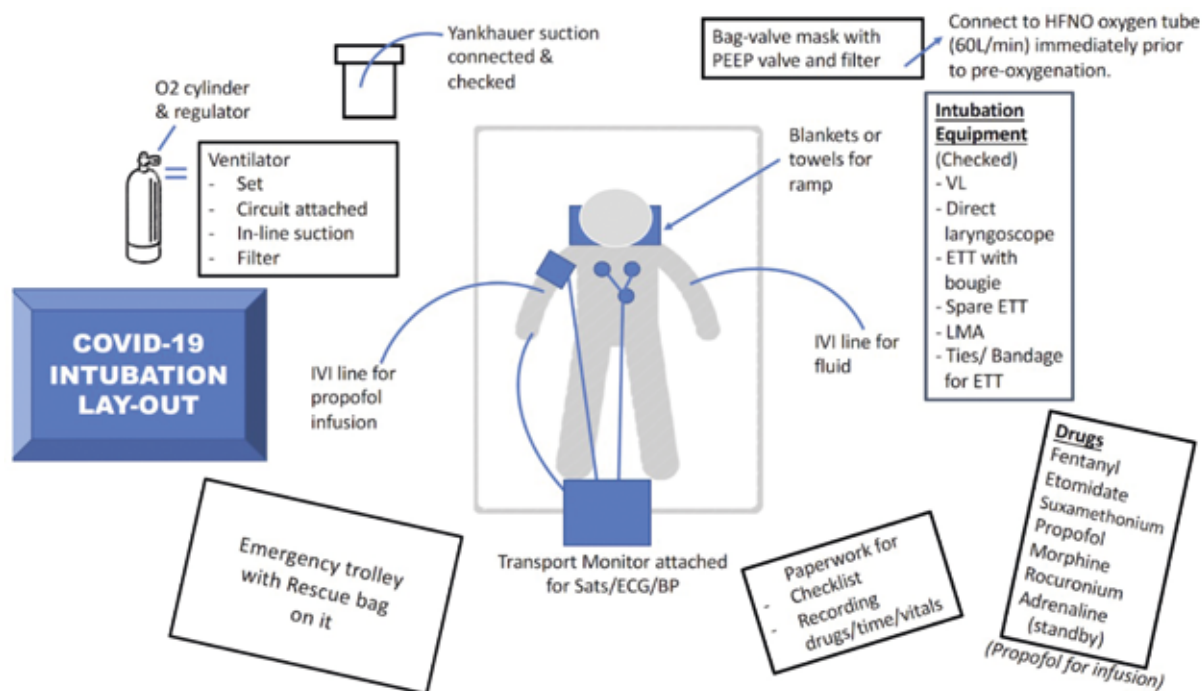
A list of non-consumable capital equipment assembled for the team is presented in Table 2. Consumables as listed in Table 3 were regularly acquired through theatre management and supply chain, which required a weekly (or more frequent) stock-taking to be performed by team members. This was especially important at the peak of the pandemic, when availability of consumables and PPE were at critically low levels due to national and global demand. Up-to-date caseload statistics were used to anticipate future stock needs, and to moderate against unnecessary hoarding.

Equipment was pre-packaged (using standardized checklists) into clear plastic bags that were easy to transport to intubation sites such as the wards, especially where High Flow Nasal Oxygen (HFNO) was used. These wards were the most frequent locations of emergency intubation for the CAIR team. Our centre adopted use of HFNO relatively early (7 May 2020) due to the severe limitation on ICU beds, although its utility in severe COVID hypoxic respiratory failure was

**Table 1:** Personal Protective Equipment

For Intubation (Hot 1, 2, 3)	For Transport (“Not-Hot”, Porters)
N95/FFP2 respirator or equivalent	Surgical mask (or N95 or equivalent if COVID area)
Plastic Apron	Plastic Apron
Non-sterile gloves (one or two sets)	Non-sterile gloves
Eye protection (Face shield or goggles)	Recommended: Eye protection
Disposable or Linen full-sleeve gown	
Head Cover	Optional: Head cover
Shoe covers	Optional: Shoe covers





**Figure 2:** Figure 3. Equipment layout for COVID-19 ward or High Care Unit intubation. (Illustration: Prof Graeme Meintjies)

unproven at the time<sup>5,16,17</sup>. The pre-packaged equipment ensured that all essential equipment required for an intubation was immediately available when needed and no items needed to be sought during an activation. Three types of bags were packed: a PPE Bag, with sufficient PPE for one intubation team; an Intubation Bag, with the standard disposables for a case; and a Rescue Bag designed to be kept sealed but opened immediately in the event of a failed intubation. Spare items, a drug box, syringes, labels and other backup equipment were stored on a secure mobile cart. When the CAIR Team is activated for a case, the three bags, transport monitor, transport ventilator and an oxygen cylinder with reservoir are transported to the area on a steel trolley which is easy to decontaminate. The second cart with backup items is kept in a clean area in close proximity. The team then uses the standard intubation protocol/checklist to undertake the intubation and transfer. Checklists and case report forms are included in the intubation bags; spare paperwork and stationery including stock records are kept in a designated file.

Meticulous cleaning and decontamination of equipment form a critical part of IPC strategies during a pandemic. Stringent precautions must be followed in order to prevent unnecessary exposure not only to the CAIR Team, but also to other clinicians and support staff who are using common spaces. The intubation bag system was designed so that only the required consumables entered into the “hot zone”, and as much contaminated material could be disposed of in medical waste bins at the point of care as possible. This includes items such as used filters, oxygen piping, disposable gowns, aprons, gloves, foot and head covers, and ventilator circuits. Reusable items (bag-valve-mask resuscitators, bougies and capital equipment such as ventilators) are sprayed and wiped down with 70% alcohol surface disinfectant in ICU or the operating theatre

before being brought back to the wet lab for processing. In the wet lab all equipment that can be submerged is first washed with soap and water, then soaked in a 0.1% hypochlorite solution for 15 minutes. This includes face shields, respirators, goggles, bougies, Magill's Forceps and video laryngoscopy blades. Thereafter the submerged equipment is rinsed with clean water and left to dry in a designated area. Electronic equipment such as transport monitors, monitoring cables, video laryngoscope screens and batteries, portable ventilators and the steel transport trolley are thoroughly sprayed and wiped down with alcohol surface disinfectant, allowed to dry and returned to be charged where appropriate.

## STATISTICS

Although not traditionally part of the 4S model of surge planning, the final component to the CAIR Team framework is to audit the team's educational and clinical activities. This includes documenting the services provided, caseload and patterns of activity, formative debriefing notes on individual cases, and de-identified aggregate patient data. We began by collecting logistical data on team activations and equipment requirements, but rapidly added capture of patient, procedure and outcome data into a registry (with expedited research ethics approval). These resources provided a feedback loop which allowed iterative improvement of the service, as well as detecting trends which could be used to improve patient safety.

The CAIR Team developed a single-page case report form (CRF) to document individual cases and act as critical patient notes for intubations and transfers.<sup>(18)</sup> The CRF data includes concise patient history, pre- and post-intubation vital signs, medications administered, critical events and any difficulties experienced. Paper CRFs are delivered to the ICU as part of the patient's notes, but

**Table 2:** CAIR Team capital and non-disposable equipment

<b>Capital Equipment:</b>		
<b>Ideal quantity</b>	<b>Item</b>	<b>Description</b>
2	Transport monitor	Portable, rechargeable vitals monitors and cables (minimum non-invasive blood pressure, three lead ECG, peripheral oxygen saturation)
2	Transport ventilator	Portable with oxygen piping (eg. Oxylog 3000, Hamilton T1)
4	Oxygen regulator	To fit oxygen cylinder forwith adaptor for ventilator
10	Self-inflating bag-valve-mask (BVMR) devices	With reservoir and peep valve
10	Nipple-and-nut oxygen connector	"Christmas Tree" adaptors to connect oxygen tubing to wall flow regulators
2	Video laryngoscope	Portable, with size 3 and 4 Mackintosh blades, rechargeable batteries and charging system
5	Direct laryngoscopes	Backup sets of manual laryngoscopes with various blades
5	Disposable video laryngoscopes	Backup single use video laryngoscopes if available
5	Magill's Forceps	For assistance with nasogastric tube placement
1	Transport/Storage Cart	Lockable with drawers
2	Steel preparation trolley	Steel with caster wheels
1	Drug box	Lockable for scheduled drugs

**Table 3:** CAIR Team consumable equipment

<b>Capital Equipment:</b>	
<b>Item</b>	<b>Description</b>
Bougies	Coude-tipped introducers for atraumatic intubation
Anaesthetic masks	Sizes 3,4,5
Oropharyngeal airways	Sizes
Supraglottic airways	Sizes 4, 5
Endotracheal Tubes	Sizes 6-8
Strapping	Ribbon tie for securing endotracheal tube
Tape	Backup sets of manual laryngoscopes with various blades
Suction tubing	Adherent for securing endotracheal tube
Magill's Forceps	
Yankauer suction catheters	
Closed In-line suction devices	
Breathing system filters	HMEF viral/bacteriological and HEPA filters
Clear plastic bags	For packing PPE, intubation and rescue bags
Emergency surgical cricothyroidotomy sets	Front of neck access
Lubricating gel	
Oxygen tubing	From "Christmas tree" nozzle to BVMR, disposable
Ventilator circuits	Disposable for portable ventilator
Oxygen cylinders	Acquisition of full cylinders as needed
Nasogastric tubes	
Syringes	5ml, 10ml, 20ml
Labels or markers	To label drugs syringes
Needles	For drawing up drugs

**Table 3:** CAIR Team consumable equipment - continued

<b>Capital Equipment:</b>	
<i>Item</i>	<i>Description</i>
ECG stickers	
IV medications - refrigeration required	Suxamethonium, rocuronium, cisatracurium
IV medications - no refrigeration required	Propofol, etomidate, midazolam, morphine, fentanyl, adrenaline, atropine
Saline flush	
Tracheal aspirate sample tubes	
Intravenous (IV) cannulas	16G, 18G, 20G, 22G
Transparent dressing	Non-occlusive for securing IV lines
Fluid giving sets	20 drops/ml and blood-giving set with filter
Intravenous fluids	Colloid: Volulyte, Crystalloid: Ringers Lactate, Plasmalyte
Central Venous Catheters	3 lumen
Arterial line and transducer sets	
Cleaning consumables	Hypochlorite granule sachets, 70% alcohol surface disinfectant, hand soap, soft sponges, wash cloths
Large plastic wash tubs	For soaking and decontaminating equipment
Stationery	Pens, markers, scissors, files
Laundry	Full sleeve gowns, towels, scrubs

a digitized copy is entered into the CAIR Registry (on a secure REDCap server).

The CAIR Team was formally constituted in the March 2020 lockdown period, allowing development of protocols and extensive training before the first surge in the region occurred. The team was thus well prepared by time the first cases presented to our institution. However, the value of in situ training and systems testing cannot be overstated. In a noteworthy example, the team performed an in situ simulation of a COVID/PUI intubation in the newly designated PUI unit one afternoon, discovering that the newly installed oxygen flow regulators had not been supplied to the ward with the nipple-and-nut connectors to allow oxygen tubing to be connected. After a debriefing, the protocol was thus modified to include these supplies in our Intubation Bags. The team's first real activation for a patient admitted in extremis with severe viral pneumonia occurred in the same area later that night, by which time the missing connectors had been added.

During the first wave of the pandemic in the Western Cape, the CAIR Team provided support to over 500 cases in COVID-19 and PUI wards, COVID-19 Theatre Complex, obstetric wards and designated COVID-19 obstetric theatres, as well as the emergency and trauma units. This includes more than 250 intubations and ICU transfers of patients with presumed or proven COVID-19 pneumonia, approximately 70 tracheostomies, nearly 200 other COVID-19 anaesthetics for surgery, multiple controlled extubations, tube exchanges, emergency department and trauma intubations, and patient transfers. While details of the patient characteristics and outcomes are reported elsewhere, our findings echo those of other similar clinical settings. Patients with COVID-19 epitomise the “physiologically difficult airway,” presenting with profound

hypoxaemia, desaturating exceptionally rapidly during airway manipulation, and suffering a disproportionately high rate of haemodynamic compromise, including peri-intubation cardiac arrest.

### PREPARING FOR THE NEXT PHASE

The COVID-19 pandemic has unquestionably had a major effect on all members of the healthcare team, the collective healthcare system, all of South Africa and the world as a whole. Whilst the negative consequences on the economic and health sectors are devastating, it is also a time that has confirmed the depth in resilience of health care workers, particularly with regards to the many challenges facing healthcare service delivery in LMICs.

Our experience has proven the value of a dedicated CAIR Team, not only for improved patient safety and efficiency, but particularly for its role in promoting interdisciplinary relationships through mutual support, training and collaboration. Vast experience has been gained and a multitude of lessons continue to be learned. The importance of collaboration, adaptation and preparedness cannot be overstated. In the face of enormous challenge and change, a group of dedicated team members can fill an important role and provide a bridge within the system. The CAIR Team has risen to this challenge, founded on the spirit of reflective and iterative improvement, while highlighting the importance of anaesthesiologists as healthcare leaders beyond the operating room.

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## Basic principles of ultrasound and the use of lung ultrasound in the COVID-19 pandemic

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### Abstract

Given that ultrasound use is increasing in healthcare, operators must be familiar with its physics in order to optimise the image and interpret potential artifacts. Ultrasound are sound waves at frequencies above the range of human hearing, that are transmitted from and received by an ultrasound transducer with piezoelectric properties. As it propagates through tissues, some of the ultrasound waves are reflected at tissue boundaries, leading to its detection by the ultrasound transducer. These are processed by the ultrasound machine and result in the generation of an image.

Various settings can be adjusted to optimise the image, such as the frequency of the transmitted ultrasound wave, depth of the focal zone and the gain. Artifacts are presentations on the monitor of the ultrasound machine which are added, omitted, or are of improper brightness, location, shape, and size compared with true anatomical features. It can result in falsely perceived objects, missing structures or degraded images. The presence or absence of such artifacts in lung ultrasound can be valuable in the interpretation of the resulting image. In the setting of COVID-19, lung ultrasound has become increasingly useful in evaluating disease progression and providing a point-of-care radiological adjunct in clinical decision making.

**Key words:** acoustic artifacts; acoustic impedance; coronavirus disease; lung ultrasound; pneumonia; severe acute respiratory syndrome; COVID-19; spatial resolution; temporal resolution; ultrasonic waves; ultrasonography

### INTRODUCTION

Ultrasound is defined as sound waves characterised by frequencies above the range of human hearing, that is greater than twenty kilohertz<sup>1</sup>. Its use in imaging has become increasingly commonplace in healthcare, with a broad array of diagnostic and therapeutic applications across a wide range of medical specialities in both resource-rich and resource-poor countries<sup>2</sup>. In view of the growing availability, portability and the technological advancement of ultrasound, its utility continues to evolve with increasing applications at the point of patient care beyond traditional radiological as well as obstetric and gynaecological indications. Examples of this include the focused scanning of particular body systems to serve as an adjunct to clinical assessment<sup>3</sup>. In particular, lung ultrasound (LUS) has been suggested to be a valuable imaging modality in the current COVID-19 pandemic, precipitated by the SARS-CoV-2 virus<sup>4</sup>. The use of ultrasound has also been recommended by the various Royal College or Society guidelines in order to facilitate procedures such as the placement of central venous catheters or

chest drains<sup>5,6</sup>. Further, ultrasound is extensively used in the targeted injection of local anaesthetic around nerves in regional anaesthesia<sup>7</sup>.

Our review aims to discuss the basic principles of ultrasound, fundamentals of image generation and optimisation, artifacts that can be produced, and the role of LUS in the current COVID-19 pandemic.

### Characteristics of ultrasound

Sound can be defined as longitudinal pressure waves, with alternating compression and rarefaction, that are propagated through a medium. It is characterised by amplitude, frequency, wavelength, and speed (Figure 1). Amplitude, measured in decibels (dB), is the maximum displacement of a point in the wave from equilibrium. The frequency ( $f$ ) of an ultrasound wave is the number of cycles, or pressure peaks, occurring in one second and is measured in hertz (Hz). Medical ultrasound has a frequency of between one to twenty megahertz (MHz). Its wavelength ( $\lambda$ ), inversely proportional to the frequency, is the distance between

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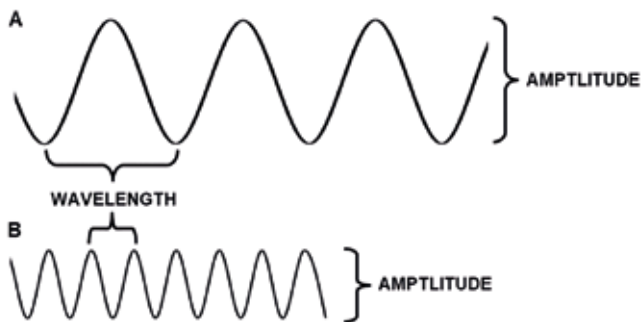
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**Figure 1:** Characteristics of an ultrasound wave with lower frequency, longer wavelength and larger amplitude (A) and higher frequency, shorter wavelength and lower amplitude (B)

the pressure peaks and is measured in metres<sup>1</sup>. The speed (*c*) of ultrasound is dependent on the physical properties of the medium through which it is propagated and is measured in metres per second (ms<sup>-1</sup>). Speed, frequency, and wavelength are related to each other in the equation:

$$c = f \times \lambda$$

Ultrasound has a speed of 330, 1450 and 1540 m s<sup>-1</sup>, respectively, in air, fatty tissue and soft tissue.

### Generation of an ultrasound image

In order to generate an image with ultrasound, sound waves are transmitted from and received by an ultrasound transducer, the latter containing ferroelectric polycrystalline ceramic materials with piezoelectric properties such as lead zirconate titanate<sup>8</sup>. In the reverse piezoelectric effect, under the influence of an alternating current, the crystalline material of the transducer expands and contracts as the polarity of the voltage changes, and the consequent vibrations produce the pulse of an ultrasound wave of two or three cycles of the desired frequency.

Once the ultrasound pulse has been generated, the transducer changes from emitting to receiving mode. Due to its interaction with the interfaces present within the medium, a variable proportion is reflected back to the ultrasound transducer. This reflected ultrasound wave results in the secondary mechanical deformation of the crystalline material of the transducer through the piezoelectric effect and is transformed into electrical current. In this manner, the ultrasound transducer functions as a speaker and a microphone where the process of transmission and reception is repeated thousands of times per second<sup>1</sup>.

