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Update in Anaesthesia

Education for anaesthetists worldwide

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Editor's notes

Dear readers – welcome to the latest edition of *Update in Anaesthesia*. This edition brings a wide variety of anaesthesia and critical care articles, of particular use to clinicians working in the operating room and high-care areas. We are very grateful to Baxter for providing financial support for the production of this edition. As editor I am also grateful to the editorial teams of the *BJA Education* and *Anaesthesia News* for allowing us to reproduce some of their articles, in order to bring them to our worldwide readership.

I have been working with the editor-in-chief of *Anaesthesia Tutorial of the Week*, Nick Boyd, to plan the future development of both of the WFSA's main educational publications. Historically, *Update* and *ATOTW* have had a great deal of overlap in our goal to bring on-going professional development to cadres of anaesthetists working where resources are stretched and availability of educational material is unreliable or absent. Many hundreds of anaesthetists now benefit by receiving the latest *ATOTW* by email, but we have maintained the production and distribution of *Update* in printed format in recognition that there are still significant areas of the world where internet access is unavailable or unreliable. We still feel that there is a role for a printed edition, but we should continue to be aware of the gradual move towards electronic formatting and recognise when the extra cost of printing and (in particular) postal distribution renders it redundant. We also know that for larger special editions of *Update* many would prefer a physical printed copy to allow easy reference and study for examinations.

However, there is there is scope to streamline production of these two great publications, to avoid duplication of efforts for the two production teams and, in doing so, to reduce the workload. Our proposal is to create a core editorial team that will service both publications. Members of the editorial team will liaise with authors in commissioning and providing editorial support for production of tutorials. We will try to have a more structured and tailored plan for topics to be covered. This will largely be driven by plans for certain special editions of *Update in Anaesthesia*; for example focusing on safety in anaesthesia or obstetric anaesthesia. We plan to create a pool of 'ready' tutorials, which then can then be published regularly as electronic tutorials and also drawn together in annual themed editions of *Update in Anaesthesia*. There will still be editors-in-chief of both *Update* and *ATOTW*.

Nick Boyd will present these plans to the Education Committee of the WFSA in Hong Kong in September 2016. The members of the editorial team will be appointed on a proven track record of commitment to these publications and will be for a fixed term of 4 years.

It is our vision that this plan will allow us to continue to produce high-quality material for you to read and learn from, and to improve the reliability and timeliness with which both tutorials and *Update* editions are produced. I'm sure it has not escaped your notice that *Update* editions are never published on schedule. This reflects the voluntary nature of our contributions to this work and also the fact that, in an ever-changing UK NHS, work of this nature is no longer recognised as part of our regular jobs.

Having been editor-in-chief for 10 years, the WFSA will be looking for my successor in the next year. I have been very proud to be involved in this work and to continue to contribute and support my colleagues working in challenging environments, not least those who inspired me in this project, whom I worked with for a year in Queen Elizabeth Central Hospital in Blantyre, Malawi, in 2004.

I hope to continue as an editor for the journal and support anaesthetists from around the world in producing high-quality, appropriate professional development articles for their colleagues. In the meantime, my thanks go to Iain Wilson for establishing and building *Update* in the early 1990s, to Angie Jones for her sterling work as typesetter for every edition since edition 1, and to Dave Wilkinson for his excellent illustrations.

Bruce McCormick
Editor-in-chief

The WFSA would like to thank Baxter for their financial support of this edition of *Update in Anaesthesia*

Baxter

Update in
Anaesthesia

The emergency laparotomy – principles and perioperative management

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Summary
The emergency laparotomy is a common procedure with high rates of morbidity and mortality. Recent national audits have shown wide variation in practice and outcomes. Outcomes are improved by implementation of clinical care pathways, emphasising early decision-making by experienced surgeons, early antibiotic administration, early operation involving a senior surgeon and anaesthetist, and appropriate postoperative care in a critical care facility.

INTRODUCTION

'Emergency laparotomy' has become a generic term encompassing several hundred specific non-elective abdominal surgical procedures.[1] So 'emergency laparotomy' patients are a heterogeneous group ranging from truly emergent cases, such as patients with life-threatening haemorrhage, to urgent cases with intra-abdominal sepsis and peritonitis and on to what we might term 'expedited' cases, such as those with adhesional bowel obstruction, who need a non-elective procedure if a trial of non-operative management is unsuccessful. In this article, the term 'emergency laparotomy' is used generically to describe the whole non-elective laparotomy population.

THE EMERGENCY LAPAROTOMY POPULATION

The first report of the UK's National Emergency Laparotomy Audit (NELA) demonstrated the heterogeneity of the population undergoing 'emergency laparotomy' (Table 1). Half of patients present with intestinal obstruction, which is due to adhesions in 57%, with the majority of the remainder (39%) due to malignancy; 11% of patients require surgery for complications of a recent elective abdominal procedure.[2]

The NELA report also demonstrated that emergency laparotomy patients form a diverse group in terms of age (Figure 1) and comorbid state. In the UK, 46% are over the age of 70 years, frequently with multiple comorbidities, in addition to acute pathophysiological changes caused by their surgical illness. As a group, therefore, their risk level is amongst the highest of all surgical patients.[3–5]

Thirty-day inpatient mortality rates following emergency laparotomy range from 13% to 18% – up to five times greater than what we would consider to be high-risk elective surgery, including major elective cardiac and vascular procedures.[1,6,7] In addition, major complication rates are as high as 50%.[1,6,7] This has been recognised in recent years with the publication

Table 1. *Recorded indications for performing emergency laparotomy.[2] Note that NELA was designed to investigate aspects of abdominal bowel surgery – children and procedures primarily relating to the gall bladder, biliary tree, pancreas and trauma were excluded from this audit. Both laparoscopic and open procedures were included*

Indication for surgery	Number of patients	Frequency (%)
Intestinal obstruction	9811	49
Perforation	4744	24
Peritonitis	4116	20
Ischaemia	1720	9
Abdominal abscess	1332	7
Sepsis: other	1474	7
Haemorrhage	819	4
Colitis	748	4
Anastomotic leak	618	3
Intestinal fistula	326	2
Abdominal wound dehiscence	116	0.6
Abdominal compartment syndrome	55	0.3
Planned relook	51	0.3
Other	1758	9

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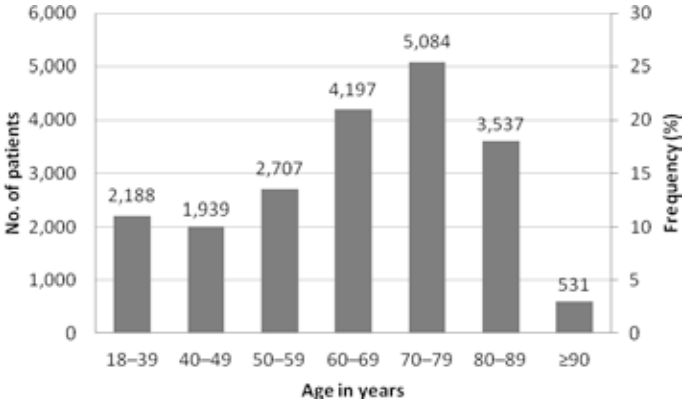

Figure 1. *Age of patients undergoing emergency laparotomy from the first NELA report*[2]

of several key documents that make recommendations for the care of such patients, with the aim of aiding decision making, channelling scarce resources and improving outcomes.[2,8–10] The Royal College of Surgeons' *The Higher Risk Surgical Patient* stands out as a very useful document that has been extensively used by regional and national groups in the UK in the design of clinical care pathways and quality improvement projects for this patient group.[9]

This article aims to bring together the main aspects of these recent recommendations, standards and quality improvement work to present a series of key principles and a clear and adaptable care pathway for these patients that can be applied in all manner of health care settings. The facilities available to manage these patients vary greatly around the world and the key themes can be adapted to local situations.

ASPECTS OF CARE

Identification of the high-risk patient and escalation of care

Patients with acute abdominal pathology may present to hospital via the emergency department (ED), as an inpatient on a ward, or via referral to a surgical assessment unit (SAU) from the community. In all patients, bedside observations should be taken immediately following admission or, in the case of inpatients, at the time of any clinical deterioration. Observations of respiratory rate, oxygen saturations, temperature, systolic blood pressure, heart rate and level of consciousness enable the calculation of an early warning score (EWS) (Table 2).[11] This score should be used by ward or ED staff to identify sick, high-risk patients and to escalate the patient's care appropriately from the outset. A middle or senior grade surgeon should review all patients with a high EWS (> 3) within 30 minutes of referral.[9] A more junior surgical doctor can assess patients with a lower EWS (< 3) and can take a thorough history, conduct an examination and carry out further investigations, ideally within an hour of arrival. Depending on availability investigations should include:

- full blood count
- creatinine and electrolytes
- liver function tests
- amylase
- glucose
- C-reactive protein (CRP)
- β-human chorionic gonadotrophin (HCG)/pregnancy test for women
- coagulation profile
- blood group and save
- ECG
- urinalysis
- arterial blood gas sample including lactate.

The timing of senior and/or consultant review and the pace of further investigation and intervention should reflect the severity of illness identified through these initial assessments and prompt a graded response depending on the presentation. However, a consultant surgeon should review all emergency surgical admissions within 12 hours of arrival, a standard that will require freedom from other routine commitments, such as elective operating lists and outpatient clinics.[2] In the case of many aspects of care of these patients, optimal performance may necessitate system changes such as redesign of surgeons' working patterns and job plans. For cases considered urgent

Table 2. *Early warning score*[11]

	Early warning score						
Physiological parameters	3	2	1	0	1	2	3
Respiratory rate (min^{-1})	≤ 8		9–11	12–20		21–24	≥ 25
Oxygen saturation (%)	≤ 91	92–93	94–95	≥96			
Supplementary oxygen		Yes		No			
Temperature (°C)	≤ 35.0		35.1–36.0	36.1–38.0	38.1–39.0	≥39.1	
Systolic blood pressure (mmHg)	≤ 90	91–100	101–110	111–219			≥ 220
Heart rate (beats min^{-1})	≤ 40		41–50	51–90	91–110	111–130	≥ 131
Consciousness level				A			V, P or U

Consciousness level is graded according to the AVPU scale: A, awake; V, responds to voice; P, responds to pain; U, unresponsive.

or immediate, a consultant should be involved as early as possible to provide timely, invaluable experience in decision-making and enable the formulation of diagnostic and surgical care plans with an appropriate degree of urgency.

Some form of preoperative imaging is commonly required and may include ultrasound, an erect chest X-ray, abdominal X-ray or an abdominal CT scan. This may help clarify the extent and urgency of the procedure, although availability of the scan and the report should be weighed against the possibility of clinical deterioration as a result of delay. A system should be in place that enables the rapid request, performance and consultant reporting of the radiological investigation. Radiological investigation reported by a consultant radiologist is also associated with more accurate diagnostics and treatment planning.[12] Direct contact and explanation of the clinical features of the case, between the radiologist and a surgeon of at least registrar grade, is appropriate and effective.

Risk assessment and postoperative planning

The use of an objective risk assessment tool prior to surgery is recommended and must become incorporated into routine practice.[2] Routine use and clear documentation of a well-recognised scoring system will help determine the degree of urgency, mobilise appropriate resources in a timely manner, involve experienced senior staff, aid communication between clinicians and plan postoperative care (e.g. in the ICU). Importantly, it also enables the expected risk of death to be communicated to patients and their families, enabling a more informed decision to consent, and provides a more realistic understanding of the severity of the patient's situation. Expected risk of death scores will also be useful in discussions with patients who are exceptionally frail or unwell to the point at which surgical intervention would probably be futile and palliative care would be more appropriate.[2,9] Various scoring systems exist and may be based on the type of procedure, surgical urgency, pre-existing co-morbidity or current physiological derangement. Table 3 shows the elements of the P-POSSUM score,[13] a commonly used system available as an online calculator or a smart phone app for areas with limited internet access.

Regardless of the scoring system used, the ability to quantify risk and classify cases as high, medium or low risk will also be a determining factor in the postoperative destination of many patients. Depending on their predicted mortality, patients may be classified as follows:

Highest risk	> 10% risk of death
High risk	5–10% risk of death
Lower risk	< 5% risk of death

Recalculation of risk using the same tool as that used preoperatively may be used to re-evaluate the postoperative destination of the patient at the end of the procedure, as part of the continuous risk assessment that is central to the care of these patients.

Management of surgical sepsis

Sepsis describes a systemic inflammatory response to infection and is characterised by tachycardia, hypotension, tachypnoea, derangement in body temperature, low urine output and reduced cognitive ability, along with raised inflammatory markers and raised lactate. The end result is impaired oxygen delivery to the patient's organs and organ failure. Successful management of surgical sepsis is a race against time – failure to recognise the time-critical nature of clinical deterioration from surgical sepsis, and of treatment of the cause, has been shown to significantly increase mortality and the importance of timely intervention cannot be overemphasised.[14]

There are three key aspects to treatment of the source of sepsis:

1. administration of antibiotics
2. prevention of organ failure by haemodynamic resuscitation

Table 3. *Parameters of the P-POSSUM score.[13] Note that, for preoperative use, you must estimate the operative findings*

Physiological parameter	Operative parameters
Age	Operation type
Cardiac comorbidity	Number of procedures
Respiratory comorbidity	Operative blood loss
Systolic blood pressure	Peritoneal contamination
Pulse	Presence of malignancy
Glasgow Coma Scale score	CEPOD (Confidential Enquiry into Perioperative Deaths) classification
Haemoglobin White cell count Urea	Online calculator available at: http://www.riskprediction.org.uk/pp-index.php
Sodium Potassium Electrocardiogram	P-POSSUM formula Ln $R/1-R = -9.065 + (0.1692 \times$ physiological score$) + (0.1550 \times$ operative severity score), where $R =$ predicted risk of mortality

3. source control by surgical or radiological intervention.

The Surviving Sepsis Campaign guidelines describe the current evidence and guidance for management of sepsis very effectively.[15]

Administration of antibiotics

The immediate treatment of sepsis and septic shock comprises administration of oxygen, achieving good intravenous access and taking blood cultures prior to the administration of broad-spectrum antibiotics. This should occur concurrently with fluid resuscitation and within 1 hour of recognition of sepsis, as *there is an increase in mortality of around 8% for every 1-hour delay in antibiotic administration*.[15] If there is no clear indication for antibiotics (i.e. no suspicion of a perforation, peritonitis or sepsis), antibiotics should be considered during surgery, if indicated at that time.

The choice of antibiotics is guided by local practice and drug availability. A combination of drugs is chosen that is most likely to cover the wide variety of organisms implicated in peritoneal soiling due to bowel perforation. Options are shown in Table 4.

Fluid resuscitation

Fluid resuscitation is vital in maintaining haemodynamic performance and oxygen delivery to the tissues. If oxygen delivery to an organ is insufficient for its demands, then organ dysfunction results, followed by organ failure. For each sequential organ failure that develops due to sepsis, the patient's mortality risk increases by 15–20%.[16] Blood transfusion may be required in anaemic patients (Hb $< 70\,g\,L^{-1}$, $7\,g\,dL^{-1}$) to increase oxygen-carrying capacity and improve oxygen delivery ($\dot{D}O_2 = CO \times C_aO_2$). Cardiac output should be optimised with goal-directed fluid therapy (GDFT) – a fluid management strategy based on achieving predefined physiological parameters. Boluses of 250 mL of fluid of crystalloid should be administered and guided by frequent reassessment of the clinical picture including observations of heart rate, blood pressure and end-organ perfusion (consciousness state, urinary output and arterial blood lactate).

There has never been clear evidence to support the use of crystalloid over colloid, or vice versa, for fluid resuscitation. However, recent studies suggest an increased requirement for renal replacement therapy in patients receiving starch-based colloids and so there has been a shift away from using all colloids except albumin. Depending on available resources, cardiac output monitoring may help monitor the physiological response. There are many cardiac output monitors on the market, but little clear-cut evidence that they improve outcome. If available, take improvement in a parameter (e.g. stroke volume) of 8–10% following a fluid bolus as evidence that haemodynamic performance has improved. Vasoactive drugs should be used to treat hypotension unresponsive to adequate fluid resuscitation (i.e. 'septic shock'). Frequent, accurate recording of all observations and fluid balance is essential and urinary catheterisation and nasogastric tubes should be inserted routinely, although central venous pressure (CVP) measurement is of no proven benefit.

Surgical intervention and preventing delay

Whilst antibiotics will begin to control and moderate the effects of surgical sepsis, definitive source control is needed by radiological drainage or surgery. Access to radiology or an operating theatre may not be immediately available and possible delays should be considered and anticipated early. The potential for harm caused by delay for radiological investigation should be weighed against the benefits of the information it may provide. The type of imaging available, the

Table 5. *Proposed time frame to different urgencies of non-elective surgery, as used in the NELA UK audit*[2]

Urgency of surgery	Planned time from decision to operate to anaesthesia (hours)
Expedited	> 18
Urgent – B	6–18
Urgent – A	2–6
Immediate	< 2

Table 4. *Options for empiric broad-spectrum antibiotic cover in abdominal sepsis*

Amoxicillin 1 g IV 8-hourly, and Gentamicin 5 mg kg^{-1} IV 24-hourly, and Metronidazole 500 mg IV 8-hourly	Good cover for Gram-positive and Gram-negative bacteria and anaerobes
Cefuroxime 1.5 g IV 8 hourly, and Metronidazole 500 mg IV 8-hourly	Reasonable broad-spectrum cover, *Streptococcus faecalis* not covered by cefuroxime
Chloramphenicol 12.5 mg kg^{-1} (max. 1 g) IV 6-hourly, and Metronidazole 500 mg IV 8-hourly	If penicillin allergic
If complication of previous recent surgery, consider opting for more aggressive cover Tazocin 4.5 g IV 8-hourly or meropenem 1 g IV 8-hourly	
If upper GI perforation, consider addition of an antifungal drug such as fluconazole	

stability of the patient and the likelihood of changing management as a result of the investigation will all be factors in this decision.

Once the decision to perform laparotomy has been made, clear time goals should be established (Table 5), as delayed source control has an impact on survival.[14] Delays in access to theatre may be resource dependent and at times unavoidable, although where possible organisations should ensure that emergency theatre access matches demand. Avoidance of delay may simply be a case of good communication and theatre management on the ground, although there may be a need for

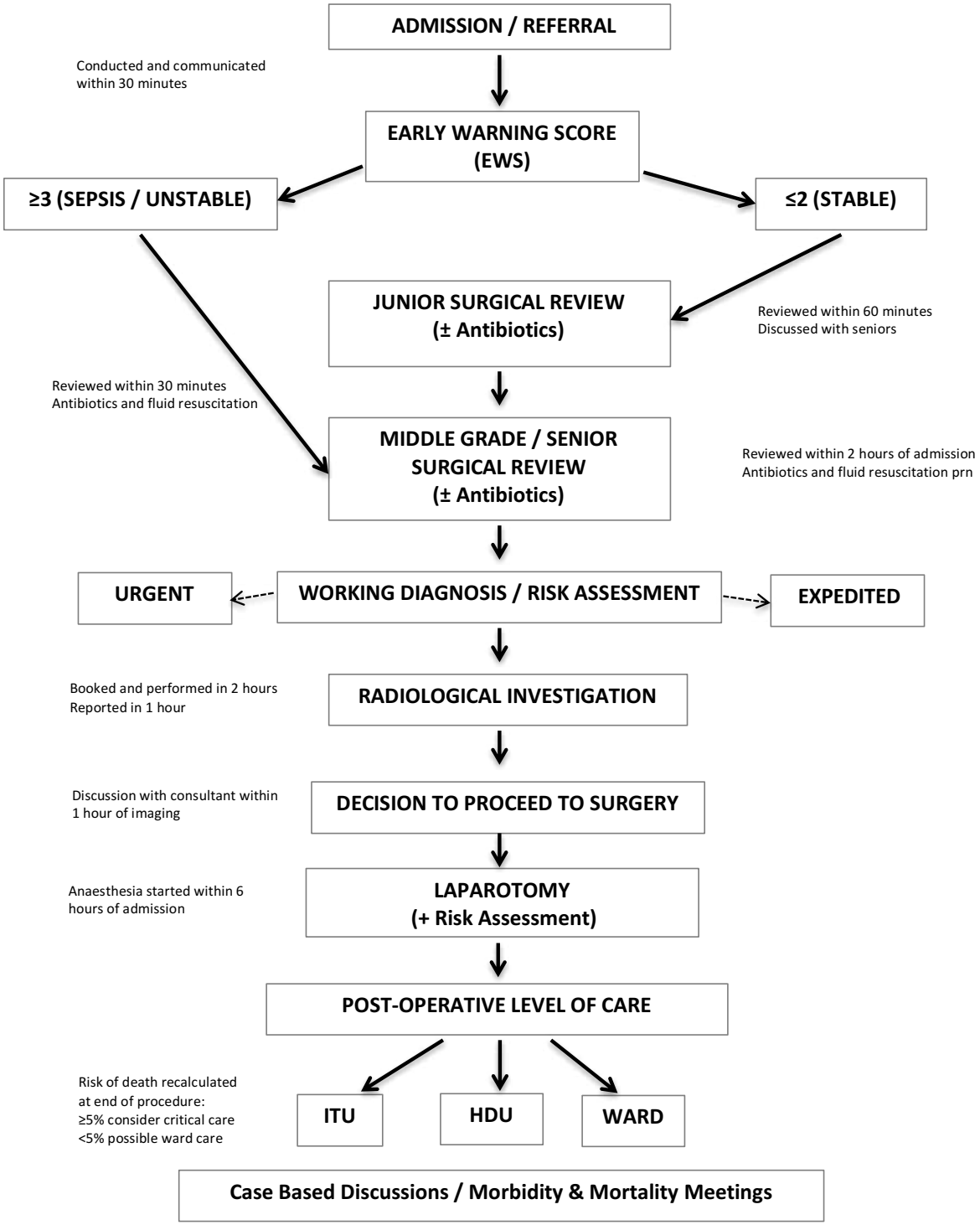

Figure 2. *Generic care pathway for non-elective laparotomy*

an institutional policy that permits prioritisation over elective cases or rota management changes. Surgical and anaesthetic documentation should accurately record the times of all significant events to enable high-quality audit and identification of specific reasons for delay.