In the generation of the image on the monitor of the ultrasound machine, the amplitude of the reflected ultrasound wave determines the brightness of an echo pixel on a grey scale. Structures that strongly reflect the ultrasound wave are brighter or hyperechoic and those that weakly reflect it are darker or hypoechoic. The horizontal position of the echo pixel on the screen is dependent on the position of the receiving piezoelectric crystalline material on the ultrasound transducer. The vertical position, or depth, of the echo pixel reflects the time delay between the emission and the receipt of the ultrasound

wave. It is this pattern of the brightness and the position of the echo pixels that results in the fundamental B-mode image<sup>9</sup>.

### Ultrasound interaction with tissues

As the ultrasound wave propagates through the body, it interacts with tissues and, in doing so, is reflected, refracted, and attenuated (Figure 2).

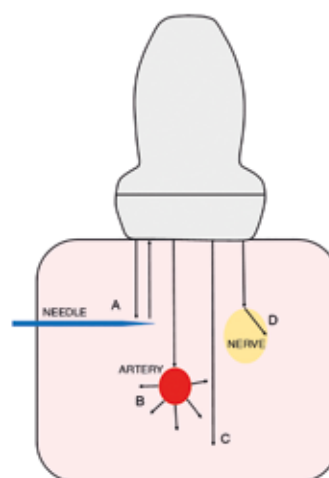
#### Reflection

If an ultrasound wave encounters an interface between two tissues of different acoustic impedance, part of the sound energy is reflected, and the remainder is transmitted. The acoustic impedance of a tissue (*Z*), measured in Rayls, is defined as a product of its density (*ρ*) and the speed of ultrasound (*c*) through that particular tissue, and is a measure of the tissue's tendency to resist the passage of an ultrasound wave:

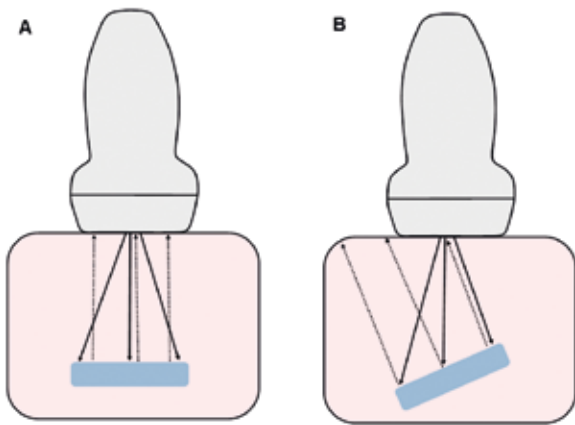
$$Z = \rho \times c$$

Compared to soft tissue, air has a lower acoustic impedance and bone has a higher acoustic impedance. Should the mismatch between the acoustic impedances of two tissues that form an interface be greater, then more of the sound energy is reflected rather than transmitted.

The nature of the reflection of the ultrasound wave can be either specular or scattered. In specular reflection, the interface is large and smooth, its dimensions larger than the wavelength of the ultrasound wave, and the reflector is like a mirror. Its reflectivity to the ultrasound transducer is most when the angle of incidence of the ultrasound wave is perpendicular to the reflector (Figure 3). In scattering, the dimensions of the reflector are smaller than the wavelength of the ultrasound wave or the interface is rough and irregular, and the ultrasound wave is reflected through a wide range of angles. Given this, less of the reflected ultrasound wave is directed towards the ultrasound transducer, but several organs such as the liver have characteristic scatter signatures that reflect their underlying structures<sup>10</sup>.



**Figure 2:** Once the ultrasound wave has been emitted from the ultrasound transducer, it can interact at interfaces with tissues to undergo specular reflection (A), scatter reflection (B), transmission (C) and refraction (D)



**Figure 3:** If the reflector is perpendicular to the ultrasound wave, then most of the ultrasound wave is reflected to the ultrasound transducer (A) and the reflector is well imaged. Should this not be the case with a decreased angle of insonation, then much of the ultrasound wave is reflected away from the ultrasound transducer (B) and the view of the target is not optimal



**Figure 4:** In the presence of higher frequency ultrasound waves and longer ultrasound path lengths, attenuation or energy loss is increased

### Refraction

Once an ultrasound wave has reached an interface between two tissues of different acoustic velocities, the part of the sound energy that is transmitted is likely to change its direction of travel or refract, unless its angle of incidence is perpendicular. It does this because the wavelength rather than the frequency of the ultrasound wave is modified to accommodate the differences, however small, in the speed of ultrasound through those tissues.

### Attenuation

Attenuation refers to the progressive loss of sound energy as the ultrasound wave passes through tissue. It is related mainly to the conversion of some of the energy into heat by induced oscillatory motion of the tissues in a process known as absorption, and is increased in the presence of higher frequency ultrasound waves and longer ultrasound path lengths (Figure 4). Further, different tissues have varying attenuation coefficients and the higher the attenuation coefficient, the more attenuated the ultrasound waves are

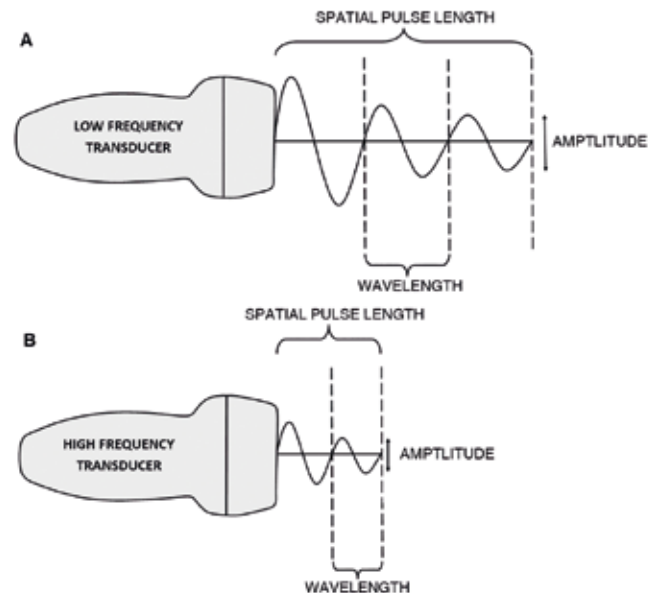
by the specified tissue<sup>9</sup>. Compared to soft tissue, blood has a lower attenuation coefficient, and air and bone have higher attenuation coefficients.

### Spatial resolution

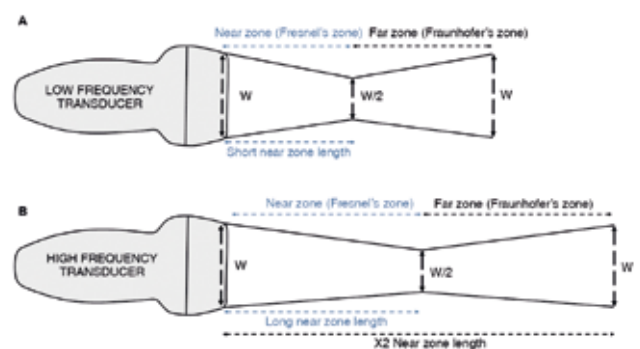
Spatial resolution can be defined as the ability of the ultrasound machine to determine two points as separate entities in space and is subcategorised into axial and lateral resolution.

### Axial resolution

Axial resolution is the minimum distance that can be differentiated between two reflectors located parallel to the direction of the ultrasound beam<sup>7</sup>. It is mathematically equal to half the spatial pulse length, that is the product of the number of cycles of the pulse of an ultrasound wave and its wavelength (Figure 5).



**Figure 5:** Illustration of a low frequency ultrasound transducer with long spatial pulse length and a consequent low axial resolution (A) and a high frequency transducer with short spatial pulse length and a corresponding high axial resolution (B)



**Figure 6:** Illustration of a low frequency ultrasound transducer with a short near zone length (A) and a high frequency ultrasound transducer with a long near zone length (B). W: width

If the spatial pulse length is short, as it would be with an ultrasound wave of high frequency and hence short wavelength, then the axial resolution is high<sup>11</sup>.

#### *Lateral resolution*

Lateral resolution is the minimum distance that can be differentiated between two reflectors located perpendicular to the direction of the ultrasound beam. At the level of the ultrasound transducer, the width of the ultrasound beam is equal to that of the ultrasound transducer (Figure 6).

The ultrasound beam then converges to its narrowest width, that is half of the width of the ultrasound transducer, at the near zone length. As the ultrasound wave passes beyond the near zone into the far zone, the ultrasound beam diverges till its width is once again equal to that of the ultrasound transducer at twice the near zone length.

If the near zone length is long, as it would be with an ultrasound wave of high frequency and thus short wavelength, then the lateral resolution is high with shorter distances between adjacent element ultrasound beams<sup>11</sup>. Lateral resolution is highest in the focal zone where the ultrasound beam is at its narrowest. Should the ultrasound beam be divergent, then the reflector can be overlooked by slipping in between these element ultrasound beams.

#### **Doppler ultrasound**

In the Doppler effect, the emission or reflection of a wave by a moving object will change its frequency as the object moves away or towards a stationary listener, the latter in this case an ultrasound transducer. If an object moves towards the ultrasound transducer, the wavelength of the sound waves travelling towards it are compressed, leading to a higher frequency. Should an object move away from the ultrasound transducer, the wavelength of the sound waves travelling away from it are stretched, resulting in a lower frequency.

It is this change in frequency of the reflected ultrasound wave that can be detected by the ultrasound transducer in order to calculate the velocity of a moving reflector ( $v$ ) with the Doppler shift equation<sup>10</sup>:

$$v = \frac{f_d c}{2f_0 \cos \theta}$$

where  $\theta$  is the Doppler angle, in other words the angle of insonation between the direction of travel of the measured object and the direction of the ultrasound wave;  $c$  is the speed of sound in the medium;  $f_d$  is the Doppler frequency shift, that is the difference between the emitted and the detected frequencies; and  $f_0$  is the emitted frequency.

Blood flow can be measured indirectly with the Doppler shift equation and information related to such moving reflectors can be superimposed onto a B-mode image with colour Doppler.

#### **Practical implications**

Choosing the most appropriate frequency of the transmitted ultrasound wave is a compromise between the axial resolution and the

depth of penetration. Higher frequencies of ultrasound wave provide superior axial resolution of superficial structures but have increased attenuation and consequent decreased tissue penetration. Lower frequencies of ultrasound wave result in deeper tissue penetration at the expense of axial resolution.

In order to limit the effect of attenuation on the quality of the image on the monitor, the gain dial on the ultrasound machine can be adjusted. Gain is defined as the amplification of the intensity of the returning ultrasound wave, and hence the brightness of the echoes, across all points in the displayed field.

Given that attenuation is increased in the presence of longer ultrasound path lengths, time gain compensation facilitates the independent manipulation of the image brightness as a function of time and thus at specific depths in the field. It can be set up to selectively amplify the more attenuated ultrasound waves returning from deeper structures without overamplification of the ultrasound waves from more superficial tissues.

The focus or focal zone, indicated on the monitor of the ultrasound machine and representing the narrowest part of the ultrasound beam, can be positioned at the depth of the area of interest to increase lateral resolution. Several focal zones can be implemented to maintain lateral resolution with increased depth, but at the expense of temporal resolution as the ultrasound transducer must emit and process the ultrasound wave directed at each focal length<sup>12</sup>.

If a target structure is of a different acoustic impedance to the surrounding tissue, then a greater proportion of the ultrasound wave is reflected at this interface and the target structure can be differentiated more easily. The position and direction of the ultrasound beam is important. In Doppler ultrasound, blood flow is best imaged if the ultrasound beam is aligned in its direction. Blood flow is not visualised should the blood vessels be perpendicular to the ultrasound beam<sup>13</sup>.

#### **Artifacts**

Artifacts are presentations on the monitor of the ultrasound machine that are added or omitted or are of improper brightness, location, shape, and size compared with the true anatomical features. In some contexts, artifacts can be beneficial. LUS, in particular, relies on the interpretation of artifacts generated in the context of a predominantly aerated lung<sup>14</sup>. In other scenarios, artifacts can cause confusion and error.

#### *Acoustic artifacts*

Acoustic artifacts are normally due to incorrect assumptions occurring in the processing by the instrumentation. It can result in either falsely perceived objects and missing structures, or degraded images. Examples of the former include overgain and undergain artifacts, acoustic enhancement and shadowing. Examples of the latter are secondary to reverberation, ensuing as a result of the ultrasound wave reflecting repeatedly between two specular reflectors.

Dropout shadows occur with loss of contact between the faceplate of the ultrasound transducer and the skin of the patient. It can be corrected with adequate conductive gel and optimal contact and positioning of the ultrasound transducer<sup>13</sup>. In overgain and



undergain artifacts, too high and low a gain, respectively, can obscure a structure or make a structure appear absent (Figure 7). In acoustic enhancement, a structure such as a blood vessel with a low attenuation coefficient weakly attenuates the ultrasound wave and the region immediately deep to it produces stronger echoes, falsely enhancing compared to surrounding structures (Figure 8). In acoustic shadowing, a structure, such as bone, with a high acoustic impedance and attenuation coefficient strongly absorbs or reflects the ultrasound wave and the region immediately deep to it produces weaker echoes. In the context of LUS, this is of particular relevance given the presence of aerated lung and ribs. Reverberation artifacts can occur in various settings. Needle visualisation for the insertion of vascular access catheters or regional anaesthesia may lead to needle reverberation artifact, where portions of the ultrasound wave undergo a varying number of reflections within the lumen of the needle. This results in the staggered return of the trapped ultrasound wave to the ultrasound transducer and the occurrence of multiple linear and hyperechoic lines deep and parallel to the reflecting surface (Figure 9)<sup>13</sup>. In the context of LUS, A-lines represent reverberation artifacts as well<sup>14</sup>, and are discussed in more detail below.

#### Anatomic artifacts

Anatomic artifacts are tissues which resemble the target structures, such as blood vessels, lymph nodes, nerve and tendons<sup>13</sup>.

### Lung ultrasound and COVID-19

LUS has demonstrated itself to be a valuable point-of-care diagnostic modality in the assessment, monitoring and the management of patients with pulmonary manifestations due to COVID-19<sup>4,15,16</sup>. It has the capacity to identify parenchymal and pleural disease with high sensitivities<sup>17</sup>, even if pulmonary pathology owing to COVID-19 does not have specific pathognomonic findings on ultrasound<sup>18</sup>.

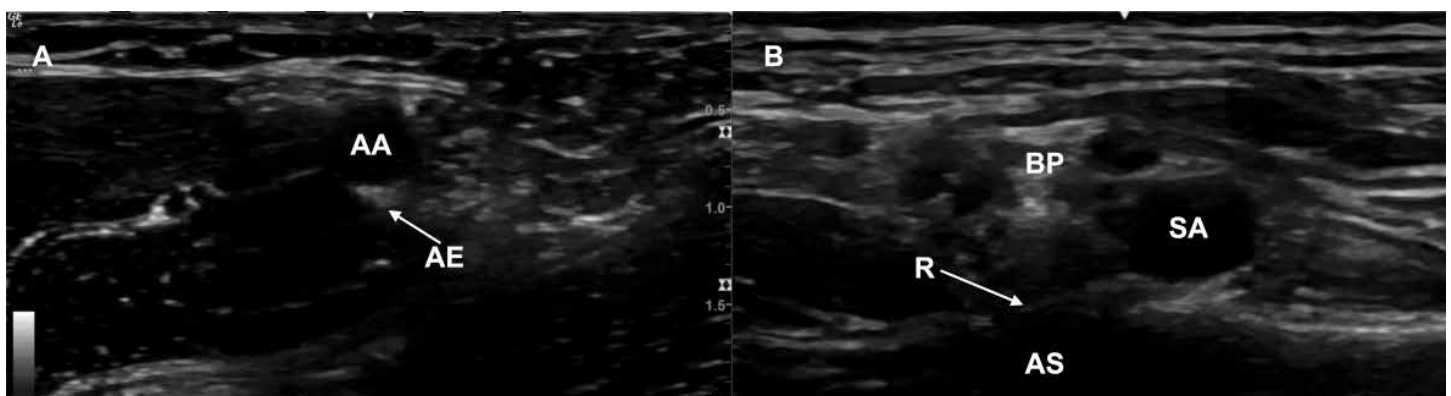
#### How to perform lung ultrasound

LUS is best performed through the intercostal space as the acoustic window. Given the high acoustic impedance and attenuation coefficient of air compared to soft tissue such as the pleura, the ratio of air and fluid in the lung underlying the pleura determines whether the image on the monitor of the ultrasound machine characterises only artifacts, as is the case in normal aerated lung, or is a direct depiction of tissue, as is the case in abnormally fluid-filled lung.