Intraoperative care

Consultant-led care

Current best practice recommendations are that care for patients with a predicted mortality risk of > 10% should be delivered by a consultant surgeon and a consultant anaesthetist, regardless of the time of day.[2] In addition, any patient with a predicted mortality risk of > 5% should receive active input from both consultant surgeon and consultant anaesthetist.[2] There are obvious logistical and resource challenges in providing this level of service, and careful consideration needs to be given to the allocation and availability of senior clinicians. The involvement of senior clinicians is one aspect of care that has shown considerable variation according to the time of day when compared with other aspects such as the administration of antibiotics, provision of radiology or times to theatre.[2] Changes in working patterns, such as consultant on calls in blocks with more freedom from fixed commitments, may enable more frequent daily ward rounds and versatility. The benefits of senior decision-making are well recognised, although there is a clear need for training of future senior decision-makers and development of this experience in trainees. This is a delicate balance between patient safety, identification of risk and resource availability and this should be considered on a case-by-case basis. The routine use of formal case-based discussions or morbidity and mortality presentations following such cases can be extremely valuable in developing good clinical decision-making in trainees.

Anaesthetic management

- This should be consultant led.
- Implement on-going resuscitation – GDFT
- Administer antibiotics if not already given.
- Implement a lung-protective ventilation strategy.
- Institute an appropriate level of monitoring – insert an arterial line where possible, especially if ICU admission is planned. Monitor lactate. Insert a central venous catheter if administration of vasopressors is anticipated. Insert a urinary catheter.
- Remind the surgeon to send microbiological samples.
- If analgesia is required, insert rectus sheath catheters.[17]
- Insert nasogastric tube – confirm position at laparotomy and document.

Postoperative care

Critical care provision

The appropriate level of postoperative care must be decided by discussion between the surgeon, anaesthetist and intensivist. The P-POSSUM score should be recalculated using the accurate intraoperative findings. Admission to critical care should be based on the risk status of the patient. All high-risk patients should be considered for admission to either the high-dependency unit or ICU and those with a risk of death of > 10% should be admitted. Surgical factors are also important; patients with an open abdomen, in whom a return for a 'second look' in 24 hours is planned, may be best managed sedated and ventilated in the ICU. Careful consideration of risk at all stages is vital and a failure to assess risk properly results in failure to provide appropriate care.[2,8] Thorough risk assessments and treatment plans at an early stage will also avoid the misallocation of scarce resources and enable appropriate treatment limits to be set in some patients if critical care admission is not desired.

LOCAL SERVICE IMPROVEMENT

At the centre of recent efforts to improve the outcome of emergency laparotomy patients are local service quality improvement initiatives. These comprise the elements of clinical governance, including teaching and education, risk management and the development of guidelines and protocols, closely aligned with national and international standards. Effective care pathways that are specific to local resource availability and demands provide the framework with which to conduct high-quality local audit to establish baseline outcomes and identify areas for improvement. Figure 2 is an example of a generic care pathway for patients with an acute abdomen that may require non-elective laparotomy. The development of local documentation based on such a pathway can include the key indicators for audit which can ultimately be set against data from other institutions and national audit initiatives. The ELPQuIC (Emergency Laparotomy Quality Improvement Care) bundle is an example of how such a care pathway can lead to a significant reduction in the risk of death following emergency laparotomy.[18]

CONCLUSIONS

Patients undergoing emergency laparotomy are at high risk of adverse outcomes. Clinical care pathways adapted to the local environment may help streamline the care of these patients and provide the basis for local service improvement over time. Key elements of care for these patients include repeated risk assessment, early antibiotics and resuscitation and appropriate timely interventions provided by clinicians with the right level of experience.

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Developing an effective day surgery service

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INTRODUCTION

Day surgery is defined as surgery for which a patient is admitted and discharged on the same day. There has been a dramatic growth in day surgery over the past two decades. Previously regarded as an option only for well patients undergoing minor procedures, the development of new surgical techniques and shorter-acting anaesthetics has allowed the field to expand to a wider range of patients and increasingly complex surgeries.[1]

The incidence of death and major morbidity associated directly with day surgery is extremely low,[2] and there are some significant advantages when compared with inpatient surgery, including reductions in staffing costs, shorter waiting times and fewer hospital-acquired infections. In the UK, the Department of Health has recommended that 75% of elective procedures should be performed as day-case surgeries,[3] and the International Association for Ambulatory Surgery (IAAS) has been promoting the worldwide development of day surgery since 1995. In 2007, the World Health Organization published a policy brief to facilitate this aim (*Day Surgery: Making it Happen*).[4] This article will explore the factors involved in planning an effective day surgery service, as well as some of the potential barriers to implementation of such a service.

PATIENT SELECTION

It is now accepted that most patients are suitable for day surgery unless there is a specific reason why an overnight stay would be required.[5] When selecting appropriate patients there are three main areas to consider: social, medical and surgical factors.

Social factors

The patient must understand the procedure and consent to have it performed as a day surgery. Patients who undergo general anaesthesia should be looked after by a responsible adult for the next 24 hours, and their home circumstances should be appropriate for postoperative care. They should not be expected to look after dependants during this time period. Patients should be within 1 hour of medical facilities in case a postoperative complication occurs, and they should have access to a telephone. They need to be able to follow postoperative instructions, and refrain from driving, operating heavy machinery and decision-making during the recovery period.

Medical factors

Patients require a preoperative assessment to determine their physical health prior to day surgery. There has been a move away from arbitrary criteria, such as those laid down by the American Society of Anesthesiologists (ASA) or body mass index (BMI), and it is generally felt that patients with a chronic but stable illness are better managed at home as this results in less disruption to their routine.[6] Anyone with an unstable medical condition, such as crescendo angina or poorly controlled diabetes, is not suitable for day surgery.

Surgical factors

It is important that any procedure considered for day surgery should not carry a significant risk of major complications, nor should it require prolonged specialist care or observation. Table 1 gives a list of some of the common procedures suitable for day surgery, but is by no means exhaustive – more information can be found on the IAAS website (www.ambulatorysurgery.org) or from the British Association of Day Surgery (www.daysurgeryuk.net). Minimally invasive surgical techniques should be employed if opening abdominal or thoracic cavities, and it should be possible to control pain with oral medications and/or local anaesthetic techniques. Patients should be able to resume normal functions (i.e. drinking) quickly, and should be able to mobilise before discharge.

In addition to the above, there are certain patient groups that may need further consideration when determining suitability for day surgery.

Infants

In the UK, day surgery is an option for full-term infants over 1 month of age, with a higher age limit for ex-premature infants (60 weeks post-conceptual age)

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Table 1. *Examples of day surgery procedures*

Cataracts
Squint surgery
Surgical extraction of teeth
Tonsillectomy
Grommet insertion
Laparoscopy
Laparoscopic female sterilisation
Circumcision
Cystoscopy
Hernia repair
Laparoscopic cholecystectomy
Polypectomy
Knee arthroscopy
Carpal tunnel release
Cruciate ligament repair
Local excision of breast
Varicose vein removal

because of an increased risk of apnoea in the perioperative period. Any infants with cardiac or respiratory disease or who have experienced a recent episode of apnoea, or from a family with a history of sudden infant death syndrome or adverse social circumstances, should be considered for overnight admission.[5]

Obese patients

Minimally invasive surgery and the use of short-acting anaesthetic agents mean that there is no longer an upper weight limit when considering patients for day-case surgery. If short-acting anaesthetics are available, the majority of complications in this group are likely to occur either intraoperatively or in the immediate perioperative period,[5] and so they can be managed as part of a day surgery pathway. If such drugs are not available, or if pain management has required use of longer-acting opiates, these patients may need to be managed in hospital.

Elderly

There is no evidence that advancing age correlates with poor day surgery outcomes,[7] and postoperative cognitive dysfunction may be better managed at home in a familiar environment.[1]

Urgent surgery

Some centres have begun to include certain urgent surgeries in their day-case schedules. Examples of suitable operations include incision and drainage of an abscess and evacuation of retained products of conception. The patient should be seen beforehand, and must be deemed safe to be left at home for 1–2 days.[5] Patients must receive clear preoperative patient information, in writing, so that they are aware of when to seek additional help.

MANAGEMENT AND STAFFING

Day surgery units should have a clinical lead with a specific interest in day surgery who is responsible for the development of local policies and guidelines.[5] Clinical leads should be supported by a day surgery manager, who is in charge of the day-to-day running of the unit and who will often come from a nursing background. Staff nurses, operating department practitioners, physician's assistants and other staff are also key to the success of any day surgery enterprise, and should ideally be multiskilled and able to work in different areas within the day surgery unit. It is recommended that surgeons and anaesthetists are senior clinicians, to promote forward flow and minimise admission rates and complications.

FACILITIES

Day surgery should ideally occur in a self-contained unit, separate from in-patient facilities and with good transport options nearby. When this is not possible efforts should be made to ensure there is a separate nursing team, so that patients having day surgery are helped to achieve a rapid recovery.[5] Trolleys can be used instead of traditional beds for day surgery, with one trolley being used for two or more patients per day. The unit should be open late enough to allow patients at the end of operating lists sufficient time to recover and be discharged, and there should be a separate area for children, with toys and nurses skilled in paediatric care.

ANAESTHETIC MANAGEMENT

Preoperative assessment

Preoperative assessment is fundamental to achieving successful day surgery pathways, and should be performed by someone trained in day surgery.[5] The service is commonly nurse led and based around a standardised questionnaire, with the aim of identifying patients at high risk of experiencing complications. Such patients can then be referred to anaesthetic team for advice. Effective preoperative assessment ensures that appropriate investigations are ordered and that necessary protocols are implemented, i.e. fasting guidelines, administration of regular medications. Patients are also given the opportunity to ask questions about the process, and so anxiety is minimised. Preoperative assessment should ideally be done before the day of surgery, to reduce cancellation rates and maximise efficiency.[8] Figure 1 shows how preoperative assessment fits into an ideal day surgery pathway.

Anaesthesia for day surgery includes general and regional anaesthesia, local techniques, sedation or any combination of these. The type of anaesthetic chosen will be influenced by surgical requirements,

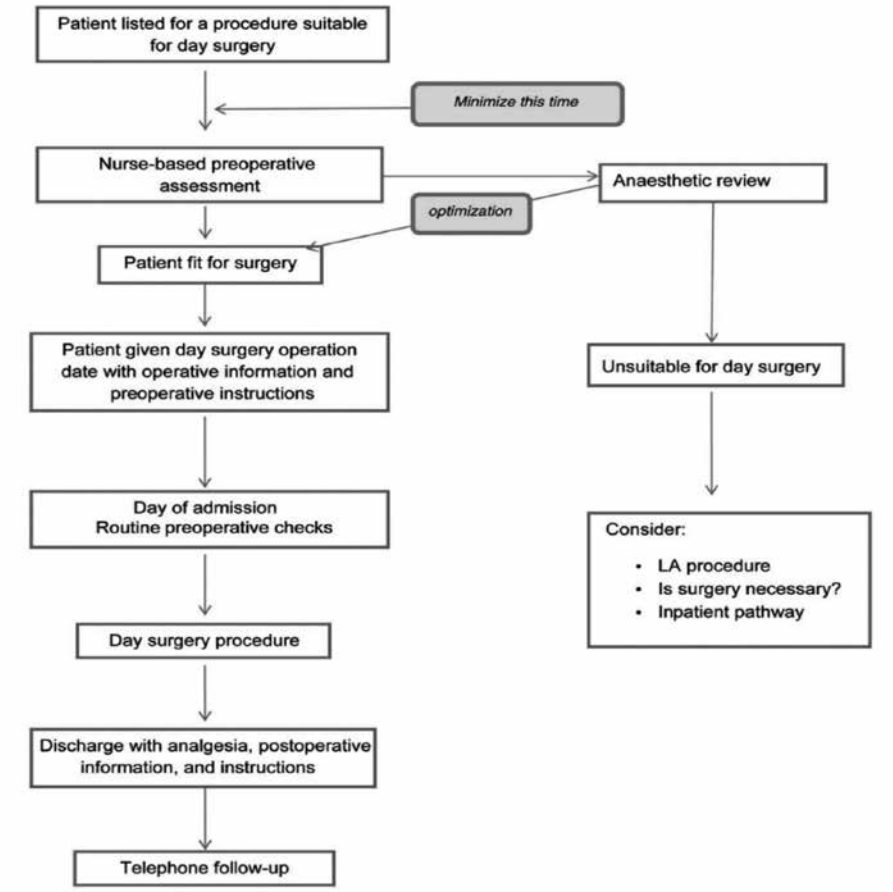

Figure 1. *An ideal day surgery pathway. Reproduced with permission from Quemby and Stocker*[1]

patient-specific considerations, the experience of the anaesthetist and the facilities and personnel available.[9] It should ideally be rapid in onset and offset, and confer minimal risk of postoperative nausea and vomiting (PONV), dizziness or drowsiness.

Providing good analgesia is essential,[8] and a multimodal approach of paracetamol, non-steroidal anti-inflammatory drugs (unless contraindicated) and local anaesthetics should be employed. Careful use of short-acting opioids is often appropriate. Longer-acting agents such as morphine should be used with caution because they may have unwanted side-effects such as nausea and sedation; if a patient has received morphine before, and has tolerated it well, it is reasonable to use it for procedures that may result in significant pain (e.g. laparoscopic cholecystectomy). If regional anaesthesia is used, it is acceptable to discharge patients with a residual blockade, provided that the affected limb is protected and that support is available to help with the patient's daily needs. Patients should be given written instructions about protecting their limb during this time, as well as information about when the block should fade and who to contact with any concerns. Of particular note, beware of inadvertent femoral nerve block following local anaesthestic administration for inguinal hernia repair. With any regional anaesthesia it is important that oral analgesia is started before the local anaesthetic wears off, and that it is given regularly afterwards. Patients should be fully informed and prepared for this – the pain of arthroscopic shoulder surgery can be considerable when an interscalene block wears off on the first postoperative night. Neuraxial blockade can be used, but predictable adverse effects, such as postural hypotension and urinary retention, can limit discharge. Lower doses and lower concentrations of local anaesthetic agents, with added neuraxial opioid can minimise these unwanted effects.[5]

PONV is a cause of unplanned admission following day surgery, and patients at risk of PONV should be given two or three prophylactic antiemetics. Minimal starvation times and the routine use of intravenous fluids can reduce the risk of PONV, and it should be treated seriously when it occurs. Total intravenous anaesthesia should be used for patients in whom antiemetics have proven ineffective after previous procedures.

The incidence of venous thromboembolism is lower in the day surgery population than among inpatients, but risk assessment and preventative measures should still be taken, in accordance with local guidelines.

RECOVERY AND DISCHARGE

There are three stages of recovery from day surgery.[5]

First stage

The initial stage lasts until the patient is awake, protective reflexes have returned and any immediate pain on waking is well controlled. This stage should take place in a recovery area with trained staff. Some patients will be able to bypass this stage, for example those undergoing regional anaesthesia with no sedation.

Second stage

This stage ends when the patient is ready for discharge from the hospital or day unit. It should occur in an area near to theatres, so that staff are able to contact both the anaesthetist and surgeon with any concerns. Nurses should be able to deal with PONV and pain, and should be trained to detect emergencies such as haemorrhage or cardiovascular events. Many day surgeries have a protocol to allow nurse-led discharge (see Table 2). There should be facility to admit patients if necessary, and resuscitation equipment such as supplemental oxygen and suction should be available.[9]

Late recovery

The final stage of recovery is complete following full physiological and psychological recovery from the procedure. This can take weeks or even months.

Prior to being discharged, patients need to be given clear information in writing about what to expect after surgery and what to do if concerned. This information should be tailored to the specific surgery and needs to provide information about possible complications and how to seek help. Instructions should also be given verbally, to assess understanding and consolidate written information. From the anaesthesia point of view, patients should be advised not to drink alcohol, operate machinery or drive for a period of 24 hours. However this advice must be appropriate to the agents that they have received during general anaesthesia – following administration of

Table 2. *Discharge checklist for day surgery. Reproduced with permission from the British Association of Day Surgery. Nurse Led Discharge. London, BADS, 2009.*

Criterion	Yes	No	Not applicable	Initials
Vital signs stable				
Orientated to time, place and person				
Passed urine (if applicable)				
Able to dress and walk (where applicable)				
Oral fluids tolerated (if applicable)				
Minimal pain				
Minimal bleeding				
Minimal nausea and vomiting				
Cannula removed				
Responsible escort present				
Has carer for 24 hours postoperatively				
Written and verbal postop instructions				
Know who to contact in an emergency				
Follow-up appointment?				
Removal of sutures required?				
Referrals made				
Dressings supplied				
Patient copy of GP letter				
Carbon copy of consent				
Sick certificate				
Has take-home medications				Next dose
Information leaflet for tablets				
Postoperative phone call required?				

longer-acting volatile anaesthetics (isoflurane and halothane), current UK recommendation is that this period should be 72 hours. After this time, patients should not resume driving until their pain is sufficiently controlled that they can perform an emergency stop and there are no procedure-specific limitations, as advised by the surgical team.

All patients should receive appropriate analgesics to take home, as well as advice on dose, dosing interval and whether to take with food or not. Many day surgeries have pre-packaged analgesia readily available to the nursing team, to prevent undue delays in discharge.

Discharge summaries should be given to the patient, with copies sent to the family doctor. This can be vital if the patient needs treatment overnight. Patients should know who to phone for first 24 hours if they have any concerns.

AUDIT

Audit should be seen as an essential tool to assess, monitor and maintain efficiency and quality of patient care. Routine nurse-led follow-up (via phone call) is one way to monitor complications and patient experience, and allows continuous collection of data for regular audit and review. Audits and evaluations of unplanned admissions may help to highlight areas for improvement in services.

BARRIERS TO DAY SURGERY

Increasing the availability of day surgery for patients often requires a change in mind-set. Alterations to national policies and regulations may well be necessary, and existing health care structures may need to be reorganised. According to the World Health Organization, there are seven main barriers to delivering effective day surgery.[4]

Economic
There may be financial incentives for either the hospital or the surgeon associated with inpatient stays.

Regulatory
National legislation may block a shift towards day surgery.

Educational
Medical students and doctors may not be trained in the benefits of day surgery, and so may lack the motivation to drive change.

Facility design
Health facilities may not be structured to favour the development of day surgery.

Local, home and community support
There may be a lack of adequate community services to support change, i.e. community nursing.

Information
Patients and health care providers may not be aware of day surgery as an option.

Organisational
Effective day surgery requires strong multidisciplinary team working, and this may be difficult to achieve.

CONCLUSION

Developing a successful day surgery requires investments in educational programmes for staff, as well as removal of any economic and regulatory barriers. Expansion of day case facilities needs to occur alongside reductions in inpatient capacity, and community services may need to be developed. Trying to shift towards viewing day surgery as the norm for most elective patients may seem a daunting challenge, but can result in real benefits to both patients and healthcare services.

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Update in
Anaesthesia

Perioperative management of patients on warfarin and the new oral anticoagulants

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Summary
Correct management of a patient's anticoagulation during the perioperative period is of great importance.

Surgery causes hypercoagulability and most patients are at increased risk of venous thromboembolism.

Interruption of anticoagulation increases this risk further and must be balanced against the risk of surgical bleeding.

INTRODUCTION

Among patients over 80 years, 23% of those who suffer a stroke have atrial fibrillation, and so the number of patients on anticoagulation therapy is growing. Around one in six of these anticoagulated patients will require interruption of therapy for a surgical procedure each year.[1]

Perioperative management of anticoagulant therapy is constantly evolving, with the primary aim being a balance between reducing the risk of systemic arterial and venous embolism and reducing perioperative bleeding risk. The traditional strategy to 'bridge' interrupted warfarin therapy for atrial fibrillation with the administration of low-molecular-weight heparin is under review, following the results of large and influential studies such as the BRIDGE trial.[1] The use of novel oral anticoagulants (NOACs) is also increasing and so it is crucial to understand both the pharmacokinetics of these drugs and their use in the perioperative period. This article aims to give a concise update of perioperative anticoagulation and to guide readers on the perioperative management of patients on NOACs.