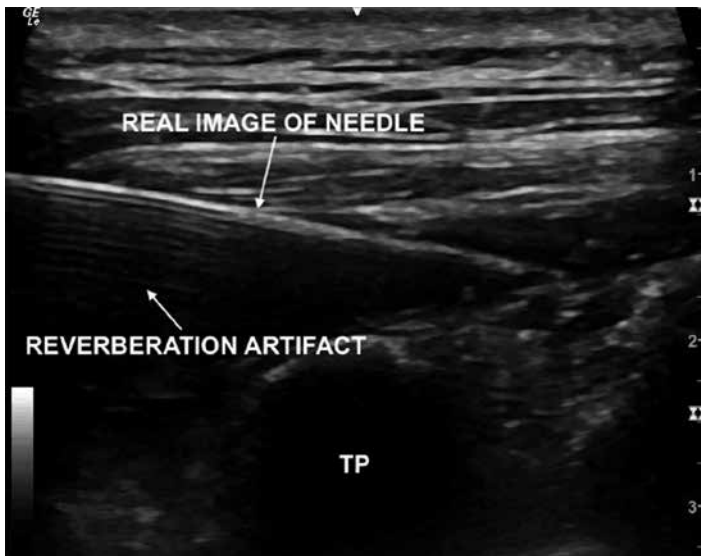
If available, the microconvex probe that has an ultrasound frequency of 3–5 MHz is optimal for LUS. Other ultrasound probes, however, are more widely available, and these include the linear, curvilinear and phased array ones. The linear ultrasound transducer enables a better definition of the subpleural space yet is limited by a narrow sector width and poor tissue penetration due to its high frequency, and the phased array probe has a smaller footprint that gives rise



**Figure 7:** Ultrasound image of the infraclavicular fossa with the correct gain setting (A) compared to too high (B) or too low (C) gain. AA: axillary artery; AV: axillary vein; LC: lateral cord of brachial plexus; PC: posterior cord of brachial plexus; PMI: pectoralis minor muscle; PMJ: pectoralis major muscle



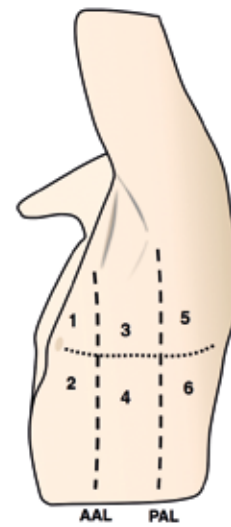
**Figure 8:** Ultrasound image of the axillary fossa demonstrating acoustic enhancement of the structure immediately deep to the axillary artery (A) and of the supraclavicular fossa showing acoustic shadowing deep to the first rib (B). AA: axillary artery; AE: acoustic enhancement; AS: acoustic shadowing; BP: brachial plexus; R: rib; SA: subclavian artery



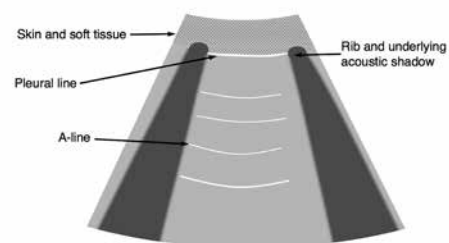
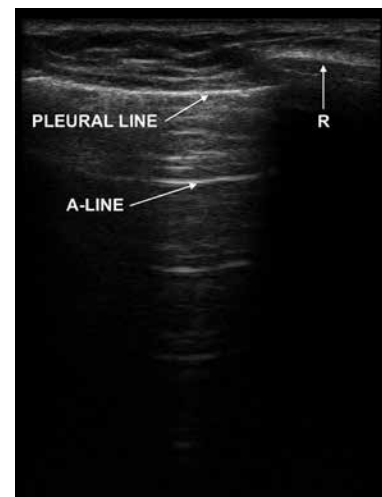
**Figure 9:** Ultrasound image of the transverse processes and overlying musculature. The needle can be visualised in long axis with underlying needle reverberation artifact. TP: transverse process

to improved access to the intercostal space, albeit with poorer image resolution. The curvilinear probe has a significant footprint and therefore can decrease dexterity across the narrow intercostal windows. Fundamentally, the choice of ultrasound probe is dependent on local availability as well as operator experience and preference. Importantly, many modern ultrasound machines have a built in lung preset that will deactivate compound and harmonic imaging, improving the appreciation of lung sliding and B-lines. Should this not be available as a preset, then the settings can be adjusted manually. Further, the presence of lung sliding can be made more obvious by adjusting the focal zone to the level of the pleural line and reducing gain.

In the scanning scheme we recommend, a six-point technique on each side of the chest represents an efficient and pragmatic approach to the evaluation of the distribution and the pattern of disease<sup>19</sup> (Figure 10). The ultrasound transducer should be positioned perpendicular to the skin in order to image the hyperechoic pleural line and its associated lung sliding, where the visceral and parietal pleura slide over one another with respiration, and the related shimmer in the subpleural space. A-lines are reverberation artifacts arising from the repeated reflection of the ultrasound wave between the pleural line and the ultrasound transducer, and are seen as horizontal lines below the level of the pleura, with the distance between them corresponding to that between the pleura and the ultrasound transducer (Figure 11A). They indicate the presence of air, but do not differentiate between alveolar air and pleural air, and hence are present in both well aerated lungs and pneumothoraces. Unlike well aerated lungs, however, lung sliding is not present in pneumothoraces. Longitudinal orientation of the ultrasound transducer leads to the visualisation of the pleural line between the acoustic shadows of the neighbouring ribs, resulting in a bat-like image (Figure 11B), while transverse orientation of the ultrasound transducer obviates this unfavourable influence of the ribs on the generated image. Each scanning zone should be scanned for at least the duration of one respiratory cycle or 5–6 seconds.



**Figure 10:** Ultrasound image of the transverse processes and overlying musculature. The needle can be visualised in long axis with underlying needle reverberation artifact. TP: transverse process



**Figure 11a and b:** Illustration of the normal sonographic findings on lung ultrasound with the ultrasound probe in the transverse orientation. The pleural line is identified as a hyperechoic horizontal line, superficial to which are the intercostal muscles and subcutaneous tissue and deep to which is the subpleural space. A-lines can be seen deep to the pleural line as horizontal and parallel reverberation artifacts. R: rib

*Sonographic signs in COVID-19*

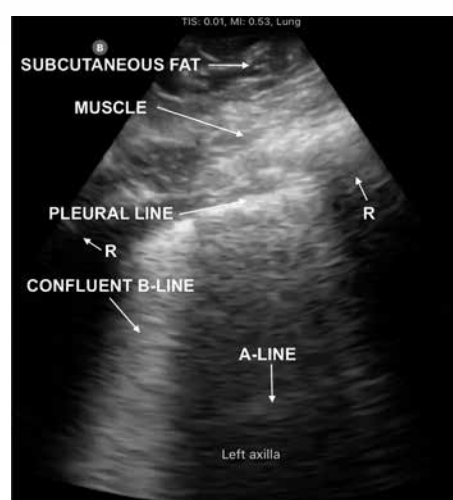
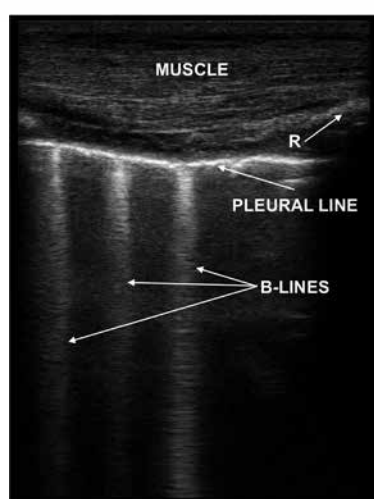
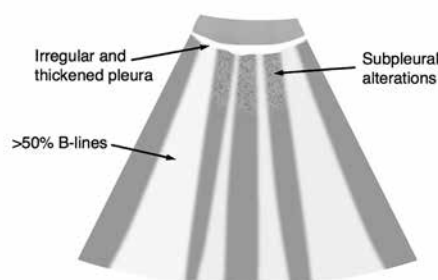
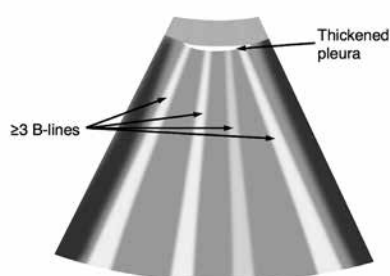
COVID-19 pneumonia is atypical for acute respiratory distress syndrome (ARDS) and manifests with a moderate degree of deaeration and an increase in extravascular lung water<sup>20</sup>. Its main

sonographic findings demonstrated on LUS are illustrated in Figure 12. In the progression from the mild to the more severe forms of COVID-19 pneumonia, the ratio of air to fluid continues to decrease and incremental deaeration occurs<sup>15</sup>.

In sonographic interstitial syndrome, where oedema is present in the interstitium, the juxtaposition of alveolar air and septal thickening causes artifacts known as B-lines to appear, reflecting the partial loss of aeration of the lung. They are displayed as discrete and vertical hyperechoic lines that arise from the pleural line and extend to the depths of the image, move synchronously with lung sliding, and replace A-lines. It is not uncommon to see one or two B-lines between the acoustic shadows of two neighbouring ribs in the lung bases of older patients, although three or more B-lines are suggestive of underlying pathology. In mild COVID-19 pneumonia, B-lines may not be found in all lung scanning zones as the disease is often multifocal (Figure 12A & 12B). Should the severity of the COVID-19 pneumonia be at least moderate, then the B-lines increase in number, become more closely spaced and eventually coalesce (Figure 12C & 12D). In sonographic alveolar syndrome, consolidation is imaged as an ill-defined and poorly echogenic focus below the pleural line with the presence of B-lines at the margins, or as hepatisation of the lung where it resembles the liver in echogenicity owing to its high fluid content. If the severity of COVID-19 pneumonia is severe, then the sonographic changes are principally found in the posterobasal region

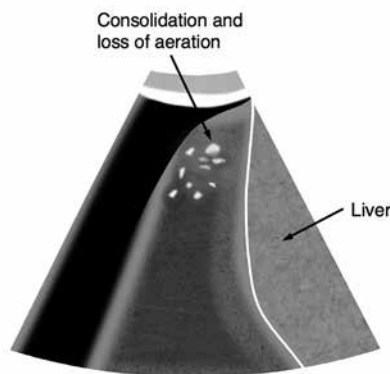
(Figure 12E). In addition to these particular sonographic signs, LUS can identify: first, the extent of extravascular lung water, indicated by the presence of B-lines which, in combination with echocardiographic assessment of the left ventricular function and doppler evaluation of the inferior vena cava, hepatic vein, portal vein, and/or renal vein for venous congestion, may help guide fluid management strategies; second, despite being uncommon in COVID-19 pneumonia, anechoic pleural effusions are often found in critically ill patients and, if present, other diagnoses should be considered; and third, the presence of pneumothorax as a complication of mechanical ventilation.

COVID-19 pneumonia is heterogenous in its presentation, but commonly there is a gradual transition from the initial predominance of a multifocal ground-glass appearance to a more dense and diffuse consolidation as the disease progresses<sup>21</sup>. Two phenotypes have been recognised at the severe end of the clinical spectrum<sup>20</sup>. In the L type, the predominant phenotype, hypoxia is common and lung compliance is normal. On LUS, B-lines can be seen. In the H type, which resembles ARDS, lung recruitment with prone positioning and increased positive end-expiratory pressure is beneficial. On LUS, consolidation is visualised. Of importance, the management strategies applicable to the L type of COVID-19 pneumonia are not effective for the H type and can indeed lead to harm<sup>20</sup>.



**Figure 12a and b:** In mild COVID-19 pneumonia, with the ultrasound probe in the transverse orientation, the pleural line is irregular and thickened. More than two B-lines are present between the ribs, and are seen as hyperechoic, non-fading and vertical comet tail-like lines extending from the pleural line to the bottom of the screen. They move in synchronisation with respiration and obliterate A-lines. R: rib

**Figure 12c and d:** In moderate COVID-19 pneumonia, with the ultrasound probe in the transverse orientation, multiple irregular and thickened pleural lines are seen, reflecting subpleural thickening. The subpleural alterations represent consolidation. B-lines are confluent and diffuse, resulting in a curtain-like pattern covering more than 50% of the width of the screen. R: rib



**Figure 12e:** In severe COVID-19 pneumonia, with the ultrasound probe in the transverse orientation, deaeration is more marked with compressed and consolidated lung, changes which are more prominent in the posterobasal zone. Lung tissue hepatisation can be seen, where the macroscopic pathological alteration of lung tissue is such that it resembles liver tissue

#### *The utility of lung ultrasound for COVID-19*

Like other modalities for the investigation of COVID-19 pneumonia, our knowledge and understanding in respect to the use of LUS continues to evolve<sup>4</sup>. Its fundamental applications to this new disease include its risk stratification, early evaluation of the severity, monitoring of the progression of COVID-19 pneumonia, and the identification of concomitant pathology that might influence management. LUS is hence a valuable technique for enabling clinical decision making and informing the selection of the appropriate treatment strategy. It is not, however, diagnostic of COVID-19 itself<sup>8</sup>, although pleural line and subpleural abnormalities have been associated with a high probability of its presence relative to other causes<sup>16</sup>. Recently, Volpicelli et al. quantified the diagnostic accuracy of LUS against the reference standard of reverse transcription polymerase chain reaction (RT-PCR). LUS studies on the included patients were classified as either intermediate probability, for example with unilateral B-lines, or high probability, for instance with bilateral confluent B-lines and subpleural consolidations. If either intermediate or high probability findings on LUS were incorporated to rule in COVID-19, sensitivity was 90% but specificity was only 53%. If solely high probability findings on LUS were used, sensitivity decreased to 60% but specificity increased to 89%. Such results suggest that there is in fact a spectrum of sonographic signs in COVID-19, and that the selected threshold for diagnosis can have a significant impact on test characteristics<sup>22</sup>.

The strengths of LUS in the context of COVID-19 pneumonia are its portable and point-of-care nature, facilitating rapid and safe examination with immediate results and without the need to transfer the patient outside of the clinical care environment to the radiology suite. LUS is a sensitive investigation for the early detection of pleural and interstitial pathology and has a high negative predictive value<sup>23</sup>. Crucially, its findings correlate well with computed tomography and, in fact, pleural line thickening and B-lines on ultrasound correspond to the ground glass appearances seen on the latter<sup>24</sup>. Moreover, the findings from LUS findings correlate with histopathological findings, B-lines and subpleural consolidation correspond to diffuse alveolar

lung damage, while pleural line thickening and dense consolidation correlate with more severe fibroproliferative disease<sup>25</sup>.

The limitations and pitfalls of LUS, however, should be taken into consideration. First, the diagnostic accuracy and the interpretation of the nuances of LUS are dependent upon sufficient experience and training of the ultrasonographer. Second, the distribution of the lung disease secondary to COVID-19 is non-homogenous and topographical, accentuating the need to scan all six zones of the chest, reducing the risk of failing to diagnose pathology which is patchy in nature. Third, it may be difficult to obtain ultrasound images of the posterolateral aspects of the lungs in supine and critically ill patients, particularly those of whom are mechanically ventilated. Fourth, conditions such as obesity and subcutaneous emphysema and dressings applied to the chest interfere with the transmission of ultrasound. Last, in view of the potential for interaction between the lungs and the heart, it is important to perform cardiac and diaphragmatic ultrasound in order to complete a comprehensive review with ultrasound.

#### **CONCLUSION**

In conclusion, in order to optimise ultrasound imaging and interpret ultrasound related artifacts, an understanding of the physics of ultrasound is valuable. The operator has the ability to control the appearance and the quality of the image on the monitor of the ultrasound machine by changing the characteristics of the ultrasound wave that is being emitted and manipulating how the returning ultrasound wave is processed. Further, ultrasound for lung scanning is starting to reveal its utility as a valuable point-of-care investigation in evaluating the progression of COVID-19 pneumonia and providing a radiological adjunct similar to computed tomography in clinical decision making.

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## Perceived Stress levels among Anaesthesia and Intensive Care staff during the third wave of the COVID-19 pandemic: A report from Afghanistan

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### Abstract

Hospitals are highly challenging and stressful workplaces. The COVID-19 pandemic adds even more stress to intensive care unit (ICU) and anaesthesia staff who are at the frontline dealing with COVID-19 patients, and are highly likely to experience psychological disturbances and mental health problems.

In this study, we examined the demographic characteristics associated with level of stress among clinical anaesthesia and ICU department staff via a questionnaire and scoring scale. 311 people were invited to participate in the survey, and a total of 175 completed it during June 19, 2021 to July 26, 2021 from thirteen Kabul public and private hospitals. The questionnaire included information about age, gender and 10 questions of Perceived Stress Scale during the third wave of COVID-19 pandemic.

The results showed that 96.6% of respondents reported moderate to high stress levels. Chi-square analysis found that age groups of equal or less than 40 years old, anaesthesia staff, participants who had occasional contact with COVID-19 and female gender were associated with high stress levels.

Anaesthesia and ICU staff experience high levels of self-perceived stress during the COVID-19 pandemic. Consideration may be given to stress reduction techniques.

**Key words:** Emotional Stress, Covid-19, Intensive Care Units, Anaesthesia Department, Afghanistan

### INTRODUCTION

The first cases of COVID-19 were reported in the Wuhan city of Hubei Province in central China on December 29, 2019 as pneumonia of unknown cause. Subsequently, the World Health Organization (WHO) declared COVID-19 as a global pandemic on March 12, 2020<sup>1</sup>. The first case of COVID-19 in Afghanistan was reported in the western province of Herat in a 35-year-old Afghan retailer who had returned from Qom city in Iran on Feb 9, 2020.<sup>2</sup> COVID-19 was responsible for 69,130 confirmed cases and 2,881 deaths in the country as of May 28, 2021. These estimates, however, do not appear to correspond to the real rate of disease transmission.<sup>3</sup>

Health-care workers involved in the COVID-19 pandemic are exposed to high levels of stressful events and exhibit significant unfavorable mental health outcomes, such as stress-related symptoms and sadness, anxiety, and sleeplessness symptoms.<sup>4</sup> When people sense a gap between the demands of a situation

and the resources of their biological, psychological, or social systems to deal with it successfully, they experience stress.<sup>5</sup> At modest amounts, stress can be beneficial to the body. When stress becomes excessive, the body has difficulties adapting or coping with it, both physically and psychologically, the harmful effects of stress arise. In these cases, stress has a role in the development of a variety of health and psychological problems.<sup>6</sup> Hospitals are highly challenging and stressful workplaces even in the best of times. Medical staff face numerous stressors such as medical emergency situations, patients' deaths, time pressure, steep hierarchies, and team conflicts.<sup>7,8</sup>

Anaesthesia and critical care physicians are at the frontline dealing with COVID-19 patients, and are highly likely to experience psychological disturbances and mental health problems.<sup>9,10</sup> Reported factors that contribute to these mental and psychological effects include increased workload in ICU, lack of Personal

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Protection Equipment, lack of a vaccine or treatment, social stigma, and concern of spreading of the disease, especially to their families. In this study, we examined the level of stress and demographic characteristics associated with level of stress among the anaesthesia and ICU departments in Kabul hospitals using a questionnaire and a specific scale.

In Afghanistan, the majority of anaesthetics are delivered by practitioners who have graduated from a two-year Nurse Anaesthetist program or a four-year Bachelor of Science in Anaesthesia technology program. The program is supervised by faculties and staff of the Anaesthesiology department at Kabul University of Medical Sciences, some of whom have completed a five-year residency program in Anaesthesiology.<sup>11</sup> Unfortunately, we do not have a formal training program in critical care and so the ICU is managed by a multidisciplinary team composed of many different health professionals without formal critical care training.