INDICATIONS FOR ANTICOAGULATION

Oral anticoagulation is indicated in the following conditions.

Warfarin[2]

- Prophylaxis of systemic embolism in patients with rheumatic heart disease and atrial fibrillation.
- Prophylaxis of systemic embolism after insertion of prosthetic heart valves.
- Prophylaxis and treatment of venous thrombosis and pulmonary embolism.
- Transient cerebral ischaemic attacks.

NOACs[3–6]

- Prevention of venous thromboembolism in adult patients undergoing elective hip or knee replacement (edoxaban not yet licensed for this indication).
- Prevention of stroke and systemic embolism in adult patients with non-valvular atrial fibrillation.
- Treatment of deep vein thrombosis and pulmonary embolism, and prevention of recurrent deep vein thrombosis and pulmonary embolism in adults.
- Rivaroxaban also licensed in acute coronary syndrome for prevention of artherothrombotic events in combination with aspirin and clopidogrel or ticlopidine.

CLINICAL RISK PREDICTION[7]

The clinical prediction tool we have used for assessing stroke risk factors in a patient with non-rheumatic atrial fibrillation during the perioperative period is $CHADS_2$. Each score (0, 1, 2) represents a risk contributing to the likelihood of an embolic event as outlined in Table 1.

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Table 1. *$CHADS_2$ tool*

Risk factor	Score
Congestive heart failure or left ventricular dysfunction	1
Hypertension blood pressure consist of above 140/90 mmHg or treated hypertension on medication	1
Age greater than 75 years	1
Diabetes mellitus	1
Stroke or transient ischaemic attack or thromboembolism	2

The initiation of anticoagulation is recommended in patients with a $CHADS_2$ score of 2 or more.

THE CLOTTING CASCADE

The classical view of the clotting cascade (Figure 1) with intrinsic and extrinsic pathways has been useful for interpreting *in vitro* tests of coagulation but is felt to be outdated and potentially inaccurate. It is now thought that generation or exposure of tissue factors at the wound surface along with interaction with factor 7 is the main event that initiates clotting and that the cascade is much more of a dynamic and interwoven process.

WARFARIN

Warfarin is the most widely prescribed anticoagulant in the UK, and was first available in the 1950s.[9] It is a vitamin K antagonist and inhibits the reduction of vitamin K to its active form, hydroquinone.

Clinical coagulation tests commonly used for warfarin

- **Prothrombin time (PT)** is the time taken (in seconds) for blood to clot in the presence of tissue factor. It assesses the extrinsic and common pathway of the clotting cascade and can vary depending on the situation and laboratory equipment used.
- **The international normalised ratio (INR)** was developed to eliminate the variation caused by different laboratories by comparing a PT against an internationally recognised standard PT control sample and expressing the result as a dimensionless ratio. Thus, an INR would be the same on a given sample regardless of the laboratory or equipment used.[8]

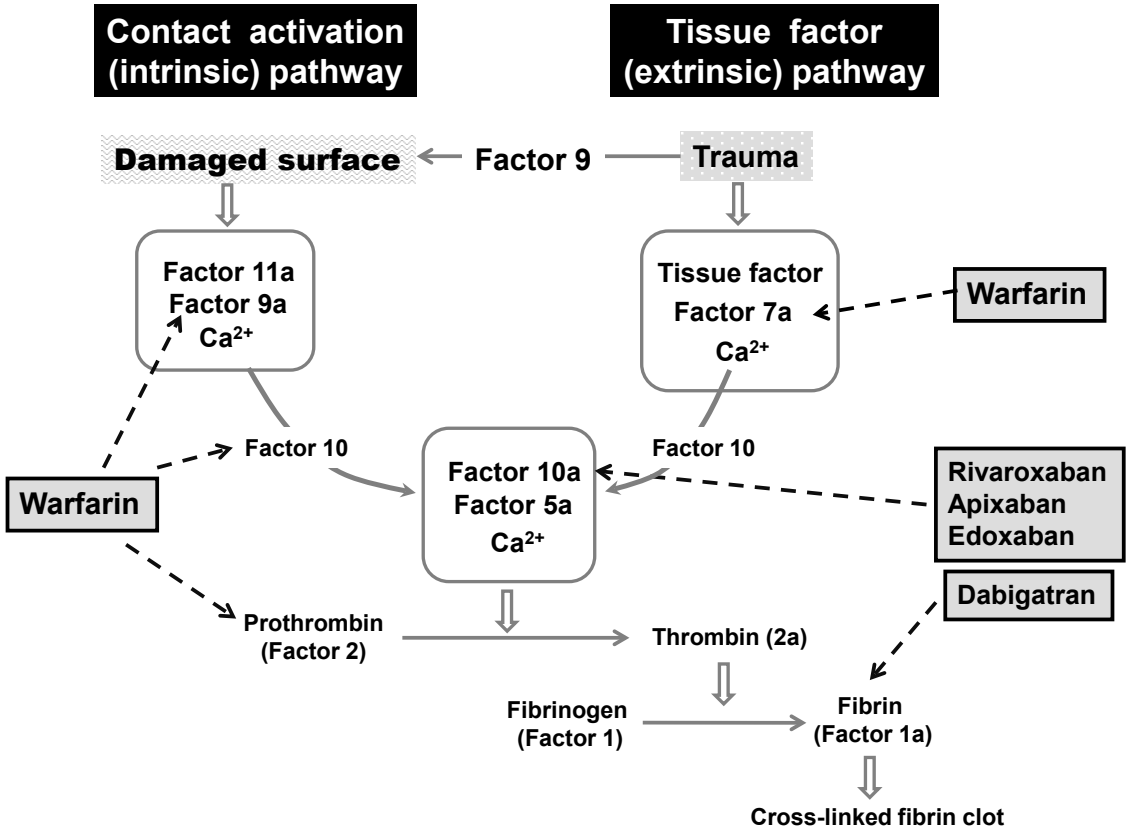

Figure 1. *A highly simplified view of the traditional clotting cascade. The sites of action of warfarin and the novel anticoagulants are shown. This format does conform with the information that laboratory coagulation tests provide; however, in the last 15 years, a cell-based model of coagulation that better explains coagulation function and pathology that is seen in clinical practice has been proposed. Further details of this theory are available in the following paper: Hoffman M and Monroe DM. A cell-based model of hemostasis. Thrombosis and Haemostasis 2001;* ***85****: 958–65*

Hydroquinone binds competitively to active clotting factors 2, 7, 9 and 10 and anticoagulant proteins C and S, decreasing their activities. Its effect can be measured using the prothrombin time or INR.[9]

Pharmacokinetics

Warfarin is almost completely absorbed from the gut with peak blood concentration reached within 4 hours. Peak time of action is 48–72 hours, and anticoagulation effect generally occurs within 24 hours. However, peak effect may be delayed 72–96 hours.[2]

Side-effects

The most common side-effect of warfarin is adverse bleeding. By inhibiting protein C, warfarin can cause a paradoxical activation of coagulation, leading to thrombosis and, rarely, erythematous swollen skin patches, leading to ecchymosis, infarction and skin necrosis. It is also contraindicated in the first and third trimesters of pregnancy as it crosses the placenta and is teratogenic.[2]

Drug interactions

Warfarin interacts with multiple other drugs, particularly those that inhibit or induce cytochrome P450 (CYP450), as well as with cranberry juice. Inducers of cytochrome P450 will generally decrease the INR and inhibitors will increase it (Table 2).

Concomitant use of non-steroidal anti-inflammatory drugs (NSAIDs), including aspirin, potentiates the effect of warfarin through displacement of warfarin from its binding site on albumin and also through inhibition of platelet function.

Therapeutic use

For effective prevention of stroke, in patients in atrial fibrillation the time spent in the therapeutic INR range (TTR) should be monitored over a period of months. Ideally TTR should be greater than 65%. If the TTR is less than 65%, patient factors contributing to poor anticoagulation control should be addressed. Examples of such factors are:

- cognitive dysfunction
- adherence to prescribed therapy
- illness
- interacting drug therapy and
- lifestyle factors such as diet and alcohol consumption.

If no reversible factors can be identified and the TTR cannot be improved, an alternative method of stroke risk prevention should be employed.

Table 2. *Common inhibitors and inducers of cytochrome P450*

Inhibitors	Inducers
Sodium valproate	Carbamazepine
Isoniazid	Rifampicin
Cimetidine	Alcohol
Ketoconazole	Phenytoin
Fluconazole	Griseofulvin
Alcohol	Phenobarbital
Chloramphenicol	Sulphonylureas
Erythromycin	
Sulphonamides	
Ciprofloxacin	
Omeprazole	
Metronidazole	

WARFARIN BRIDGING THERAPY

Most hospitals have policies to guide bridging therapy with warfarin. The surgeon who books the patient for surgery should assess the need to interrupt anticoagulant therapy based on the bleeding risk posed by surgery; skin biopsies, minor dental extraction, cataract surgery and some cardiac procedures are associated with a low risk of bleeding whilst on therapeutic warfarin. Major procedures such as abdominal hysterectomy, endoscopic resection of prostate, lumbar discectomy, thyroidectomy, total joint replacement, lung operations, colonic resection, and radical neck dissection are high-risk operations for bleeding. Typically, warfarin is stopped 4–5 days prior to surgery. The type of bridging therapy offered is based on the patient's thrombotic risk in the absence of therapeutic warfarin (see Table 3).

The BRIDGE trial[1]

In June 2015, the results of this randomised, double-blinded, placebo-controlled trial were published. The aim of the study was to determine if avoiding bridging in patients with atrial fibrillation undergoing elective procedures decreased the risk of perioperative bleeding and/or increased the risk of arterial thromboembolism. The trial included 1884 patients with atrial fibrillation (valvular and non-valvular) with at least one risk factor for stroke (hypertension, age > 75 years, congestive cardiac failure, diabetes, previous ischaemic stroke/transient ischaemic attack).

The results showed that, at 37 days postoperatively, there was no increase in thromboembolic complications but that there was a significant decrease in the amount of perioperative bleeding in patients who did not receive bridging therapy. The incidence of arterial thromboembolism was 0.4% in the no-bridging group and 0.3% in the bridging group, a difference that was not statistically significant different ($P = 0.01$ for non-inferiority, $P = 0.73$ for superiority). Among patients who experienced arterial thromboembolism, 70% had undergone a minor procedure, the median time to event was 19 days and the average $CHADS_2$ score was 2.4.