## METHODS

This is a cross sectional study modelled after a published research study by Hassan et al.,<sup>12</sup> at Cairo University in Egypt in which a questionnaire was used to assess levels of stress in staff. Approval was given by the scientific research and ethics center of the Allied Health Kabul University of Medical Sciences committee. All aspects of this study followed the ethical standards of the relevant national and institutional committees. We obtained a list of anaesthesia and intensive care unit staff who work in clinical settings from the directorate of the hospitals.

The questionnaire was distributed to all the anaesthesia and ICU staff in thirteen Kabul public and private hospitals via social media and official email. Participation was voluntary, the survey was anonymous, and researchers were blinded to the participants. 311 staff were invited to participate in the study, and 184 filled in the questionnaire during the period of June 19, 2021, to July 26, 2021 by using the Survey link. Nine respondents were eliminated from consideration because of incomplete information.

The questionnaire included information about age, gender, speciality, contact with Covid-19 and 10 questions of Perceived Stress Scale (PSS-10) during the third wave of COVID-19 pandemic. The PSS-10 questionnaire contains 10 questions which assesses the perceived stress of an individual. The questions are answered from 0 to 4, where 0 indicates never and 4 indicates always. The PSS scores are obtained by reversing responses (4=0, 3=1, 2=2, 1=3, 0=4) to the question and then adding all scale points. For PSS-10, a score of 13 is considered moderate, and a score of 20 or higher shows a high level of stress requiring lifestyle modification and learning stress reduction techniques.<sup>12</sup> See Appendix A for the survey in Dari and English.

Initially, the data was entered into an excel datasheet and then exported to IBM SPSS version 24 for Windows for statistical analysis. Bi-variable analysis was used to determine factors which are associated with stress level. A p-value of <0.05 was set as significance level at 95% confidence interval.

## RESULTS

There were a total of 175 anaesthesia and intensive care participants, with 113 (64.6%) males, 55 (31.4%) females and 7 (4%) participants who preferred not to say their gender. 41.1% of the study population were in the 20-29 age group. Among the study population, 61.7% were anaesthesia physicians, technicians and nurses, and the remaining 38.3% were ICU physicians and nurses. More than half of the study population (53.7%) had continuous contact with COVID-19. (Table 1)

**Table 1:** Demographic characteristics of the subjects (n=175)

Characteristics		n (%)
<b>Gender</b>	Male	113 (64.6)
	Female	55 (31.4)
	Not mentioned	7 (4)
<b>Age group</b>	20-29	72 (41.1)
	30-39	56 (32)
	40-49	29 (16.5)
	50-59	12 (6.9)
	=>60	6 (3.4)
<b>Speciality</b>	Anaesthesia physician	37 (21.14)
	Anaesthesia technician	60 (34.29)
	Anaesthesia nurse	11 (6.28)
	ICU physician	59 (33.29)
	ICU nurse	8 (4.57)
<b>Contact with Covid-19</b>	Continuous contact	94 (53.7)
	Sometimes	42 (24)
	Don't know	22 (12.6)
	No contact	17 (9.7)

3.4 % of study participants reported low stress levels, 92.6% reported moderate stress levels, and 4% reported high stress levels.

Table 2 shows significant demographic characteristics associated with level of stress. Female participants reported high stress levels more than male participants with an odds ratio of 5.9 and a 95% confidence interval (1.1-31.4), as demonstrated in Table 2. Subjects 40 years old or younger reported high stress levels more than subjects 40 years old or greater, with an odds ratio of 2.1 and its correspondent 95% confidence interval (0.5-9.8) in this study, but this did not reach statistical significance (p-value = 0.388).

ICU staff reported lower stress levels compared to anaesthesia staff with an odds ratio of 3.9 and its correspondent 95% confidence interval (0.5 -33).

Participants who had occasional contact with COVID-19 patients reported high stress levels, more than those who had continuous contact with COVID-19 patients, with odds ratio of 3 and its correspondent 95% confidence interval (0.6-16).

## DISCUSSION

The COVID-19 pandemic is unprecedented in contemporary history. Previous studies have shown that epidemics and the spread of the disease are associated with severe psychological, individual and social effects that eventually become more widespread than outbreaks.<sup>13</sup> Due to the worldwide high prevalence of COVID-19 and the high rate of hospitalizations, health care workers are more likely than others to be exposed to the disease as they are in the first line of defence.<sup>14</sup>

The level of moderate stress in our study population was 92.6 %, which was higher than what has been reported by studies in the middle east including AI Ateeq et al.,<sup>15</sup> Almater et al.,<sup>16</sup> Ahmed Arafa et al.,<sup>17</sup> and Barnaz A et al.,<sup>18</sup> where moderate stress levels of 36.1%, 68.2%, 36.6% and 67.3% were reported. This might be due to differences in the training environment of health workers, including more attentive training to deal with an epidemic such as COVID-19,

and the increased availability of personal protective equipment, which could all lead to lower stress levels<sup>19</sup>. Lai et al., indicated that health care workers experienced high levels of depressive symptoms, anxiety and stress.<sup>20</sup> However the level of high stress in our study population was 4%, which was similar to the study conducted by Almater et al.,<sup>16</sup> in Saudi Arabia with a reported level of 3.7% and was lower than what were by AI Ateeq et al.,<sup>15</sup> Ahmed Arafa et al.,<sup>17</sup> and Barnaz A et al.,<sup>18</sup> who reported high stress levels of 32.3%, 19.3% and 17.3% respectively.

Chi-square analysis found that female participants reported higher stress levels than the male participants in our study. Natasha Shaukat et al.,<sup>19</sup> Lai et al.,<sup>20</sup> and Deldar Morad Abdullah<sup>21</sup> reported similarly. It has been proposed that long working hours, childcare, household responsibilities, and exposure to moral dilemmas can increase anxiety and stress in female participants.<sup>22</sup>

Subjects 40 years or less in age had higher risk of high stress levels compared to those aged 40 years or older, which were consistent in the study accompanied by Barnaz A et al.,<sup>18</sup> in Iraqi Kurdistan and Tahereh Sarbozi Hosseinabadi et al.,<sup>23</sup> where they reported high stress levels in the age group of 31- 40 years old. Also in a study conducted by Ahmed Arafa et al.,<sup>17</sup> high stress levels were found in age group of subjects equal or less than 30 years old. In contrast, a study conducted by Mohammad Rahmanian et al.,<sup>24</sup> in Jahrom, Iran, reported the highest anxiety in the age group of 41-50 years and over 50 years in health workers who had contact with COVID-19 patients.

In our study population, ICU staff had lower rates of high stress levels compared to anaesthesia staff. In contrast, Tahere Sarbozi Hossein abadi et al.,<sup>23</sup> demonstrated that levels of stress in internal medicine doctors were higher than ICU and infectious disease doctors. Additionally, the study conducted by Nhan Phuc Thanh Nguyen et al.,<sup>25</sup> revealed that 50.3% of doctors, 46.3% of nurses and 50% of laboratory staff had mild mental stress. Ahmed Arafa et al.,<sup>17</sup> also reported 55.9% of mild mental stress existed among

**Table 2:** Results of chi-square analysis for demographic characteristics associated with level of stress

Characteristics		Level of stress		ORC ** (95 % CI)	p-value
		Moderate n (%)	High n (%)		
<b>Gender</b>	Female	50 (90.90)	5 (9.09)	5.9 (1.1-31.4)	0.032*
	Male	118 (98.33)	2 (1.66)		
<b>Age Category</b>	=>40	124 (96.87)	4 (3.12)	2.1 (0.5-9.8)	0.388*
	<40	44 (93.61)	3 (6.38)		
<b>Speciality</b>	Anaesthesia staff	102 (94.44)	6 (5.55)	3.9 (0.5-33)	0.253*
	ICU staff	66 (98.5)	1 (1.49)		
<b>Contact with COVID-19</b>	Occasionally contact	76 (93.82)	5 (6.17)	3.0 (0.6-16)	0.252*
	Continuous contact	92 (97.87)	2 (2.12)		

\* Fisher's exact test

\*\*Crude odds ratio



health workers. Anaesthesia doctors might be at higher risk for mental health problems due to conventional airway management of suspected or confirmed COVID-19 patients.<sup>26</sup>

Moreover, our study participants who had been in contact with COVID-19 occasionally had higher stress levels than those who had continuous contact with COVID-19, unlike Phuc Thanh Nguyen et al.,<sup>25</sup> findings in Vietnam. They reported high stress levels in workers with continuous contact with COVID-19 patients. This could be due to fear of transmitting the disease to their relatives, social stigma, lack of access to personal protective equipment and the lack of clear protocol to cope with COVID-19 cases.

## CONCLUSION

Moderate to high stress levels were reported by 96.6% of clinical ICU anaesthesia workers in Kabul, Afghanistan. Associated risk factors for high stress levels included age less than 40 years old, working in the anaesthesia department, participants who had only occasional contact with Covid-19, and female gender. Attention may be given to stress reduction ways.

## LIMITATIONS

We acknowledge that our study had several limitations. As data were collected via an online survey, we do not know whether the anaesthesia and intensive care staff who participated in the survey were representative of all anaesthesia and intensive care staff in Afghanistan. Response bias may also cause the data to not accurately reflect the entire ICU and anaesthesia staff. Recall bias and social desirability may have affected the quality of data provided by some anaesthesia and intensive care staff.

## RECOMMENDATIONS

The authors would like to suggest the following:

1. Further prospective trials with stress reduction interventions should be conducted to evaluate for practices that may improve stress levels.
2. Necessary attention and investment should be given to standardized training, access to equipment and clear protocols in the clinical setting.

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## APPENDIX A

### Dari version of Questionnaire

#### فورم جمع آوری معلومات :

سوالات در رابطه معلومات دیموگرافیک اشتراک کننده گان

آیا درین سروی به صورت داوطلبانه اشتراک میکنید؟

• بلی

• نخیر

جنسیت اشتراک کننده

• مرد

• زن

• بهتر است ذکر نکنم

سن اشتراک کننده

• 20-29

• 30-39

• 40-49

• 50-59

•  $\geq 60$

رشته تخصصی اشتراک کننده

• داکتر ICU

• نرس ICU

• داکترانستیزی

• نرس انستیزی

• تکنیشن انستیزی

• کارمند صحتی سایر بخش ها

تماس اشتراک کننده با مریضان کووید -۱۹

• به صورت دوامدار با مریضان کووید ۱۹ در تماس میباشم

- بعضاً با مریضان کووید ۱۹ در تماس می باشم
  - با مریضان کووید ۱۹ در تماس نمی باشم
  - در مورد مصاب بودن مراجعه کننده گان ام به مرض کووید ۱۹ نمی دانم
- شما به مریضی کووید ۱۹ مصاب شده اید؟

- اعراض کووید ۱۹ داشتم و همچنان تست لابراتواری ام مثبت بود
- اعراض کووید ۱۹ داشتم اما تست را انجام ندادم
- هیچ اعراض کووید ۱۹ را تجربه نکردم اما اعضای خانواده ام مصاب شده بودند
- در مورد مصاب بودنم به مرض کووید ۱۹ نه فهمیدم

#### سوالات در رابطه به نگرانی و اضطراب (PSS-10)

۱. در ماه گذشته، بخاطر حوادث غیر متوقعه، مصابیت و پیامد های آن چند مرتبه احساس افسردگی نمودید؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثراً اوقات

۲. در ماه گذشته چند مرتبه احساس کرده اید که به امورات مهم تنظیم شده خویش رسیدگی نتوانسته اید؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثراً اوقات

۳. در ماه گذشته چند مرتبه نگرانی و یا اضطراب را تجربه نموده اید؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثر اوقات

۴. در ماه گذشته، در رسیدگی به مشکلات خویش به چه اندازه اعتماد به نفس داشتید؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثر اوقات

۵. در ماه گذشته، امورات روزمره تان به چه اندازه مطابق میل شما انجام شده اند؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثر اوقات

۶. در ماه گذشته، تمام امورات معمول که باید انجام می دادید، چند مرتبه نتوانستید که انجام دهید؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثراً اوقات

۷. در ماه گذشته، چند مرتبه توانستید که خشم خویش را کنترل نمائید؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثر اوقات

۸. در ماه گذشته، چند مرتبه احساس کردید که تمام امورات خویش را به وجه احسن تنظیم نموده اید؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثر اوقات

۹. در ماه گذشته، از سبب عدم رسیدگی به خود و فعالیت های خویش چند مرتبه خشمگین شده اید؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثر اوقات

۱۰. در ماه گذشته، چند مرتبه احساس کرده اید که مشکلات زندگی تان به شکل تصاعدی زیاد شده رفته که از توان رسیدگی تان خارج شده اند؟

- هیچگاه
- بسیار کم
- بعضاً
- چندین مرتبه
- اکثر اوقات

## English version of Questionnaire

### Data collection sheet

#### Questions regarding to demographic characteristics

1. Do you want to participate in this survey voluntarily?

- Yes
- No

2. Your gender:

- Male
- Female
- Prefer not to say

3. Your age group:

- 20-29
- 30-39
- 40-49
- 50-59
- $\geq 60$

4. Your Specialty:

- Anaesthesia Physician
- Anaesthesia technician
- Anaesthesia nurse
- ICU Physician
- ICU nurse
- Others

5. Exposure to COVID-19 patients:

- Not dealing with symptomatic or confirmed cases
- Occasionally dealing with symptomatic or confirmed cases
- Regularly dealing with symptomatic or confirmed cases

6. Have you affected to COVID-19 disease?

- I had COVID-19 symptoms and my lab test was positive
- I had COVID-19 symptoms but did not take the lab test
- I did not experience any Covid 19 symptoms but my family members were affected
  
- I did not understand that I was infected by Covid disease

## Questions regarding to mental stress (PSS-10)

1. In the last month, how often have you been upset because of something that happened unexpectedly?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

2. In the last month, how often have you felt that you were unable to control the important things in your life?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

3. In the last month, how often have you felt nervous and stressed?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

4. In the last month, how often have you felt confident about your ability to handle your personal problems?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

5. In the last month, how often have you felt that things were going your way?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

6. In the last month, how often have you found that you could not cope with all the things that you had to do?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

7. In the last month, how often have you been able to control irritations in your life?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

8. In the last month, how often have you felt that you were on top of things?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

9. In the last month, how often have you been angered because of things that happened that were outside of your control?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often



## **Non-Operating Room Anesthesia During Covid-19 Pandemic Era**

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### **Abstract**

Over the last 30 years, non-operating room anesthesia (NORA) has grown from a minor portion of overall anesthesia cases to a substantial anesthesia workload. This shift presents the profession with several new challenges, especially during the pandemic era. Along with new sites, insufficient surveillance equipment, insufficient assisting personnel, unfamiliarity with procedures, complicated machinery, and a lack of expertise in the NORA suite, infection management practices must be standardised during the COVID time to avoid spread and contamination. Therefore, anesthesiologists must recognize possible risk factors during anesthesia in non-operating rooms and familiarize themselves with standards to improve safe practice, by utilizing detailed protocols for infection prevention and medical management, ensuring adequate personal protection equipment (PPE) supplies and training, forecasting demand, and prioritizing diagnosis. This review article emphasizes suggested guidelines for NORA during COVID time to improve patient outcomes and reduce adverse events.

**Key words:** non-operative room anesthesia; COVID-19; outpatient anesthesia; office-based anesthesia

### **INTRODUCTION**

Anesthesiologists are the frontline workers in managing acute respiratory distress syndrome in patients caused by novel coronavirus disease (COVID-19) pandemic across the globe<sup>1</sup>. Apart from routine peri-operative management of surgical patients, critical care unit, and pain management, anesthesiologists are an indispensable part of non-operating room anesthesia (NORA). Non-Operating Room Anaesthesia (NORA) refers to administering sedation, analgesia, or anesthesia outside the operating room to patients with pre-operative anxiety or undergoing painful and/or uncomfortable procedures<sup>2</sup>. Standard NORA procedures include anesthesia in the radiology suite, gastro-intestinal endoscopy suite, nuclear medicine unit, cardiac catheterization laboratory, neuro-interventional unit, Electro-convulsive Therapy (ECT) /psychiatric unit, bronchoscopy suite, and dentistry. According to a recently published article, NORA comprises about 50% of all anesthesia services provided at Mayo Clinics<sup>3</sup>. This rise in NORA procedures can be attributed to the advent of less invasive procedures, an aging population with a more significant co-morbidity burden, increased proficiency of interventionists, and growing sensitivity to pain.

### **Search Strategies**

A systematic search was conducted exploring various databases including PubMed, Cochrane Databases of Systematic Reviews, Scopus, EMBASE, Google and Google Scholar; keeping search words (Anesthesia; Cardiac catheterization; Computed tomography; COVID-19; endoscopy; electroconvulsive therapy; Non-operating Anesthesia; NORA; Pulmonology Suite; Interventional Radiology; MRI; Radio diagnosis) as the primary keys either single or in various combinations from the year 1995 to 2020. The references of relevant articles were cross-checked, and the review was written from the articles which elaborated on these keywords.

### **Need of the hour**

NORA has significant unique challenges which are related to the environment, patient, and procedure. Nagrebetsky, et al. demonstrated that NORA patients have different characteristics than their operating room (OR) counterparts. NORA cases include higher mean patient age and tend to have a higher percentage of American Society of Anesthesiology (ASA) Class III-V cases<sup>4</sup>. Data from the ASA Closed

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Claims database suggested that anesthesia at remote locations poses a significant risk to patients with over-sedation and inadequate ventilation/oxygenation during monitored anesthesia care. This risk is likely related to NORA-specific challenges such as remote location, inadequate workspaces, lack of support staff, and unfamiliar equipment<sup>5</sup>.

During the COVID-19 pandemic, these procedures pose even more significant challenges to anesthesiologists. Many of the NORA procedures, such as endoscopy and bronchoscopy, are associated with increased aerosolization of the virus. Limited space in the NORA scenario restricts proper barrier protection devices like aerosol boxes and sheets, which are generally used in the operation room during the COVID-19 pandemic. It is usually challenging to assign a dedicated donning and doffing area in NORA premises; therefore, proper use of Personal Protection Equipment (PPEs) is challenging and is a daunting task.

To provide safe and standard NORA services during the COVID-19 pandemic, anesthesiologists need to construct a uniform institutional protocol. The standard operative procedure will ensure the patient's safety and improve all healthcare providers' safety. The current situation has led to an urgent need for expert recommendations on NORA using the best available evidence to guide healthcare professionals during the pandemic. This article's suggestions are

based on three principles: a) safe anesthesia procedure in NORA scenario, b) healthcare worker safety due to COVID-19 pandemic, and c) resource preservation. This review discusses the risk associated with NORA during the COVID-19 pandemic and suggestions to mitigate the risk.