Major bleeding occurred in 1.3% of patients in the no-bridging group and in 3.2% in the bridging group.

There was no significant difference between the groups with regard to myocardial infarction, venous thromboembolism or death. The mechanisms of perioperative arterial thromboembolism may be closely related to factors such as the type of procedure and to intraoperative alterations in blood pressure. The premise that warfarin interruption leads to rebound hypercoagulability and that the milieu of the procedure confers a prothrombotic state, which in turn leads to arterial thromboembolism, is not supported by the results of this trial.

Limitations of the BRIDGE trial

A few groups were under-represented in the study sample, for example patients with $CHADS_2$ scores of 5–6 and patients undergoing carotid endarterectomy, major cancer surgery, cardiac surgery and neurosurgery, and patients with mechanical heart valves.

Current guidance following the BRIDGE trial

For warfarinised patients with atrial fibrillation, no bridging is required. Bridging should be considered only if the $CHADS_2$ score is greater than 4 or there is history of a CVE (including TIA) within the preceding 3 months.[10,11]

Table 3 takes into account recent updates in evidence.

PERIOPERATIVE MANAGEMENT OF THE NOACS[12]

The European Society of Cardiology (ESC)[13] recently recommended that surgical procedures be classified in three categories:

- interventions not requiring discontinuation of anticoagulation (dental, ophthalmology procedures);
- intervention with low bleeding risk (prostate or bladder biopsy, angiography, pacemaker insertion);
- high bleeding risk procedures (spinal, epidural anaesthesia, lumbar puncture, cardiothoracic surgery, abdominal surgery, major orthopaedic surgery, liver biopsy, transurethral resection of the prostate and kidney biopsy).

The ESC guidelines advise the NOACs be stopped 24 hours before a low bleeding risk procedure, and between 48 and 96 hours before a procedure with a high bleeding risk.

DABIGATRAN

Dabigatran has predictable pharmacokinetics and can usually be stopped close to the time of surgery. Bridging is not currently recommended. Check renal function preoperatively and use results to plan the timing of the last dose presurgery (see Table 5).

Postoperatively, if adequate haemostasis is achieved, dabigatran can be restarted at the preoperative dose when haemostasis achieved. Alternatively, depending on the risk of a venous thrombotic event (VTE), prophylactic low-molecular-weight heparin (LMWH) can be given 6–8 hours after surgery.

RIVAROXABAN, APIXABAN AND EDOXABAN

Rivaroxaban, apixaban and edoxaban also have predictable pharmacokinetics and can be stopped close to the time of surgery; consequently, patients receiving these medications do not require bridging. The advice is to stop these agents 48 hours before surgery. Rivaroxaban/apixaban/edoxaban can be restarted at the same dose the patient was receiving preoperatively as soon as adequate haemostasis is achieved. The factor Xa inhibitor betrixaban is currently in phase III trials, but it is thought to have similar pharmacokinetics to other factor Xa inhibitors. Owing to lack of information we cannot safely give recommendations on stopping this anticoagulant.

REGIONAL ANAESTHESIA AND ANTICOAGULATION

Regional anaesthesia is an invaluable option for many procedures, either in place of or combined with general anaesthesia. Serious complications in patients with normal coagulation are very rare. For example, in the third UK national audit project, the incidence of vertebral canal haematoma after neuraxial blockade was 0.85 per 100 000 cases.[14] The extent to which the risk of haemorrhagic complications is increased in patients with abnormalities of anticoagulation is unquantifiable, but is likely to be small.[15] Table 6 shows the latest recommendations for performing regional anaesthesia in patients on medications that render their coagulation abnormal.

In the UK, the Association of Anaesthetists of Great Britain and Ireland (AAGBI) recognises a spectrum of increased risk with different regional techniques. Risk relates to complications such as bleeding, haematomas and compression of other structures leading to potential airway compromise or tissue ischaemia. Epidurals and spinals are thought to be associated with the highest risk of complications, with the risk decreasing as the blocks become more peripheral.

ASSESSMENT OF COAGULATION WITH NOACS

Conventional tests of coagulation

The NOACs are an appealing alternative to warfarin as they do not need to be monitored and they have been shown to be as efficacious as, or indeed superior to, warfarin in preventing stroke or systemic embolisation. However, clinicians remain wary of these agents because of the lack of options for reversal of their anticoagulant effects in situations where this is imperative – such as emergency surgery and/or haemorrhage.[16]

The activated partial thromboplastin time (aPTT) is a measure of the activity of the intrinsic pathway of the coagulation cascade.

Table 3. *Assessment of thrombotic risk and need for bridging therapy*[11,12]

Low risk of thrombosis	
Bileaflet AVR without AF, hypertension, stroke/TIA, diabetes, CCF, or age >75	No bridging
	Check that INR on day of surgery is < 1.5
Single VTE > 1 year ago	Postoperative VTE assessment for prophylaxis
Atrial fibrillation with CHADS2 score of 1–4	Restart warfarin post operation if haemostasis adequate
Moderate risk of thrombosis	
VTE > 3 months ago but < 1 year	Bridge only if thrombotic risk > bleeding risk
Recurrent VTE	If required, stop warfarin 4–5 days prior to surgery
Active cancer (treatment < 6 months or palliative)	Start prophylactic LMWH once daily 2 days after stopping warfarin
	Give last dose of LMWH 24 h pre-operatively
	Post operation: check adequate haemostasis
	Restart LMWH 6–8 hours post-operatively (may be delayed in high-risk bleeding)
	Continue bridging therapy until INR therapeutic
Bileaflet AVR with AF, hypertension, stroke/TIA, diabetes, CCF or age >75	Stop warfarin 4–5 days prior to surgery
	Start therapeutic LMWH once daily 2 days after stopping warfarin
	Give last dose 24 hours preoperatively
	Post operation: check adequate haemostasis. Give therapeutic LMWH 6–8 hours post-operatively (may be delayed in high-risk bleeding)
	Continue bridging therapy until INR in therapeutic range
High risk of thrombosis	
Mitral valve replacement	Stop warfarin 5 days prior to surgery
Older AVR (with tilting disc)	Start therapeutic LMWH once daily 2 days after stopping warfarin
Any mechanical valve with stroke/TIA <6 months	Give last dose 24 hours preoperatively
	Post operation: check adequate haemostasis. Give therapeutic LMWH 6–8 h post-operatively (may be delayed in high-risk bleeding)
	Continue bridging therapy until INR in therapeutic range
AF with stroke/TIA/mitral stenosis/arterial embolism < 3 months	Stop warfarin 5 days prior to surgery
	Start therapeutic daily LMWH 2 days after stopping warfarin
	Give last dose as a half-dose 24 hours preoperatively
	Post operation: check adequate haemostasis. Give therapeutic LMWH at 18.00 hours on first postoperative day
	Continue bridging therapy until INR in therapeutic range
Star–Edwards (ball and cage) AVR	Discuss with cardiology, as unfractionated heparin infusion may be required owing to high risk of thrombosis
VTE < 3 months	Defer surgery if possible. If not possible, consult with haematology as may require therapeutic dose LMWH or an inferior vena cava filter

AF, atrial fibrillation; AVR, aortic valve replacement; CCF, congestive cardiac failure; LMWH, low molecular weight heparin; TIA, transient ischaemic attack; VTE, venous thrombotic event.

Whilst there is evidence that the aPTT becomes prolonged by dabigatran, rivaroxaban, apixaban and edoxaban, there are varying results depending on the reagents used and no standard calibration is available. It is, however, a readily available test, and a normal aPTT would suggest that haemostatic function is not impaired.[16]

The prothrombin time and international normalised ratio (INR) are measures of the extrinsic pathway. Warfarin is well known to increase the prothrombin time and its effect can be reliably measured by the INR. Dabigatran has been shown to have a linear relationship with INR; however, it is not possible to estimate the therapeutic

Table 4. *Comparison of NOACs*[3–6]

	Dabigatran etexilate	**Rivaroxaban**	**Apixaban**	**Edoxaban**
Pivotal trials	AF; RELY ($n = 18\,113$) Low-dose dabigatran; high-dose dabigatran; warfarin Low dose – stroke or embolism: 1.53% vs. 1.69% ($P \leq 0.001$ non-inferiority) Major haemorrhage: 2.71% vs. 3.36% ($P = 0.003$) High dose – stroke or embolism: 1.4% vs. 1.6% ($P = 0.41$) Major haemorrhage: 1.11% vs. 1.69% ($P \leq 0.001$ superior) VTE; RE-COVER ($n = 2564$) Dabigatran vs. warfarin VTE or death: 2.7% vs. 2.5% Any bleeding 16.1% vs. 21.9% RE-NOVATE Hip replacement ($n = 3493$) Dabigatran vs. enoxaparin VTE or death 7.7% vs. 8.8% $P \leq 0.0001$ non-inferior Major bleeding 1.4% vs. 0.9% ($P = 0.40$)	AF; ROCKET-AF ($n = 14\,264$) Rivaroxaban vs. warfarin Stroke and systemic embolism 1.7% vs. 2.2% ($P = 0.01$ superior) Bleeding 14.9% vs. 14.5% ($P = 0.44$) DVT; EINSTEIN-DVT ($n = 3449$) DVT: rivaroxaban vs. warfarin Recurrent VTE 2.1% vs. 3.0% ($P \leq 0.001$ non-inferior) Bleeding 8.1% vs. 8.1% $P = 0.77$ PE; EINSTEIN-PE ($n = 4832$) Rivaroxaban vs. warfarin Recurrent VTE 2.1% vs. 1.8% Major bleeding 1.1% vs. 2.2% RECORD1 ($n = 4541$) Rivaroxaban vs. enoxaparin VTE or death 0.8% vs. 3.4% non-inferior Major bleeding 0.3% vs. 0.1%	AF; ARISTOTLE ($n = 18\,201$) Apixaban vs. warfarin Stroke or systemic embolism 1.27% vs. 1.60% ($P < 0.001$ non-inferior) Major bleeding 2.13% vs. 3.09% ($P < 0.001$) VTE; AMPLIFY ($n = 5395$ Apixaban vs. warfarin Recurrent VTE or associated death 2.3% vs. 2.7% ($P < 0.001$ non-inferior) Major bleeding 0.6% vs. 1.8% ($P < 0.001$ superior) ADVANCE-2 ($n = 3057$) Apixaban vs. enoxaparin VTE or death 15% vs. 24% ($P \leq 0.001$) Major bleeding 4% vs. 5% ($P \leq 0.09$)	AF; ENGAGE-AF-TIMI 48 ($n = 21\,105$) Warfarin vs. high dose edoxaban vs. low dose edoxaban Stroke or systemic embolism 1.5% vs. 1.18% vs. 1.61% ($P = 0.001$ non-inferior) Major bleeding 3.43% vs. 2.75% vs. 1.61% VTE; Hokusai-VTE ($n = 8292$) Edoxaban vs. warfarin Recurrent VTE 3.2% vs. 3.5% ($P \leq 0.001$ non-inferior) Major and non-major bleeding 8.5% vs. 10.3% ($P = 0.004$ superior)
Target	Direct thrombin inhibitor including free thrombin, fibrin-bound thrombin and thrombin induced platelet aggregation	Direct factor Xa inhibitor. No effect on thrombin or platelets	Direct factor Xa inhibitor Indirectly inhibits platelet aggregation	Direct factor Xa inhibitor.