### General Guidelines for NORA during COVID-19 Pandemic

Most patients have "suspected COVID-19" or "unknown COVID-19" status when they are presenting for NORA. In NORA settings, the need for pre-procedure testing for COVID-19 is based on the nature of the procedure, symptoms, risk of aerosolization, and prevalence of community transmission. (Figure-1)

Irrespective of the anesthetic technique, airborne, droplet, and contact precautions should be taken for all NORA procedures. Anesthesiologists should use properly fitted N95 masks/Powered Air Purifying Respirator (PAPR), goggles/face-shield, impermeable gown, and double gloves while performing aerosol generating procedures (AGP). These precautions should also be taken while providing NORA in a diagnosed COVID-19 patient, even if AGP is not involved. Given the possible shortage of N95 masks, N95 masks may have to be preserved and reused according to various suggested protocols<sup>6</sup>. The patient's nose and mouth should be covered with a three-ply surgical mask during NORA and transport; it decreases the

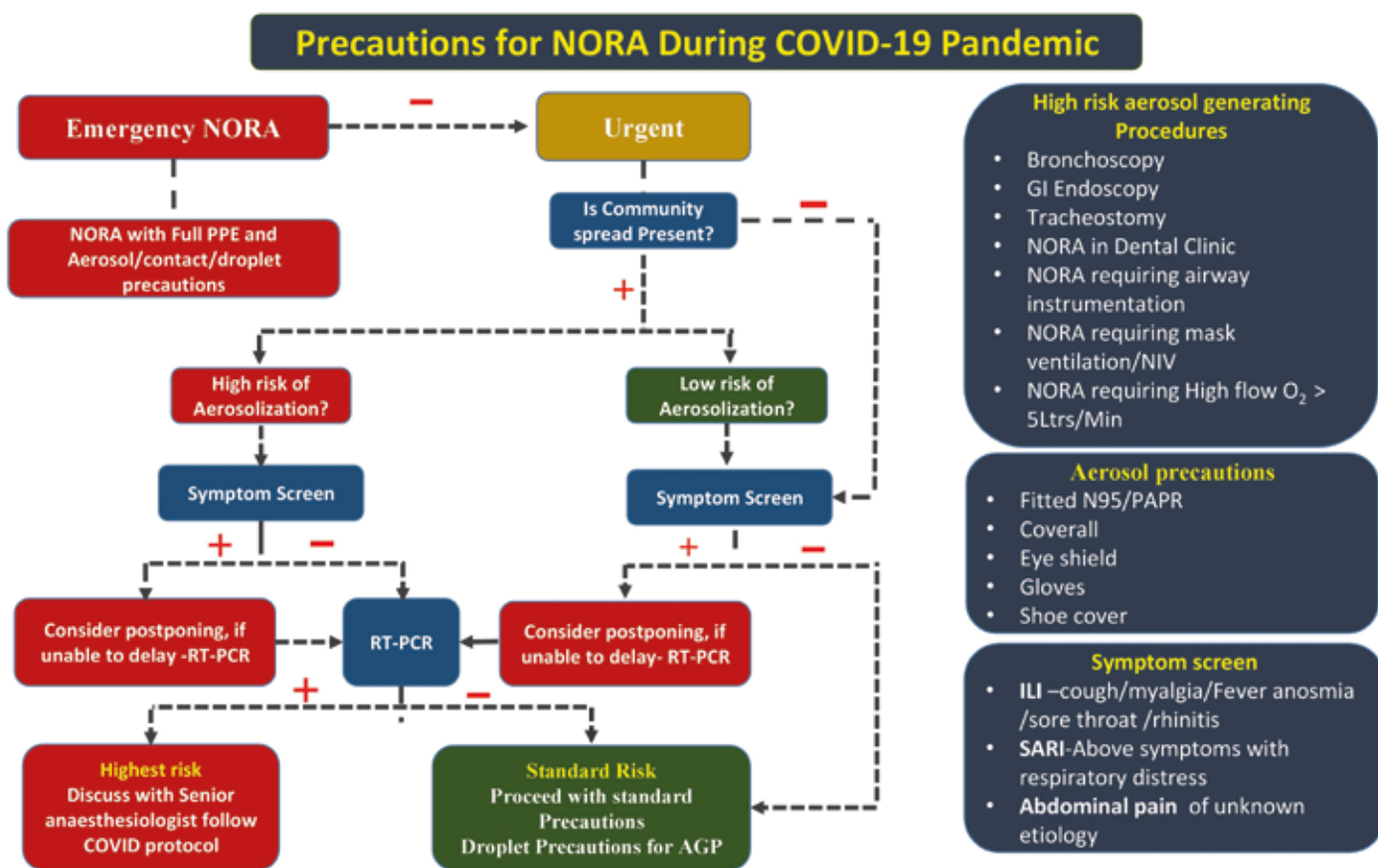


Figure 1: Precautions during COVID 19 pandemic for NORA proedures

distance of aerosol spread during coughing and high flow oxygen supplementation, reducing the disease transmission.

The choice of anesthetic technique for NORA should be carefully individualized based on procedure, risk of aerosolization, comorbidities, duration of the procedure, age, neurological status, infrastructure, and COVID-19 status (Figure 2). Unplanned conversion from Monitored Anaesthesia Care (MAC) to General Anaesthesia (GA) during NORA is undesirable given aerosolization risk in an uncontrolled environment. Whenever anticipated, elective intubation should be performed in a controlled environment, and then the patient should be moved to the NORA unit. There should be a low threshold for elective intubation in patients prone to oxygen desaturation. Medication cart including anesthetic and emergency drugs, airway instruments, suction, Oxygen source, ventilators, and monitors should be ready before NORA procedures. (Figure-3) High oxygen flow rates increase aerosolization both with a nasal cannula and Hudson mask<sup>7,8</sup>. High-flow oxygen is associated with increased transmission of the SARS-COV-2<sup>9</sup>. It is advisable to consider General Anaesthesia (GA) with intubation in patients requiring high flow oxygen to maintain SpO<sub>2</sub>>94%.

For GA with tracheal intubation, following pre-oxygenation with a good mask seal (two hands technique), modified rapid sequence induction should be performed. It is advisable to use a videolaryngoscope for intubation<sup>10</sup>. Adequate doses of neuromuscular blocking agents need to be used to prevent coughing during intubation. Extubation should be smooth and ideally be performed in isolation or negative pressure room but not at NORA locations. Avoid using Supraglottic airway devices (SGA) for GA unless it is for rescuing a difficult airway.



**Figure 2:** Choice of anaesthesia technique (NORA)

The equipment and room surfaces should be cleaned after every procedure using a 1% hypochlorite disinfectant. Deep cleaning and fumigation should be performed when a COVID-19 positive patient undergoes a procedure. All equipment and monitors should be covered with a transparent plastic sheet.

### Specific NORA Scenario:

#### I. Interventional Pulmonology Suite:

##### Rationale

Novel Coronavirus generally transmits by respiratory droplets, but airborne transmission is also possible during aerosol-generating procedures (AGP) and has unique implications during anesthetic management for bronchoscopy. Routine bronchoscopy for known or suspected COVID-19 for the mere indication of diagnosis or confirming the diagnosis is a relative contraindication; accepted indication in COVID-19 patients includes inconclusive non-invasive COVID-19 test and suspicion of an alternative diagnosis. Non-COVID-19 indications for bronchoscopy during COVID-19 pandemic includes emergent conditions like severe or moderate tracheal or bronchial stenosis, symptomatic central airway obstruction, massive hemoptysis and migrated stents, as well as urgent conditions like lung mass suspicious of cancer, mediastinal or hilar adenopathy suspicious of cancer, whole lung lavage, foreign body aspiration, mild-moderate hemoptysis and suspected pulmonary infection in immune-compromised patients<sup>11</sup>. Although specific data on the risk of infection with severe acute respiratory



**Figure 3:** Preparedness for NORA during COVID 19 pandemic

syndrome SARS-CoV-2 during bronchoscopy are not available, WHO has classified bronchoscopy as AGP<sup>12</sup>. Coughing during bronchoscopy is unsafe for the bronchoscopy and anesthesia teams working in close proximity. Coughing may lead to the production of up to 3000 droplet nuclei<sup>13,14</sup>. According to the Centers for Disease Control (CDC), it is still uncertain whether small respirable particles, i.e., aerosols or droplets, lead to proximity transmission of COVID-19 infection<sup>15</sup>. However, it has been seen that coughing or sneezing in a COVID-19 spontaneously breathing patient increases the risk of aerosolization and increases both the stay and distance of viral particles, thereby posing a potential contamination risk to HCW nearby. Therefore, bronchoscopy puts healthcare workers (HCWs) at high risk of exposure and infection, and to minimize this risk, we suggest the following measures.

### ***Suggested Measures***

Apart from general suggestions for NORA during the COVID-19 pandemic, certain specific measures are required for bronchoscopy. Bronchoscopy should be performed in airborne infection isolation rooms or negative pressure rooms whenever possible. All personnel must be donned with N95 masks, eye protection, impermeable gown and double gloves. A disposable bronchoscope can be considered if available. Nebulization of local anesthetic agents, jet ventilation and high-frequency nasal cannulae should be avoided for their potential to generate aerosols. While procedural sedation is the anesthesia technique for routine bronchoscopy, it should be used cautiously in the COVID-19 pandemic. Bronchoscopy under procedural sedation requires high flow oxygen supplementation, and increased oxygen flow rates increase aerosolization<sup>4,5</sup>. Coughing during bronchoscopy under sedation is also undesirable in this COVID-19 era. Emergent conversion of sedation to GA is also an unsafe intervention. So, procedural sedation should be reserved for proven COVID-19 negative cases and in the region where community transmission is low.

General anesthesia with an endotracheal tube should be the anesthesia technique for bronchoscopy in suspected or diagnosed COVID-19 patients and should be preferred at places where community transmission is high. Use of larger internal diameter cuffed endotracheal tube to allow room for the passage of the bronchoscope is advisable. Other practice changes during anesthesia for bronchoscopy during COVID-19 pandemic include modified rapid sequence induction, video laryngoscope, deep plane anesthesia with complete muscle relaxation irrespective of airway device used, avoidance of deep extubation as the patient requires high oxygen flow, and to avoid chances of reintubation. Avoid using supraglottic airway device (SGA) for GA unless it is for rescuing a difficult airway as it increases aerosolization due to a leak around the cuff. Avoid awake intubation as possible; if awake intubation is needed, topical anesthesia should be provided with lignocaine lollipop or nerve block. Atomization or nebulization of local anesthetic agents should be avoided, and balanced sedation should be used, preferably with TIVA. In anesthesia for a rigid bronchoscope, use ventilating bronchoscope and pack sides of the bronchoscope with a throat pack. In general, the threshold for GA use for bronchoscopy may be reduced during the COVID-19 pandemic.

## **II. Interventional Radiology Suite**

### ***Rationale***

In patients with COVID-19 disease, the incidence of cardiovascular disease, hypertension, and ischemic stroke was reported to be 16.4%, 17.1%, and 5%, respectively<sup>16,17</sup>. There is a great challenge to both the anesthesiologist and interventional team when these COVID-19 patients with acute ischemic stroke (AIS) require endovascular therapy (EVT). Besides, patients requiring EVT may be pre-symptomatic or carriers of the novel coronavirus from community exposure. Peri-operative care and anesthesia techniques are required for EVT in these patients, to minimize the transmission of SARS-COV-2. Interventional radiology [IR] suites also witness some procedures with high aerosol generation potential: thoracocentesis, pleural drain placement, gastrostomy, or percutaneous trans-hepatic biliary drainage (PTBD). So, it is essential to formulate a standard protocol for providing NORA services in interventional radiology suites.

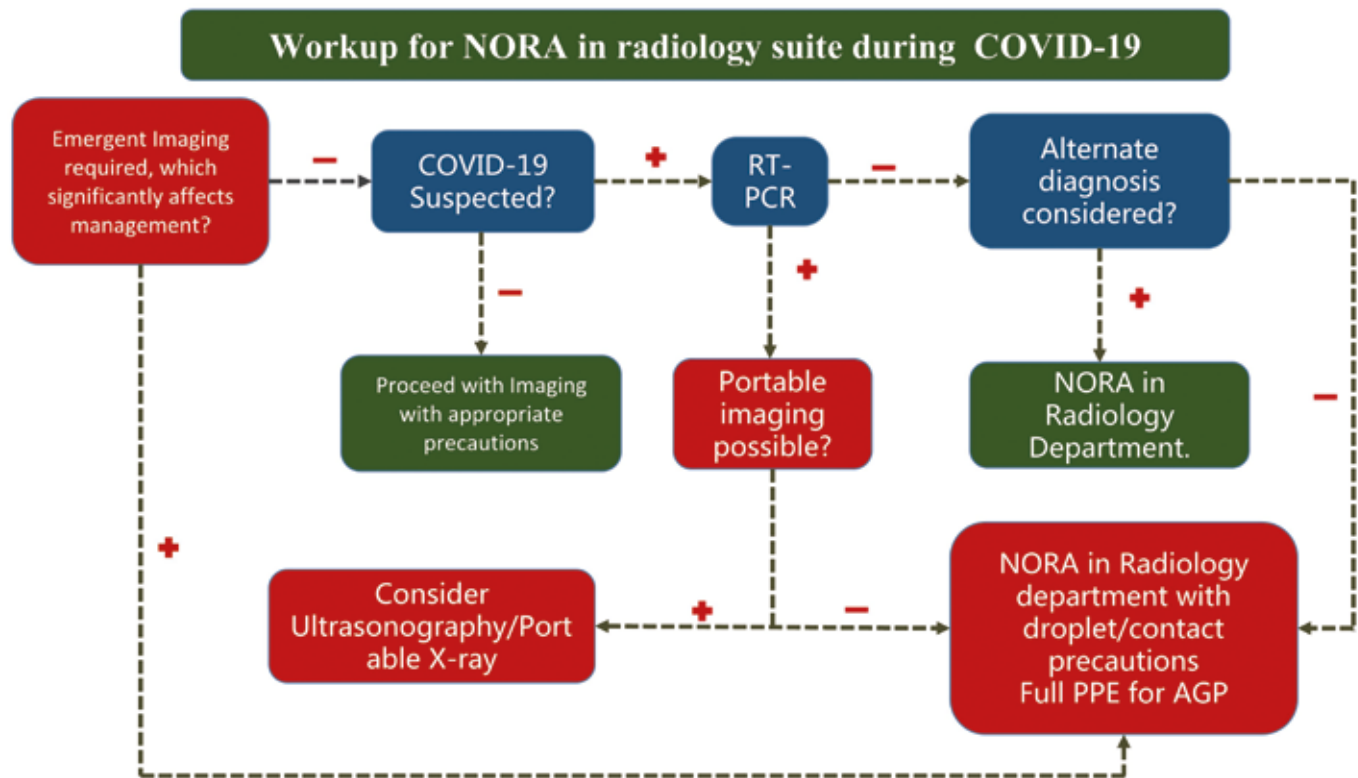
### ***Suggested measures***

All general measures suggested above for NORA during the COVID-19 pandemic should be implemented in IR suites. Elective procedures should either be postponed or taken up after COVID-19 testing (RT-PCR). Diagnosed or suspected patients with COVID-19 should be posted as the last case in the list. Surface cleaning in IR suites requires special attention. Transparent plastic sheets can be used to cover both monitors and machines. A lead apron should be worn prior to “donning” PPE. Intraoperative neurological complications can occur in the neuro-radiological procedure. It is also necessary to optimize cerebral blood flow, control perfusion pressure and maintain intracranial pressure. So, for most of the neuro-radiological interventions, general anesthesia with endotracheal intubation is required. General anesthesia should be given in an isolation room with all the precautions described above for COVID-19 pandemic. The patient should be then shifted to IR suite. Disconnections of ventilator tubing in ED, during transfer, and inside IR suite should be avoided. For specific procedures (e.g., peripheral stenting, PTBD), monitored anesthesia care or procedural sedation are indicated. The decision to continue with MAC or sedation should be based on the patient's condition and aerosolization risk.

## **III. Radio diagnosis:**

### ***Rationale***

Anaesthesiologists have to face multiple challenges of administering anesthesia or sedation in the radiology suite during the COVID era, apart from working in limited spaces involving complex machinery, exposure to ionizing radiation, and limited emergency availability of equipment. Anesthesiologists face additional risk during the COVID-19 era of disease dissemination and infection to HCWs, patients, and the general community while providing anesthesia in the radiology suite. Anaesthesia, sedation, and analgesia in the radiology suite are usually risky, and now it is further complicated with the risk of transmission of SARS-COV-2, both for patients and health care workers. Imaging should be based on emergency and whether the imaging will change patient management<sup>1</sup> (Figure-4). Wherever possible other imaging modalities like ultrasonography,



**Figure 3:** Workup in Radiology suite

which does not require anesthesia or sedation, should be considered. Apart from restricting the use of ferromagnetic devices and other radiology suite limitations, infection control measures need to be standardized.

### **Suggestions**

During the Covid-19 pandemic, general NORA recommendations should be followed in the radiology suite as well. The number of visitors in the radiology area should be limited. Bedside diagnostic modalities for inpatients should be preferred to reduce the need for patient transport. To provide procedural sedation, TIVA should be the preferred method. When necessary, regional anesthesia can be used. In patients prone to desaturation, a low threshold for intubation should be maintained, and all such patients should be intubated before being referred to radiology. Appropriate PPE should be used based on the degree of community transmission and the patient's COVID status. Before donning PPE for MRI procedures, the respirators must be tested outside the MRI control area with a handheld magnet of less than 1,000 Gauss. Also, the patient mask must be tested for MRI compatibility, as a metal strip on masks can cause image artifacts. The Halyard FFP2 respirator and standard disposable Dalhousie surgical mask are the only MRI-compatible respirators and masks; all 3M respirators and PAPRs are not<sup>18</sup>.

## **IV. Endoscopy**

### **Rationale**

HCW involved in endoscopy will inevitably be exposed to either the respiratory or gastro-intestinal fluids from patients, thereby

increasing the risk of contamination as the viral load is high in both of these secretions. Possible transmission routes during endoscopy may be person to person, respiratory droplets, contact with body fluids or surroundings, and aerosols generated during endoscopy. Pan L et al. demonstrated that 48.5% of COVID-19 positive patients presenting with gastro-intestinal symptoms had anorexia (83.3%), diarrhea (29.3%), and vomiting (0.8%), with severity increasing as the disease progressed<sup>19</sup>. Endoscopy procedures are considered AGP as coughing and retching both can occur during endoscopy and can generate aerosols. Contaminated fluids/secretions can splatter while inserting or removing accessories from the endoscope's working channel, adjusting the air/water button, or retrieving tissues for a biopsy bottle. Often patient's saliva can contaminate the pillow or bed, and during the colonoscopy procedure, there is a risk of contamination of the bed with the patient's feces.

### **Suggested measures**

Note that as an AGP, endoscopy of suspected or confirmed COVID-19 patients requires the use of respiratory protection, N95 respirator masks for all HCWs. The powered air-purifying respirator (PAPR) is a desirable alternative that does not require fit testing and can be used by employees with facial hair who would otherwise not achieve a good seal with the N95.

## **V. Cardiac catheterization Lab**

### **Rationale**

Novel Coronavirus disease has placed an enormous strain on the nations' health care systems where it has spread widely, with

specific implications of the disease on practice in the catheterization laboratory. Implications in cardiac catheterization lab procedures include modifications required in practice for standard cardiac patients in those suspected of COVID or positive cases which either have cardiac manifestations as a part of the disease process or have an unrelated cardiac condition. There is a paucity of literature regarding this dynamic situation. Zhou F et al. suggested that patients with established cardiovascular disease are at high risk of mortality associated with infection with COVID-19. Remarkably, among the cohort of 191 reported by them, 54 died, 13 of 15 patients with coronary artery disease had a fatal course (odds ratio, OR: 21.4; 95% confidence interval, CI: 4.6–98.8), and those with co-morbidities including either hypertension or diabetes were three times more likely to die<sup>20</sup>.

### **Suggested measures**

All patients who present with ST-elevated myocardial infarction (STEMI) should be screened clinically and for COVID-19. For patients at low risk of STEMI, systemic fibrinolysis may be considered. Low-risk STEMI conditions include lateral MI with hemodynamic stability and inferior wall STEMI without the right ventricular involvement. For any procedure in the cardiac cath lab, adequate PPE should be worn by all personnel. Whenever feasible and indicated, procedures can be carried under monitored anesthesia care. Early intubation is advisable in patients with respiratory distress and should be considered in ER/ICU/Negative pressure isolation area before moving the patient to the cath lab. If intubation is inevitable in the cardiac cath lab, all precautions described in general measures should be undertaken. All procedures requiring high oxygen flow, including high flow nasal cannula or non-invasive ventilation, should be avoided to decrease aerosolization. If cardiopulmonary resuscitation (CPR) is required, consider using automated CPR devices or don full PPE before CPR.

## **VI. Electro-Convulsive Therapy [ECT]**

### **Rationale**

It is crucial to consider the implications of COVID-19 for ECT. If ECT is stopped, the 6-month relapse rate with continuation pharmacotherapy will mount up to 37%<sup>21</sup>. Relapse rates after discontinuing an ongoing maintenance-ECT (M-ECT) are similar<sup>22-23</sup>. Moreover, a depressive relapse might make older patients more vulnerable to infectious diseases<sup>24</sup>. Very high risk is involved for healthcare professionals during ECT. ECT involves anesthesia and non-invasive bag-mask ventilation, which often do not create a perfect seal. A patient may also need oral and nasal suctioning. So, anesthesia for ECT is an aerosol-generating procedure.

### **Suggested measures**

Aside from general NORA considerations in the COVID-19 pandemic, the following precautions should be taken to ensure safe ECT. ECT providers should keep in communication with their anesthesiologist colleagues. ECTs at the bedside should be avoided. ECTs should only be administered in ECT rooms. Inside the ECT room, all personnel must wear full PPE. Pre-oxygenation for 5 minutes, followed by rapid sequence induction with minimum

bag-mask ventilation, should be considered. During bag-mask ventilation, a two hand technique should be used to achieve a proper seal. One HEPA/HMEF should be placed between mask and circuit or AMBU bag. For patients prone to rapid desaturation, the threshold for GA with intubation should be kept low. If needed, GA should be administered as suggested above. Intubation is a high-risk procedure for aerosol dispersion in COVID-19 patients, so full personal protective equipment (PPE) with airborne precautions, as well as using equipment that minimises dispersion (e.g., video laryngoscopy), should be worn.

### **Conclusion**

An exponential increase in COVID-19 cases is predicted by most of the models leading to increased hospitalizations and deaths over the next few months, depleting hospital resources. Anesthesiologists are at the forefront of this battle. The anesthesia care providers need to amend their practice to safeguard themselves and the hospital staff. NORA has its unique challenges. With the rapid rise in the NORA cases in our day-to-day practice, standard COVID-19 measures should be implemented. Due to the lack of published evidence, the suggestions provided in this article are based on expert opinion. These recommendations can be used as guidance to make NORA practice in the COVID-19 era safe. In the end, we would also like to highlight that COVID should not change our care pathways.

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## **ICU experience of a Nigerian resident intensive care doctor on posting in United Kingdom at the height of First wave of COVID-19 Pandemic**

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### **Abstract**

Months into Covid-19 pandemic, United Kingdom(UK) became one of the epicenters of the disease. A lot of the critically ill patients ended up in Intensive care Units (ICU) around the country. As one of the doctors at the forefront of the pandemic, I would like to share my experience with the disease as an International fellow in the UK during this pandemic with a view to offering some suggestions on what can work in the developing country settings.

**Key words:** NIV, Intubations, CPAP, Nigerian, Resident doctor, Intensivist, Covid-19, ICU, Experience, International fellow, Prone

### **INTRODUCTION**

Covid-19 pandemic as we know was first discovered in China in late 2019, but quickly spread all over the world within months giving rise to a worldwide pandemic that has gone ahead to infect millions and lead to death of hundreds of thousands. A lot of the disease burden is also being felt in the United Kingdom (UK) where I am currently engaged in an international training fellowship mainly in the intensive care. This article is to share my experience as a Nigerian Anaesthetist/ Intensivist Resident doctor in a critical care unit in a developed country.

### **Background**

Intensive care unit is the place for the management of critically ill patients where level 2 and level 3 support is given to patients who meet the criteria for them. I was already on a posting in the Intensive care unit of Lancashire Teaching Hospital NHS Foundation Trust before the pandemic struck in the UK. The ICU's usual patient's disease presentations include neurosurgery cases, trauma cases, and respiratory cases, progressive neurological diseases, obstetrics and post operative cancer patients amongst others. With the onset of Covid-19, the cases drastically changed to reflect mainly Covid-19 patients more especially with the suspension of elective hospital admissions and restrictions placed on movement of UK residents. Being a novel disease, the treatment modality was being sought and it wasn't uncommon to see a recommendation come out only for another one to be issued within days.

### **General Experience**

The experience I have gotten from this international fellowship is highly unquantifiable and will be highlighted under the following headings.

*Funding* - The UK has a national health service where the health system is basically public owned and supported with taxes from the residents. It means that health care delivery at the point of access is free and hence generally open to residents.

*Critical Care set up* - The critical care set up in the hospital just like most units in the hospital are independent with budget and funding ensuring the decisions they make are owned by the unit and hence allowing them to make progressive changes in areas of best service delivery provision to patients, staffing needs of the unit, the medication needed and able to make request for special required equipments as needed.

*Staffing* - This involves Consultants, tens of Trainee doctors, Nurses, Physiotherapist, Pharmacists, Nutritionists, Health care assistants, administrative and domestic staff all working in unison as a team with mutual respect for each other.

*Criteria for admitting patients* - In the unit although the decision to admit a patient may vary from consultant to consultant, generally patients are admitted if critical care support is likely to change a disease process and will be in his/her best interest. The country has done

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well to develop escalation plans and resuscitation criteria protocols while enlightening their populace on what this means.

*Process of management of patients in ICU* - The unit devised protocols for management of patient from drugs administered, to how to escalate management, to antibiotics administration, to appropriate fluids, to sedation drugs and vasoactive agents use amongst others. These have ensured uniformity of care and baseline for measurement of variables and audit of service provided to patients.

### **Covid Experience**

The experience gained from this international fellowship programme will form a significant part of my clinical practice going forward. For the purpose of more understanding, I will split them into subunits as follows:

*Decision to admit in ICU* - Most patients with Covid-19 in the UK are asymptomatic and are mainly advised to self isolate at home and present to hospital if they have worsening symptoms. Even those that make it to the hospital are assessed at the A and E where triage is performed. If the patient has respiratory symptoms like breathlessness or has become hypoxic, the patient is usually admitted into the hospital under the respiratory unit for treatment and monitoring. Sometimes, patients are admitted straight from A and E to the intensive care unit if they are severely hypoxic and require some form of level 2 care (Non Invasive ventilation) or Invasive ventilation if they are appropriate candidates for it.

*Ventilation* - Our understanding of Covid-19 has kept on changing in the course of the pandemic. Initially, it was thought of as an Acute Respiratory Distress Syndrome (ARDS) and high peep was used. However with more understanding, it is now thought of as involving two stages in the disease process. There is a microvascular and an oxygenation one. The microvascular problem is the micro thrombosis thought to be due to an exaggerated body immune response, which can lead to early infarcts. There is also the component of being unable to oxygenate due to lack of exchange surface in the alveoli.

At the later stage, in those with poor compliance, ARDS protocol was to be used. The initial recommendation from early data obtained from Italy was that early intubation was better, but later observation suggested that there was high mortality for those patients that ended up on invasive ventilation. This led to policies to keep patients longer on non invasive ventilation (usually on a CPAP hood) for as long as possible.

*Proning*: Early proning was encouraged on all intubated patients as it helps in redistribution of perfusion leading to improved oxygenation. It was also encouraged for use in intubated patients with up to 70% of  $\text{fiO}_2$  irrespective of the stage of the disease as long as there is still response to it. The concept of self-proning was also used in patients that are on non-invasive ventilation – CPAP (Continuous positive Airway Pressure) hood in ICU. This essentially means encouraging them to lie on their abdomen.

*Specific treatments for the Virus*: As the virus is a novel one, minimal reproducible studies have been performed on medications that work. I am participating in a number of research studies that might offer treatment modalities in the future like Recovery and REMAP CAP

in my center. As of the time of writing this paper, Dexamethasone has been found to be of benefit in reducing death in people requiring oxygen, as one of the outcomes of the Recovery trial.

*Humidification*: Before the onset of Covid-19, Intubated patients were placed on Wet circuits. Initially there were concerns regarding potential spread of infection with the continued use of wet circuits. However, it was decided to continue with wet circuits, in addition to use of HME as individual areas as people in those rooms are supposed to don Personal Protection Equipment (PPEs)

*Sedation*: With Covid-19 patients, it was found that despite being on maximal sedation, most times there were added breaths and patients not fully relaxed, therefore muscle relaxants as infusions were added to the sedation infusion protocols of propofol, midazolam and alfentanil to aid in complete paralysis in a bid to get the patient well relaxed and adequately ventilated to ensure adequate oxygenation.

*Fluid balance*: In the early stage of the disease, the patients are usually found to be dry due to low fluid intake at home. Also being placed in a CPAP hood, may exacerbate dryness of the patient. The recommendation was to keep the patient euvoletic to slightly dry. During the course of the disease, the kidneys might fail for a lot of these patients and usually require dialysis- almost daily. Of note is that removing excess fluid usually with dialysis when patient is in the recovery phase helps in weaning from ventilator.

*Antibiotics*: The use of antibiotics in the management of Covid-19 has evolved with initial continued use for community acquired Pneumonia and more recently to use only if bacterial infection is strongly suspected. The use of trend in Procalcitonin as a guide to antibiotics use was also adopted.

*Nutrition*: Use of NG feeding to ensure adequate calorie intake is maintained as applicable in normal ICU patients.

*Thromboprophylaxis/Anticoagulation*: The issue of giving therapeutic anticoagulation to Covid-19 patients was left to be decided on a case to case basis. The use of Low molecular weight heparin (LMWH), in addition to stockings and mechanical thromboprophylaxis continued to be used for all patients as a routine. If it was decided that a patient will benefit from therapeutic anticoagulation, the dose of LMWH is adjusted as deemed appropriate.

*Lines* - Insertion of Central venous catheter and any other line (for e.g. VASCATH) were done for all intubated patients immediately after intubation to help minimize exposure and enhance adequate resuscitation as required.

*Extubation*: The decision to extubate is usually taken by consultants on duty usually as a consensus. Before extubation, patients are usually placed on a 48hrs of dexamethaxone to help with airway edema present in these patients. A leak test is also done before deciding to remove the tube.

*Re-intubation/tracheotomy*: With failed extubation patients that had to be re-intubated and patients not yet appropriate for extubation, tracheotomies are usually planned for them. In our unit, this is usually percutaneous but can be surgical in cases where percutaneous tracheostomy is not feasible. The weaning process from the ventilator continues after tracheostomy.

## CONCLUSION

I have tried to explain my experience during Covid-19 pandemic with small emphasis on what we did that worked. We can pick up some things from the management of these patients like self proning, outlining protocols for management of conditions and mutual team support as applicable. Although capacity issues in some centers in the developing world may hinder us practicing some of these, the area of self proning, outlining protocols from management of conditions specific to local centres and mutual team support can be adopted.

## Recommendations

1. More provision of facilities by the government especially in the area of funding/ health insurance.
2. Adequate incentives for health care staff and provision of more training opportunities to improve morale.
3. Development of treatment protocols that we can own in our individual centers.

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## Validation of Apple Watch heart rate monitoring for patients under general anaesthesia

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### Abstract

**Background:** The popularity and capabilities of wearable devices are increasing. We evaluated the accuracy of series III Apple Watch heart rate monitoring for patients under general anaesthesia.

**Methods:** Heart rate monitoring was performed on 5 patients (66.80 +/- 11.34 years) undergoing plastic/reconstructive surgery procedures. The Apple Watch heart rate records were compared with the heart provided by lead II electrocardiograph (1214 matched pairs) and differences assessed against the heart rate device accuracy criterion stipulated by the American National Standards Institute.

**Results:** The Apple Watch measurements were in close agreement with the electrocardiograph recordings with concordance correlation coefficient = 0.975). Only 3 of the 1214 Apple Watch records differed from the corresponding electrocardiograph heart rate by more than the American National Standards Institute criterion and the standard deviation of differences was 1.25bpm. The small average difference of 0.60 bpm is not clinically significant.

**Conclusions:** The results validate the series III Apple Watch as a reliable HR monitoring device for patients under general anaesthesia. This is supported by current literature. However, further investigation is required to determine the broader applications of the Apple Watch in anaesthesia.

**Key words:** Fitness Trackers, Photoplethysmography, General Anaesthesia, Heart Rate, Physiologic Monitoring and Telemetry

### To the editor:

Accurate assessment of heart rate (HR) is imperative in anaesthetic monitoring. Both electrocardiography (ECG) and photoplethysmography (PPG) are useful technologies for monitoring HR and rhythm in anaesthesia. Wearable devices like the Apple Watch (AW) use PPG to monitor HR.

Wearable devices have the potential to be used as adjuncts to or replacement for traditional monitoring techniques and may become standard telemetry equipment, allowing long-term monitoring. Wearable devices also have the capacity to be used in resource poor settings.

They can be shipped without great difficulty and some can be provided at low cost. It is also possible for the wearable device to be used as a health system itself. This may be particularly applicable to refugees who experience significant physical displacement.

The accuracy of wearable device HR monitoring has been discussed extensively in the literature<sup>1-6</sup>. The accuracy of the AW HR monitoring system has

not been reported on adult patients under general anaesthesia.

We evaluated the accuracy of HR measurement by a series III AW in patients undergoing general anaesthesia to assess its utility in anaesthesia monitoring. This was done by comparing AW HR values with those of the gold-standard monitoring system, ECG.

### Materials and methods

#### Study design:

Patients wore a series III AW while under general anaesthesia. Lead II ECG was used as the HR control. Recordings at 5 second intervals, on average, were taken for about 25 minutes per patient. The data were examined to assess differences between the AW and lead II ECG recordings against the American National Standards Institute (ANSI) specified error criterion for cardiac monitors and HR meters, which holds that readout errors should be no greater than 5bpm or 10% of the HR, whichever is greater.

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### Test subjects:

The five participants were patients undergoing elective surgical procedures requiring general anaesthesia. The study was explained verbally and in written format, and informed consent was obtained.

### Data collection:

The AW was set to “workout” mode which prompts more frequent HR measurements (12 per minute). The AW measured HR 12 times per minute but not strictly every 5 seconds.

Recording intervals varied from 1 to 9 seconds with 80% being 4, 5 or 6 seconds. Each ECG HR record was matched with the nearest AW data point, provided the time difference was no more than 2 seconds. There were approximately 250 matched readings for each patient with a combined total of 1214 pairs.

### Statistical analysis:

Any difference between the AW reading and the accompanying ECG reading was assumed to reflect AW error:

$$\text{Error} = \text{AW reading} - \text{ECG reading}$$

The ECG and AW traces, error scatterplots and AW vs. ECG scatter were examined to develop a qualitative understanding of the data. A matched pairs t-test was used to investigate any mean error (offset) in AW readings.

## RESULTS

Five participants were enrolled. The mean (SD) age was 66.80 (11.34) years with a range of 47 to 75.

The ECG and AW traces for patients 2 and 4 are depicted in Figures 1 and 2 to give a visual comparison of heart rate readings. Figure 3 displays the errors (AW – ECG HR) and the ANSI error bounds plotted against ECG HR. For most data pairs the AW reading was within 4 bpm of the ECG readings. Only 3 in a total of 1214 pairs had a difference outside the ANSI criterion.

ECG readings of HR varied from 45bpm to 72bpm. The mean difference between AW and ECG readings was 0.60bpm (95% CI: 0.53 to 0.67bpm) which is statistically significant (matched pairs t-test,  $p=0.000$ ) but not clinically significant. The standard deviation in errors for the combined data for all five patients was 1.25 bpm. The smallest standard deviation was 0.68 for Patient 3 and the largest was 1.95 for patient 4.