Continued on next page

Table 4. *Comparison of NOACs[3–6] (continued)*

	Dabigatran etexilate	**Rivaroxaban**	**Apixaban**	**Edoxaban**
Absorption	Dabigatran etexilate is a pro-drug of dabigatran. Absolute availability is 6.5% following oral administration. Absorption is slower on the first day post operatively (peak at 6 hours post administration)	Availability is 80–100% following oral administration but lowers on fasting conditions.	Absolute bioavailability is 50% for doses up to 10mg.	Absolute bioavailability is approximately 62%.
Distribution	C_{max} is attained within 0.5–2 hours Volume of distribution is 60–70 L	C_{max} is attained within 2–4 hours Volume of distribution is ~50 L	C_{max} attained within 3–4 hours Volume of distribution is ~21 L	C_{max} is attained in 1–2 hours Volume of distribution is ~107 L
Half-life and elimination	Half-life is around 12–14 hours 85% is renally excreted, increasing the half-life in renal impairment. Faecal excretion accounted for 6%	Half-life is approximately 5–13 hours On administration two-thirds undergo metabolic degradation with half then being eliminated renally and half faecally. One-third is renally excreted without metabolism	Half-life is approximately 12 hours Multiple routes of elimination including 25% renal clearance	Half-life is approximately 10–14 hours Over 70% excreted unchanged, with 35% excreted by the kidneys
Protein binding and dialysis	Low protein binding is observed with moderate tissue distribution 50–60% dialysed with 200 mL min^{-1} over 4 hours	Plasma protein binding is approximately 92–95%. with serum albumin being the main binding site. Owing to high protein binding it is not expected to be dialysed.	Plasma protein binding is approximately 87% Owing to high protein binding it is not expected to be dialysed	Plasma protein binding is approximately 55% and is not expected to be dialysed
Dosing	AF: 110–150 mg twice daily VTE: 110–150 mg twice daily Elective orthopaedic surgery: 150–220 mg daily	AF: 20 mg daily VTE: 15 mg twice daily for 21 days then 20 mg daily Elective orthopaedic surgery: 10 mg daily	AF: 5 mg twice daily VTE: 10 mg twice daily for 7 days then 5 mg twice daily Elective orthopaedic surgery: 2.5 mg twice daily	AF: 60 mg once daily VTE: 60 mg once daily
Interactions	Concomitant use of anticoagulants should be avoided. Strong P-glycoprotein (P-gp inhibitors such as ketoconazole, ciclosporin, intraconazole and dronedarone are contraindicated. Mild P-gp inhibitors such as amiodarone, verapamil, quinidine, clarithromycin and tigarelor may increase dabigatran exposure	Concomitant use of anticoagulants should be avoided. CYP3A4 and P-gp inhibitors such as ketoconazole or ritonavir increase concentration of rivaroxaban and inducers cause decreased levels	Concomitant use of anticoagulants should be avoided. CYP3A4 and P-gp inhibitors such as ketoconazole are expected to increase levels and inducers are likely to cause decreased levels.	Concomitant use of anticoagulants should be avoided. P-gp inhibitors such as ciclosporin and ketoconazole are expected in increase levels. Reduced levels with P-gp inducers

Table 5. *Using renal function to time dosing of dabigatran*[4]

Renal function (estimated glomerular filtration rate in mL min^{-1})	Timing of last dabigatran dose before surgery
≥ 50	2 days
30–50	4 days
≤ 30	> 5 days

Table 6. *AAGBI Recommendations related to drugs used to modify coagulation*[15]

Drug	Time to peak effect	Elimination half-life	Acceptable time after drug for block performance	Administration of drug while spinal or epidural catheter in place	Acceptable time after block performance or catheter removal for next drug dose
Warfarin	3–5 days	4–5 days	INR 1.4 or below	Not recommended	After catheter removal
Rivaroxaban prophylaxis (creatinine clearance > 30 mL min^{-1})	3 hours	7–9 hours	18 hours	Not recommended	6 hours
Rivaroxaban treatment (creatinine clearance > 30 mL min^{-1})	3 hours	7–11 hours	48 hours	Not recommended	6 hours
Apixaban prophylaxis	3–4 hours	12 hours	24–48 hours	Not recommended	6 hours
Dabigatran prophylaxis or treatment					
Creatinine clearance > 80 mL min^{-1}	0.5–2 hours	12–17 hours	48 hours	Not recommended	6 hours
Creatinine clearance 50–80 mL min^{-1}	0.5–2 hours	15 hours	72 hours	Not recommended	6 hours
Creatinine clearance 30–50 mL min^{-1}	0.5–2 hours	18 hours	96 hours	Not recommended	6 hours

effect based on the INR and, therefore, the INR is not suitable for monitoring. Rivaroxaban, apixaban and edoxaban also increase the prothrombin time; however, again, this effect is unreliable and varies depending on the reagents used. Similarly to using the aPTT, the prothrombin time can be used as an adjunct before surgery to confirm if haemostatic function is impaired in patients on NOACs.[16]

The thrombin time reflects the activity of thrombin in the plasma. The amount of thrombin present and the concentration of thrombin inhibitors determine the time to clot formation. The thrombin time can be used to detect if there is any dabigatran present. There is a linear relationship between the thrombin time and therapeutic doses of dabigatran. However, at high doses the coagulometers cannot calculate this accurately. The test is therefore not suitable for routine use; however, it can be useful for testing for the presence of dabigatran in an emergency situation. It could be useful to check for a normal thrombin time in patients who are taking dabigatran and need to undergo a high-risk intervention such as epidural cannulation or neurosurgery. Rivaroxaban, apixaban and edoxaban have no effect on the thrombin time.[16]

Novel alternatives

There is slowly emerging evidence in support of the Hemoclot direct thrombin inhibitor assay (Hyphen BioMed, France). The test is based on inhibition of a constant amount of highly purified human alpha-thrombin by adding it to diluted test plasma mixed with normal pooled human plasma. It has shown some accuracy in calculating the quantity of dabigatran present in small study populations. However, over the past 2 years no really convincing evidence for its accuracy has emerged and therefore it is not in widespread use. Cost and availability limit its use in low-income settings.

EMERGENCY REVERSAL MANAGEMENT

Assessing the severity of bleeding is the key to managing bleeding complications. Minor bleeding or moderate bleeding may be managed symptomatically. Major and life-threatening bleeding needs to be managed aggressively and reversal agents, where available, should be considered.

Dabigatran is the only NOAC with a specific reversal agent available at the time of writing. Idarucizumab (Praxbind) is a monoclonal antibody indicated for emergency reversal of dabigatran with the recommended dose being 5 g and reversal effects being evident immediately.[17] Praxbind binds to dabigatran with very high affinity. Binding affinity is approximately 300-fold greater than the binding affinity of dabigatran to thrombin.

The half-life of dabigatran after multiple doses is approximately 14–17 hours and is not dose dependent. This makes dabigatran useful in patients with minor bleeding since withdrawal of the drug may be enough. Since the anticoagulant effect of dabigatran declines in parallel with its plasma concentration, urgent but not emergency surgery may need to be delayed for 12 hours from the last dose of dabigatran.[18] If a specific reversal agent is not available, dialysis may be used for patients on dabigatran. It is expected to remove two thirds of dabigatran within a couple of hours.[19] Rivaroxaban, apixaban and edoxaban are not dialysable because they are highly plasma protein bound.

If no specific reversal agent is available, non-specific haemostatic agents can be used for reversal of excessive bleeding.

- Recombinant factor 7a (NovoSeven) initiates thrombin generation by activating factor 10.
- Four-factor prothrombin complex concentrates (Beriplex, Octaplex) contain large amounts of non-activated vitamin K-dependent factors 2, 7, 9 and 10.
- Three-factor prothrombin complexes (Profilnine SD, Bebulin VH) contain small amounts of non-active factor 7 relating to 2, 9 and 10.
- Activated prothrombin complex concentrate (FEIBA NF) contains activated factor 7 and factors 2, 9 and 10.

Studies of non-specific haemostatic agents have not concluded that one agent or another is better for emergency reversal. No studies have produced results showing complete reversal of anticoagulation using the measurements of aPTT, PT and thrombin time. However, use of non-specific haemostatic agents does reverse parts of the coagulation pathway. Bleeding with rivaroxaban, edoxaban and apixaban is best managed symptomatically with withdrawal of the drug and delaying of the surgery if possible. Most guidelines suggest 48 hours from last dose, which is around four half-lives, for necessary surgery. Alternatively, a regional technique could be considered. For example, a block could be performed 18 hours post prophylactic rivaroxaban dose if the patient has normal renal function.[15]

It should be noted that there are phase II and III trials under way looking at specific NOAC reversal agents. Phase III clinical trials with modified factor Xa (andexanet alfa) are on-going. A molecule with broad activity against various anticoagulants including NOACs (aripazine/ciraparantag) is currently undergoing phase II trials.

REVERSAL OF WARFARIN[20]

Warfarin reversal depends on the presentation of the patient and consideration should be given to the indication for warfarin in the patient. Where possible, procedures should be postponed if the INR is too high rather than routinely reversed.

The reversal agent used for warfarin is a synthetic preparation of phytomenadione (vitamin K_1). The presence of vitamin K is essential for formation of prothrombin, factor 7, factor 9 and factor 10.

- Major bleeding – stop warfarin sodium; give 5 mg phytomenadione (vitamin K_1) by intravenous injection; give four-factor prothrombin complex (factors 2, 7, 9 and 10); if prothrombin complex unavailable, fresh-frozen plasma can be given but is less effective.
- INR > 8.0, minor bleeding – stop warfarin sodium; give 1–3 mg phytomenadione (vitamin K_1) by slow IV injection; repeat dose of phytomenadione if INR still too high after 24 hours; restart warfarin sodium when INR < 5.0.
- INR > 8.0, no bleeding – stop warfarin sodium; give 2.5 mg phytomenadione (vitamin K_1) by mouth using the IV preparation orally; repeat dose of phytomenadione if INR still too high after 24 hours; restart warfarin when INR < 5.0.
- INR 5.0–8.0, minor bleeding – stop warfarin sodium; give 1–3 mg phytomenadione (vitamin K_1) by IV injection; restart warfarin sodium when INR < 5.0.
- INR 5.0–8.0, no bleeding – withhold one or two doses of warfarin sodium and reduce subsequent maintenance dose.
- Unexpected bleeding at therapeutic levels – always investigate possibility of underlying cause, e.g. unsuspected renal or gastrointestinal tract pathology.