## DISCUSSION

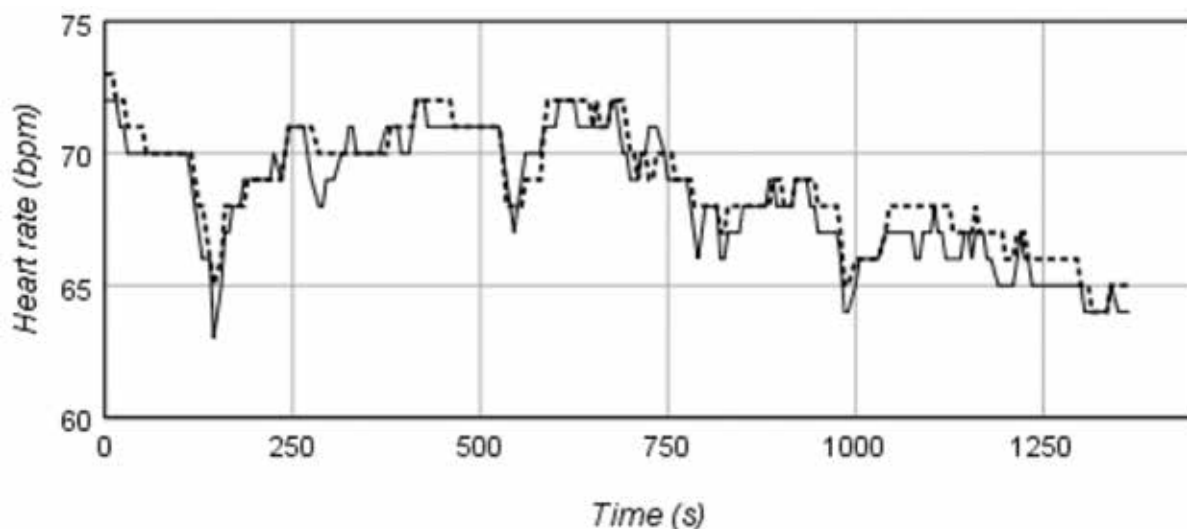
The main finding is that the series III AW is sufficiently accurate in determining HR in patients under general anaesthesia to be viable as an adjunct to current monitoring systems. A total of 3 in 1214 (0.25%) of AW readings had error magnitude outside the ANSI criterion. The conclusion that the AW measures HR accurately agrees with previous studies conducted regarding the accuracy of wrist-worn fitness trackers.

There were several cases where the AW did not match the ECG result and was likely ECG artefact rather than AW error. ECG is subject to artefacts due to motion, improper lead connection, electrode distortion and diathermy use.

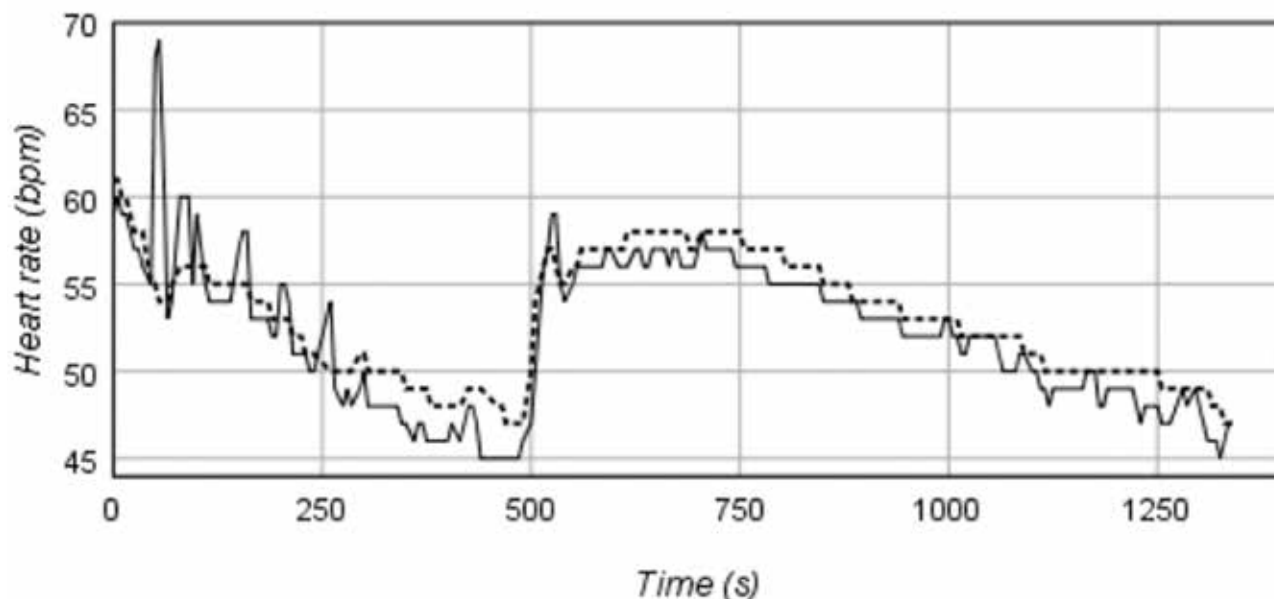
The evidence that the AW records HR accurately compared to ECG is important for a range of groups. It is important for both consumers and clinicians to understand wearable device accuracy. Additionally, it suggests that the AW can reliably monitor HR in anaesthetized patients. This may also be applicable to constant inpatient monitoring to detect clinical deterioration. A device which is comfortable, wearable, accessible and accurate may improve patient monitoring.

This study has several limitations. The number of patients was small (intended as a pilot study) and only a single AW was used. HRs were in a relatively narrow range from 45 to 73bpm. Lastly, all patients were in sinus rhythm and results cannot be extrapolated to patients not in sinus rhythm.

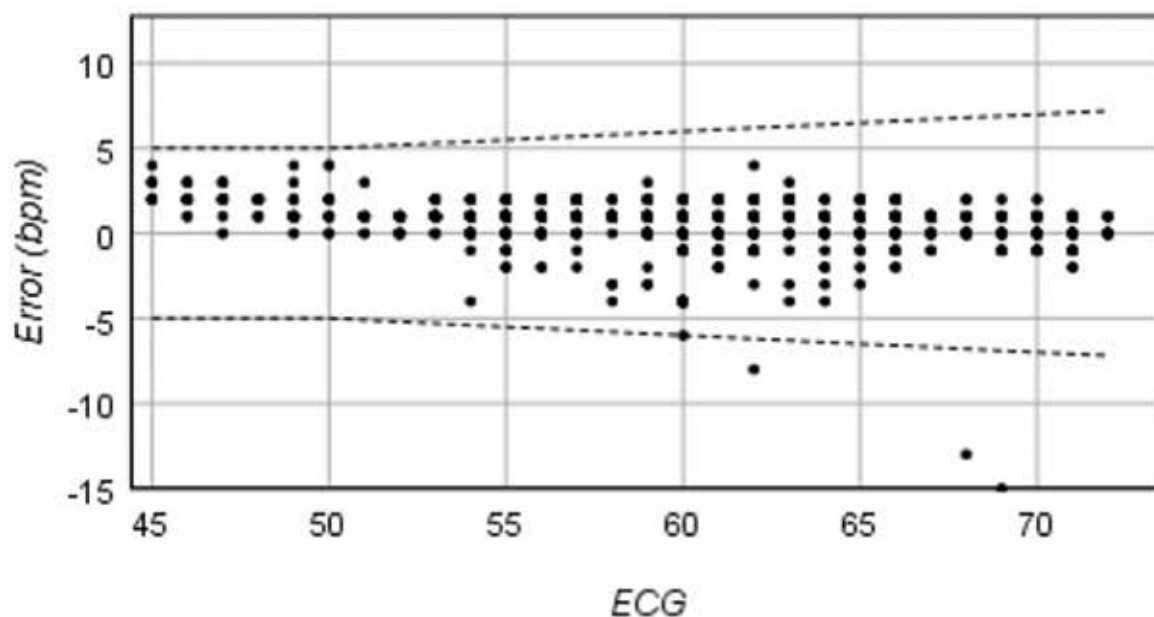
**Figure 1:** ECG (filled line) and Apple Watch (dashed line) traces for patient 2



**Figure 2:** ECG (filled line) and Apple Watch (dashed line) traces for patient 4



**Figure 3:** AW errors plotted against ECG HR and ANSI error bounds (---)



## CONCLUSION

This study assessed HR measurement in five patients undergoing elective surgery using a series III AW compared with ECG readings. The AW error was found to be within the bounds specified by the American National Standards Institute for almost all readings (1211 of 1214 or 99.8%) and the concordance correlation, 0.975, is very close to unity. The AW may be a useful monitoring tool for HR in patients undergoing general anaesthesia.

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## Atrial Myxoma Complicating The Course Of ARDS: A Case Report

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### Abstract

We report a case of a 42 year-old with community acquired pneumonia and hypoxic respiratory failure. Thus, intubated and shifted to intensive care unit (ICU) for ventilator support on (acute respiratory distress syndrome) ARDS protocol. Then, all of sudden his condition deteriorated. Thus, bed side echocardiography was done by the intensivist, which showed a big myxoma causing obstruction to the mitral flow with good systolic function. That can explain the reason for pulmonary edema and the deterioration which happened. He was extubated successfully and then transferred to Mater hospital for surgical removal of the tumour. He was discharged home few days later.

**Key words:** acute respiratory distress syndrome, atrial myxoma, pulmonary edema

### INTRODUCTION

Myxomas are the most common primary cardiac neoplasm. The prevalence of cardiac tumors at autopsy ranges from 0.001% to 0.3%, and more than 50% of benign cardiac tumors are myxomas. In 7%, it has genetic origin and arises as a component of a heritable disorder with some clinical manifestations. Over 72% of primary cardiac tumors are benign. In adults, the majority of benign lesions are myxomas<sup>1,2</sup>.

Its clinical manifestations are variable and non specific. Commonly observed symptoms and signs are dyspnea, orthopnea, paroxysmal nocturnal dyspnea, pulmonary edema, cough, hemoptysis, edema, and fatigue<sup>6</sup>.

### Case report:

We report a case of 42- year old male patient with a history of gout, hypercholesterolemia and ex-smoker. He was admitted to the hospital ward with cough, fever, vomiting and rigors. He was hypoxic on presentation with Spo<sub>2</sub> 80% on room air which improved on oxygen mask 5L/m to 94%. Initial diagnosis was community acquired pneumonia.

2 days later, he became more hypoxic with respiratory distress and worsening bilateral infiltrates on the CXR (Figure 1A and B). His laboratory findings showed leukopenia (WBC 2.6), Hb 14.9, neutrophils 3.5, lymphocytes 0.66, platelets 188, CRP 103, urea 7.7, creatinine 88, sodium 138, influenza A +ve, ECG was normal, sinus tachycardia, thus he was treated with ceftriaxone, clarithromycin and oseltamivir.

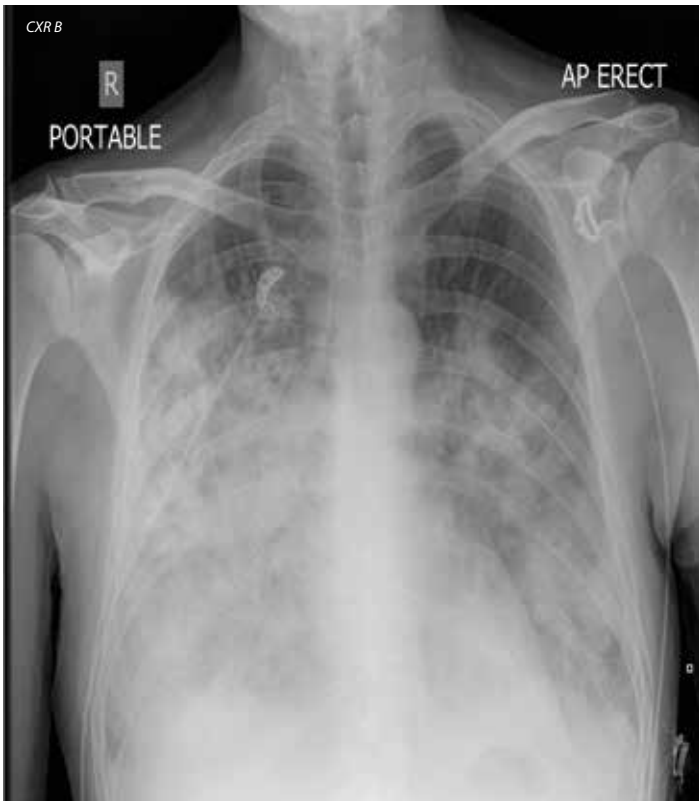
ICU on call was consulted at that stage for worsening respiratory distress( respiratory rate 40/minute, heart rate 125 beat/minute, desaturating on 5 liters/minute oxygen), temperature 38.6 C°. He was therefore intubated and moved to the ICU for ventilatory support and further management. ABG: PH 7.36, PaO<sub>2</sub> 7.8, PaCO<sub>2</sub> 4.8, lactate 0.8, (Figure 2a)

He was treated as severe ARDS P/F was 58 on fio<sub>2</sub> 1.0 and PEEP 14, lung protective strategy was applied, sedation and paralysis for 24 hours. He was hemodynamically stable throughout.



**Figure 1A:** Showing the CXR on admission and 2 days later, with worsening bilateral lung infiltrates

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**Figure 1B:** Showing the CXR on admission and 2 days later, with worsening bilateral lung infiltrates

All septic screening, bronchoalveolar lavage, respiratory panel were -ve except for influenza A positive.

Four days later the ventilatory parameters started to improve,  $\text{fio}_2$  45%, PEEP 10  $\text{cmH}_2\text{O}$  on pressure support ventilation, therefore, weaning from the ventilator was planned.



**Figure 2B:** CXR on the day of planned extubation

In spite of keeping him on negative fluid balance, all of sudden, two days later, his oxygen requirements increased again to  $\text{fio}_2$  90%, PEEP 12 and P/F ratio 90 with radiological deterioration (worsening bilateral infiltrates) (Figure 3).

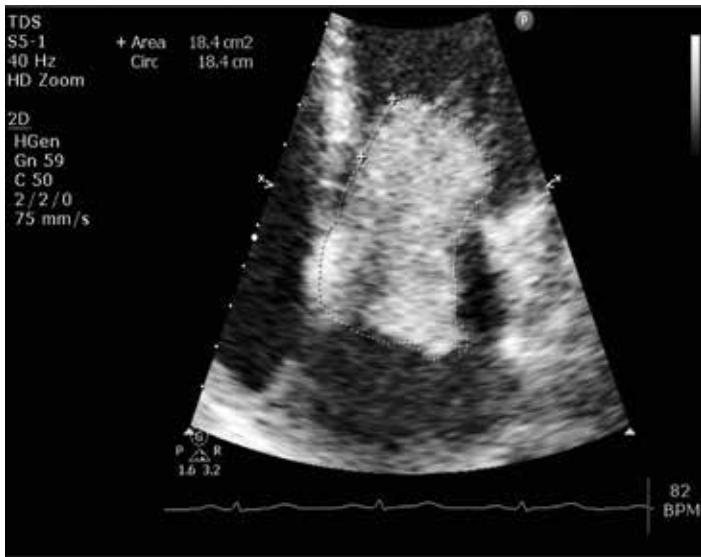


**Figure 3:** CXR shows worsening bilateral lung infiltrates

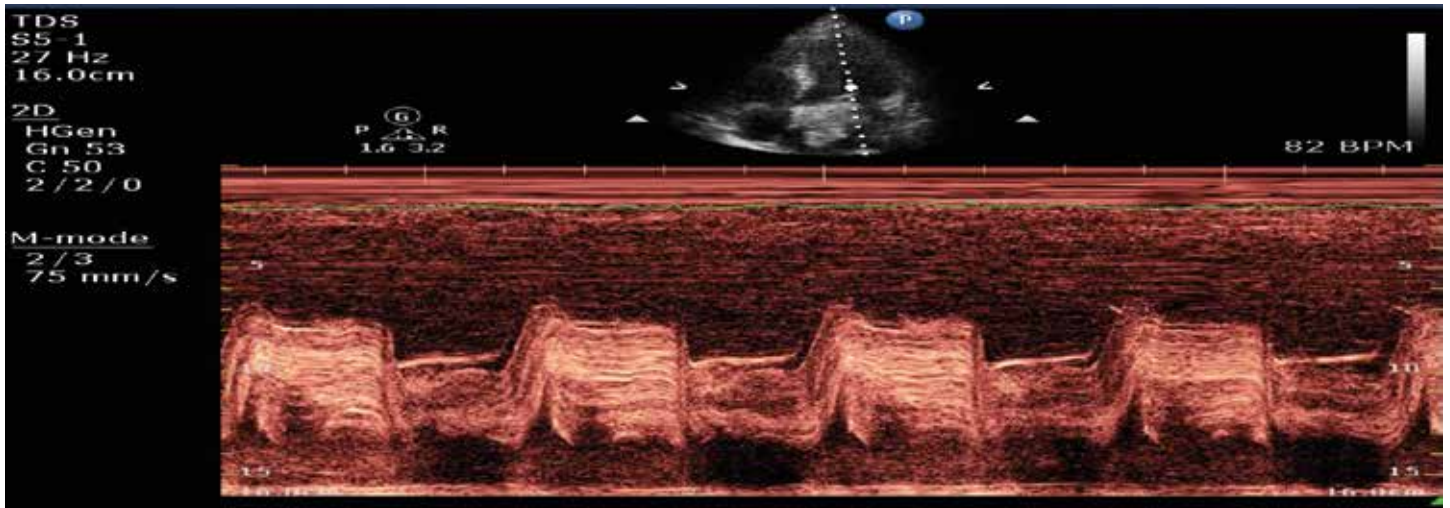
Thus, bed side transthoracic echocardiography was performed by the intensivist, which showed a big myxoma (6x4 cm) which is attached to inter-atrial septum and protruding through the mitral valve leaflets to the left ventricle causing obstruction to the mitral flow with good systolic function. That can explain the reason for pulmonary edema and the deterioration which happened (Figures 4 a & b).



**Figure 2A:** CXR post-intubation



**Figure 4A:** transthoracic echocardiography shows left atrial myxoma protruding through the mitral valve



**Figure 4B:** transthoracic echocardiography shows left atrial myxoma

Cardiologist was contacted to confirm the findings and she did the TTE which confirmed our findings. Microbiologist escalated the antibiotics coverage and amphotericin B was added to cover the possibility of fungal endocarditis, however all were de-escalated when all cultures came back negative. CT thorax was done and showed bilateral consolidations, effusion and cardiac filling defects (Figure 5). Transesophageal echocardiography was done and confirmed the findings.

Five days later a weaning trial was done on pressure support ventilation, Fio2 30% and PEEP 5, ABG: PH 7.47, PaCO2 6, PaO2 11.6, SPO<sub>2</sub> 98%, while keeping him on negative fluid balance over the previous days and he was extubated successfully and kept on HFNC 25% with good gas exchange (Figure 6). Mater hospital was contacted and the patient was transferred for urgent cardiac surgery.

The surgery was performed 2 days after transfer and the patient was discharged home few days after that.



**Figure 5:** CT thorax





**Figure 6:** CXR post extubation

## DISCUSSION

The ARDS is a well known complication of pneumonia and its management is well established. Cardiac myxomas can present with symptoms secondary to obstruction of blood flow, nonspecific constitutional symptoms such as fever, malaise, arthralgias, rash, or thromboembolic phenomena such as stroke or transient ischemic attack<sup>3,4</sup>. Sudden cardiac death has been reported in the literature, the incidence being only 0.01%–0.005%. Syncope is reported as the most common symptoms in patients with sudden cardiac death, and the cause is obstruction of blood flow either due to ball valve mechanism or due to embolization of tumor to the coronary circulation<sup>5</sup>.

In our scenario, when the patient improved and he was ready for extubation, he developed an acute deterioration that mandates finding out the reason. Bedside Echocardiography is widely available and provides a simple, noninvasive technique for rapid evaluation of the cardiac function in addition to detection of any underlying pathology which might contribute to the patient's sudden deterioration. Transthoracic echocardiography is sufficient to confirm the diagnosis of atrial myxoma<sup>6</sup>. Obstructing left atrial myxoma is reported in many cases as a cause of cardiogenic pulmonary edema<sup>7-10</sup>. Moreover, Echocardiography helps in distinguishing cardiac myxomas from atrial thrombus. A thrombus usually arises from the posterior wall of the atrium and is generally immobile and does not have the characteristic stalk<sup>4</sup>.

In our patient, the cardiac mass was pedunculated with a stalk arising from the interatrial septum which is the common site of origin of an atrial myxoma. Its definitive treatment is surgical excision.

## CONCLUSION

Cardiac masses are rare and they could present with obstructive shock or pulmonary edema which might complicate the course of a disease like ARDS. They need to be diagnosed at the earliest, so as to initiate timely interventions. Echocardiography remains the only modality which makes a point of care diagnosis in cases of cardiac masses and makes an invaluable tool in the armament of an intensivist. This case, however highlights the importance to equip intensivists with point of care ultrasound skills to help in the diagnosis of such cases with confidence

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## Anaesthetic Management of a Patient with Suspected Tracheal Amyloidosis

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### PATHOPHYSIOLOGY

Amyloidosis is a protein misfolding disease - the failure of proteins to adopt functional conformational states. It is caused by the conversion of soluble and functional peptides or proteins into organized fibrillar aggregates with a cross-beta super-secondary structure known as "amyloid".<sup>1</sup> This process might involve the intracellular protein quality control system, extracellular chaperones and matrix components, proteases, and other cofactors.<sup>2</sup> There are up to 30 different types of amyloidosis, each due to a specific protein misfolding.<sup>3</sup> Amyloidosis can be localized or systemic. Systemic amyloidosis affects more than one body organ or system whereas localized amyloidosis affects only one body organ or tissue type. The lung presentation of amyloidosis can be classified into tracheobronchial, nodular and alveolar septal amyloidosis.<sup>4</sup> Tracheobronchial amyloidosis (TBA) is a rare condition with only a few hundred cases reported in the world.<sup>5,6</sup> Male to female ratio suffering the disease is around 2:1, with middle-aged males being the most diagnosed group.<sup>7</sup> The mean age at presentation is 50 - 60 years.<sup>8</sup>

### CLINICAL FINDINGS

Patients with TBA may present with respiratory symptoms including cough with sputum, hemoptysis, hoarseness of voice, progressive dyspnea, stridor and dysphagia.<sup>8</sup>

It presents with non-specific signs such as reduced air entry, bilateral basal crackles or wheeze.

### DIAGNOSIS

TBA is diagnosed with bronchoscopy and transbronchial biopsy. Bronchoscopy may detect uneven inner luminal wall, mucosal hyperaemia and edema, localized or diffuse luminal stenosis, easy bleeding mucosa and nodules within tracheobronchial lumen etc.<sup>8</sup>

The definite diagnosis is made by Congo red staining of the biopsy specimen. Histological finding of

"apple-green" birefringence with Congo red staining on polarized microscopy confirms the diagnosis.

### RADIOLOGICAL FINDINGS

Computed Tomography (CT) may show mucosal thickening +/- calcification involving segments of the trachea + bronchi and narrowing of the affected airway. The posterior membrane of trachea is classically involved.<sup>9</sup>

Chest X-ray may show nodular and irregular narrowing of the tracheal lumen. Lung collapses may be seen secondary to obstruction caused by amyloid deposition. However, up to 25% of cases can have normal findings in plain films.<sup>9</sup>

### CASE REPORT

A 90-year-old lady was admitted for right mastectomy + sentinel lymph node biopsy +/- axillary dissection. She had a body weight of 75kg and a height of 173cm (i.e., BMI of 27.5) Preoperative anaesthetic assessment was unremarkable with no obvious difficult airway. The patient was edentulous. Patient had two general anaesthesia done with no history of difficult airway. Blood tests showed normal results.

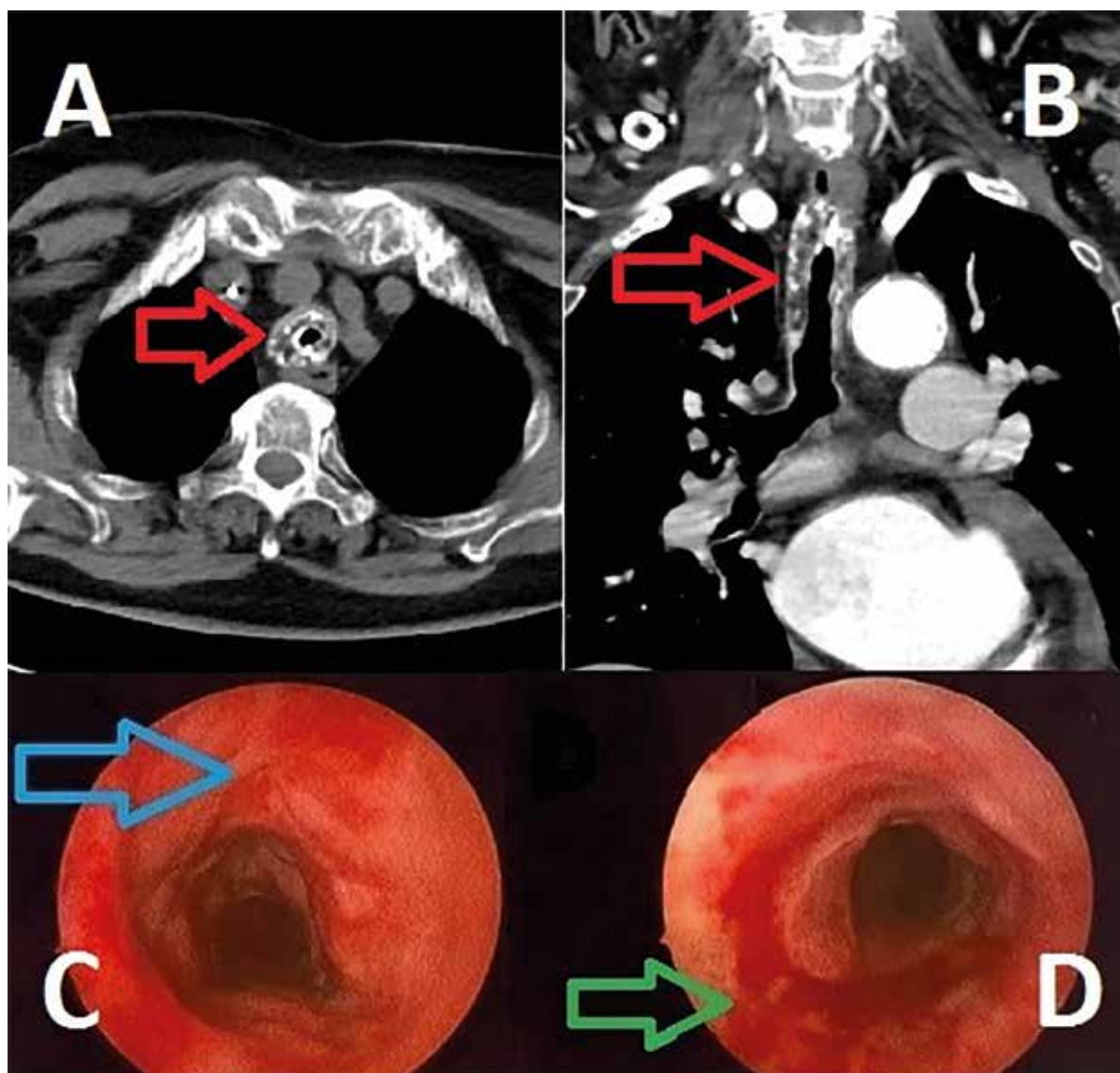
During intubation, despite videolaryngoscope showing VL grade1, resistance was felt when a 7.0mm tracheal tube (TT) was inserted. It could not pass beyond 18cm at lip. The TT was immediately withdrawn and switched to gum elastic bougie. Bougie insertion through the vocal cord was successful with some resistance. We attempted to intubate with a 6.5mm TT but were only able to insert at 20cm at lip. Auscultation of the chest reviewed reduced air entry over the left chest. A 4cm blood clot was evacuated from the TT and air entry over the left chest improved afterwards. Bronchoscopy assessment showed blood pooling at floor and left main bronchus and irregular tracheal rings. Operation was abandoned and the patient was sent to Intensive care unit (ICU).

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**Figure 1:** CT and endoscopic images

CT neck + thorax with contrast were done and the report was written: “Mucosal thickening and circumferential calcifications mainly involving the intrathoracic trachea. Query related to tracheal amyloidosis.” (Figure A, B)

Looking at the CT retrospectively, the distance between patient’s lip and the vocal cord is around 14cm. As the length from the tip of TT to proximal cuff end of tube is around 6cm, the ETT should be inserted to at least 20cm at lip to pass beyond the vocal cords and allow ventilation.

Ear, Nose and Throat Surgery (ENT) colleagues were consulted, and they decided for direct laryngoscopy/ microlaryngoscopy + trial of extubation in the same session as breast surgery. We maintained the anaesthesia with Target controlled infusion propofol and remifentanyl and monitored the depth of anaesthesia with BIS. Intraoperative assessment found ~25% circumferential narrowing ~5cm below true cord. It also revealed irregular tracheal luminal wall, mucosal hyperaemia and edema, and blood pooling on mucosal surface

(Figure C, D). ENT team, decided for a trial of extubation and not for biopsy in view of bleeding risk. Prior to extubation, BIS level was larger than 90; the patient was spontaneously breathing with spontaneous eye opening; the respiration was regular with adequate tidal volume. Extubation was successful. The patient was sent back to ICU.

Unfortunately, the patient developed desaturation shortly after extubation. She was re-intubated with a 6.5mm TT fixed at 22cm at lip with aid of videolaryngoscope and gum elastic bougie. The patient developed right sided pneumothorax afterwards and a chest drain was inserted.

With reduction of oxygen requirement and re-expansion of lung in CXR, the patient was sent for another trial of extubation. Trial of extubation was unsuccessful due to poor respiratory effort and persistent drowsiness despite injection of Naloxone and Flumazenil. After a multidisciplinary discussion, we decided for one more trial of extubation and proceed to tracheostomy if failed in view of repeated

failure of extubation and ventilator related complications. Before extubation, the patient was alert and obeyed command; Bispectral index (BIS) was >90; respiration was regular with adequate tidal volume. She was successfully extubated. SpO<sub>2</sub> maintained at 99% on room air. Arterial blood gas after extubation reviewed normal results with no acidosis. Patient was discharged from hospital after 3 weeks.

## DISCUSSION

### *Options of management for suspected cases of TBA*

The non-specific clinical manifestations and investigation results of TBA raise diagnostic challenges in elective operation settings. A discussion with surgeons, patient and family members should be conducted to consider possible options of management when there is clinical suspicion of undiagnosed TBA. A preoperative formal bronchoscopy assessment and/ or a preoperative CT neck and thorax with contrast can be offered. This may delay the surgery with potential harm to the patient. Alternatively, one may proceed to operation with anticipated difficult intubation, while a formal bronchoscopy assessment and CT scan can be arranged after operation. Pros and cons of each option should be clearly explained to patient.

### *Airway management when TBA is suspected*

A fiberoptic bronchoscopy assessment can be done before intubation. Bronchoscopy assessment of the airway before intubation gives important information on the airway e.g., the extent of luminal stenosis, presence of an active bleeding site, nodule(s), or mass within tracheobronchial lumen etc. Subsequent steps of management will depend on the bronchoscopy findings. If intubation is considered possible, awake fiberoptic intubation can be performed. An appropriate tracheal tube size can be chosen based on bronchoscopy findings which facilitates a smoother intubation. If the luminal stenosis is so severe that intubation is not possible, or an active bleeding site/ obstructing mass is found during assessment; anaesthetists should abort intubation. Other possible methods for airway management include the use of facemask or supraglottic airway for ventilation. The choice of method would depend on both surgical and anaesthetic factors. A discussion with surgeons and patient is required for further plan of management.

### *Airway management for unexpected / undiagnosed TBA*

The possible diagnosis of TBA can be missed despite high levels of suspicion. Unanticipated difficult airways may occur due to the poor predictive value of airway tests or failure of adequate assessment.<sup>5</sup> Difficult Airway Society (DAS) guideline provides a reference for anaesthetists of plans to be implemented when unanticipated difficult intubation is encountered.<sup>6</sup> Unfortunately, the case mentioned above demonstrates that the guideline is not exhaustive when it comes to the unusual presentations of TBA during intubation. There are several points to be considered when there is difficulty in advancing tracheal tube during intubation.

Firstly, the length of the tracheal tube within trachea. Clinical findings under laryngoscopy provide important information. If the proximal end of tube cuff is seen below the vocal cord, the trachea tube is considered adequately deep within the trachea to maintain airway. It is not advisable to advance the tube further even if resistance is felt.

This can prevent traumatic injury from forceful insertion of tracheal tube.

Alternatively, patient's height could be used as a reference to give an indication of the distance from the tip of the tube to the level of teeth. The relationship between a person's height and appropriate tracheal tube length has been studied in adult subject and formulae have been derived which predict appropriate lengths for tracheal tubes<sup>10</sup>:

$$\text{Distance from teeth to mid-point of trachea} = \text{Height(cm)}/10+2$$

It is important to note that this calculation only acts as a reference. The calculated value may not be accurate if the patient is edentulous. Average length of adult trachea can also be used as a reference. The mean tracheal length was found to be 107.8 ± 13.2mm in males and 101.4 ± 12.8mm in female in a recent study.<sup>11</sup>

Alternative airway management other than intubation should be considered if there is likelihood of bleeding when tracheal tube is to be further advanced. Supraglottic airway or bag-mask ventilation are possible alternatives if not contraindicated. Patient, surgical and anaesthetic factors should be carefully considered. A thorough discussion with surgeons is crucial for decision-making.

### *Post-operative management - trial of extubation*

A spontaneous breathing trial (SBT) should only be performed when there is improvement of the underlying pathology, satisfactory PaO<sub>2</sub>, adequate cough reflex and minimal requirement for PEEP.<sup>7</sup> Assessment of airway should be done before extubation. A bronchoscopy assessment with ENT colleagues is advised. The expertise and experience of ENT colleagues on the bronchoscopy assessment can reassure that the patient's airway is fit for extubation. The presence of ENT surgeons also allows for emergency tracheostomy while necessary. Depth of anaesthesia should be monitored with BIS, which should be larger than 90 before extubation. The patient should be alert and obey commands. The reversal of neuromuscular blockade (if any) should be monitored with Train-of-four using a peripheral nerve stimulator. A 100% ratio of the fourth twitch to first twitch should be achieved. The breathing effort should be regular with an adequate tidal volume. If all the conditions mentioned are satisfactory, the patient should be extubated carefully. It is advised to transfer the patient to ICU for close monitoring.

### *Decision for Tracheostomy*

The extubation outcome depends on age, amount of endotracheal secretion, respiratory effort; level of consciousness etc.<sup>7</sup> Extubation failure is defined as the need for reintubation or emergency support with non-invasive positive airway pressure within 48 to 72 hours after planned extubation.<sup>12</sup> Prolonged intubation increases the duration of invasive ventilation which increases incidence of ventilator related pneumonia and other complications e.g., pneumothorax. Although there is no protocol for the decision of performing tracheostomy, patients fail to satisfy the SBT criteria after 2 weeks of invasive mechanical ventilation or patients who are not expected to satisfy the criteria within 2 weeks are considered candidates for tracheostomy.<sup>7</sup>

## CONCLUSION

Tracheobronchial amyloidosis (TBA) is a rare condition. Its non-specific clinical manifestations and investigation results raise diagnostic challenges in elective operation settings. TBA should be considered in patients who present with cough with sputum, hemoptysis, hoarseness of voice, progressive dyspnea, stridor and dysphagia. Options of management include formal pre-operative bronchoscopy and/ or CT assessment or proceed to surgery with anticipated difficult intubation. A clear communication between patient, family members, colleagues from different specialties and all operating theatre members is crucial for a successful outcome. The unusual presentations of TBA may pose challenges to anaesthetists during intubation. Subsequent plan of management will depend on the situation encountered.

### List of Abbreviations

- **TBA:** Tracheobronchial amyloidosis
- **ENT:** Ear, Nose and Throat
- **CT:** Computed Tomography
- **AL:** Amyloidosis
- **TT:** Tracheal tube
- **ICU:** Intensive care unit
- **FOB:** Fiberoptic bronchoscopy intubation
- **SBT:** Spontaneous breathing trial
- **PaO<sub>2</sub>:** Partial pressure of oxygen
- **PEEP:** Positive end expiratory pressure

**Table 1:** List of abbreviations

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1. Roberts F. Chapter 22: Ear, nose and throat surgery. In: Allman KG, Wilson IH, eds. *Oxford handbook of Anaesthesia* (1st edition) Oxford: Oxford University Press, 2001: 506-39.

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