CONCLUSION

- In all patients, attention should be paid to the balance between the thrombotic risk posed by stopping a patient's anticoagulation and the risk of bleeding.
- New evidence has shown that patients at low thrombotic risk can safely stop warfarin for a surgical procedure without bridging therapy.
- NOACs can be stopped preoperatively with no bridging because of their predictable and consistent pharmacokinetics. Special consideration should be given to dabigatran, whose excretion can be reduced by poor renal function.
- Thrombin time can be used to detect the presence of dabigatran in an emergency situation.

- Specific emergency reversal of dabigatran is now available and antidotes to other NOACs are expected on the market soon.

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Update in
Anaesthesia

Perioperative acute kidney injury

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Key points

Acute kidney injury (AKI) is a common problem in the perioperative period and an independent contributor to morbidity and mortality.

Newer diagnostic criteria based on changes in serum creatinine and decreased urine output have improved earlier detection of AKI but are neither fully sensitive nor specific.

Tubular injury results from a complex interaction between baseline predisposition, haemodynamic disturbances, nephrotoxic insults and inflammatory responses.

Striking a careful balance between fluid under- and over-resuscitation, maintaining adequate systemic arterial pressure and avoidance of nephrotoxins are the cornerstones to preventing or halting the progression of kidney disease.

Cardiopulmonary bypass and IV contrast are additional factors contributing to AKI in cardiac and endovascular surgery respectively.

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INTRODUCTION

Acute kidney injury (AKI) is a syndrome of abrupt decline in renal excretory and homeostatic function. This results in bloodstream accumulation of products of nitrogenous metabolism and failure to regulate body fluid volume, electrolyte concentrations and acid–base balance. Although the incidence of AKI varies according to the sensitivity of definition, some form of renal dysfunction can be observed in about 10% of all acute care hospitalisations[1] and more than 50% of patients admitted to intensive care units (ICUs). In a large study of patients with normal renal function undergoing non-cardiac surgery, the incidence of AKI using sensitive modern definitions was 7.5%.[2] AKI is both a sensitive marker of physiological distress and an independent contributor to morbidity and mortality and even mild transient renal dysfunction has been associated with increased risk of death[1,2] and health care costs.[1] In addition, it is now recognised that, in survivors, recovery from AKI is often incomplete and episodes of AKI are a significant risk factor to development or worsening of chronic kidney disease (CKD).[3] Therefore, high-quality perioperative care should focus on evaluation of risk, early detection of renal dysfunction and appropriate supportive management of AKI in order to improve patient outcomes.

DIAGNOSIS OF AKI

The term AKI has replaced the term 'acute renal failure' as it best describes a clinical spectrum of disease of differing severity rather than an all-or-none phenomenon of organ failure. This change has been accompanied by the realisation that serum creatinine (SCr) has many limitations for the diagnosis of acute renal dysfunction. SCr is a product of muscle breakdown and therefore depends on age, gender, nutrition and muscle mass. Creatinine values thus have to be placed in the context of the individual patient and point in the time-course of AKI. At steady state, SCr is reciprocally related to glomerular filtration rate (GFR), but starts to increase significantly only when about 50% of glomerular filtration has been lost (Figure 1). In addition, baseline SCr values will imply very different GFR depending on age, sex and race (Figure 2). Therefore, it is possible that early renal dysfunction may often go undetected.

The development of the Risk, Injury, Failure, Loss, End Stage (RIFLE) classification of AKI in 2004 refocused approaches to AKI.[4] These criteria have most recently been updated in the 2012 Kidney Disease Improving Global Outcomes (KDIGO) criteria for the diagnosis and management of AKI (Table 1).[5] This diagnostic classification of AKI emphasises relative

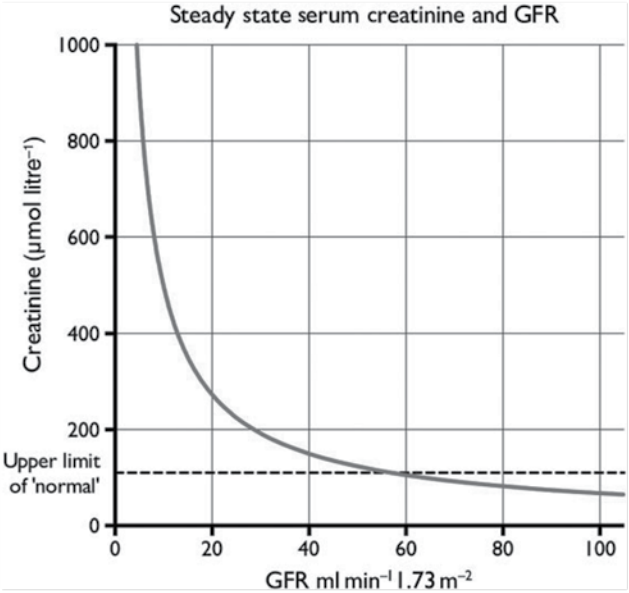

Figure 1. *Steady-state SCr plotted versus GFR in a 70-year-old white male. Large changes in GFR can be associated with small changes in SCr in and just above the 'normal range'.*

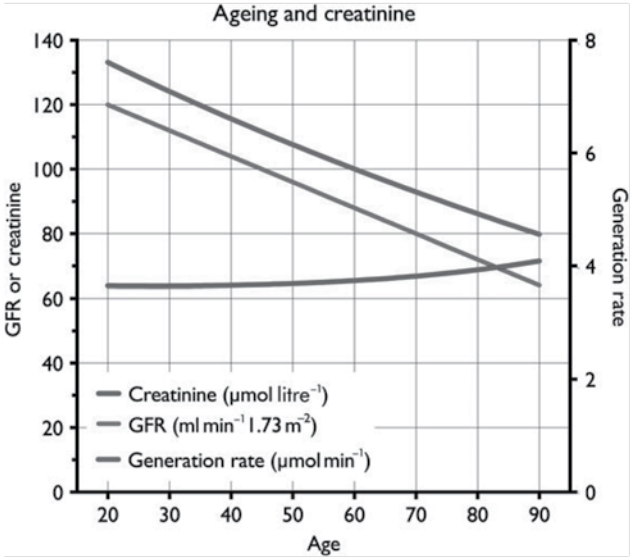

Figure 2. *Predicted change in normal GFR and SCr with age in a white female. The same creatinine is associated with very different GFR at different ages. Creatinine generation and GFR decline in parallel with age.*

Table 1. *KDIGO clinical practice guideline for AKI: staging of AKI*[5]

Stage	Serum creatinine	Urine output
1	1.5–1.9 × baseline or ≥ 0.3 mg dL^{-1} (≥ 26.5 μmol L^{-1}) increase within 48 hours	≤ 0.5 mL kg^{-1} h^{-1} for 6–12 hours
2	2.0–2.9 × baseline	≤ 0.5 mL kg^{-1} h^{-1} for 12 hours
3	3.0 × baseline or Increase in serum creatinine to 4.0 mg dL^{-1} (≥ 353.6 μmol L^{-1}) or Initiation of renal replacement therapy or In patients < 18 years, decrease in eGFR to < 35 mL min^{-1} per 1.73 m^2	≤ 0.3 mL kg^{-1} h^{-1} for 24 hours or Anuria for 12 hours

ACEI, angiotensin-converting enzyme inhibitor; A2RB, angiotensin II receptor blocker; NSAID, non-steroidal anti-inflammatory drug; CKD, chronic kidney disease.

increases in SCr from baseline as a more accurate marker of worsening glomerular function than actual SCr values alone. However, in the dynamic situation of individuals with acute illness, applying these definitions can be more difficult as there is often a time lag between an acute decrease in GFR and an increase in SCr to a new steady state, which itself may be further delayed by changes in volume of distribution and creatinine generation rate. In recognition of this, urine output criteria have been incorporated into standardised AKI definitions. Sustained oliguria (> 12 hours) is a highly specific marker of AKI; however, it is insensitive as significant reduction in GFR can occur in the absence of oliguria. Conversely, shorter periods of low urine output are less specific in the perioperative situation as they may merely reflect response to physiological stress and transient haemodynamic changes in the absence of worsening kidney function.[6]

AKI PATHOPHYSIOLOGY

The aetiology of AKI is traditionally classified into pre-renal, intrinsic and post-renal causes (Table 2). However, while the identification of obstruction and intrinsic kidney diseases (such as interstitial

Table 2. *Aetiological classification of AKI*

Haemodynamic 'pre-renal'	Intrinsic renal disease	Post-renal
Hypovolaemia • Bleeding • Dehydration • Extravasation *Vasodilatory hypotension* • Sepsis *Low cardiac output states* *Acute and chronic heart failure* *Locally impaired renal circulation* • Medication (ACEI, A2RB, NSAIDs) • Renovascular disease • CKD • Chronic liver disease • Abdominal compartment syndrome	*Acute tubular injury* Multifactorial aetiology with common inflammatory pathogenesis Causes include: Systemic inflammation • Sepsis, major surgery, cardiopulmonary bypass, etc. Prolonged or total ischaemia • Unresolved haemodynamic factors Exogenous nephrotoxins • Aminoglycosides • Radiological contrast etc. *Pigment nephropathy* • Rhabdomyolysis, haemolysis including cardiopulmonary bypass *Metabolic syndromes* • Hypercalcaemia • Hyperuricaemia *Autoimmune/inflammatory* • Glomerulonephritis • Vasculitis • Thromobotic microangiopathies • Interstitial nephritis	*Obstruction* • Prostatic hypertrophy • Nephrolithiasis • Retroperitoneal fibrosis • Pelvic masses • Bladder tumours, etc.

nephritis) is important, these diagnoses account for only a small proportion of cases of postoperative AKI, the majority of which are related to tubular injury of have a multifactorial aetiology.

In true pre-renal AKI, haemodynamic compromise and neuro-endocrine responses result in decreased GFR and oliguria that is fully reversible with correction of haemodynamic disturbances. In reality, there is usually significant overlap with tubular injury triggered by prolonged haemodynamic disturbance, and so clinical efforts to distinguish pre-renal AKI from intrinsic tubular injury are rarely successful or helpful. The pathogenesis of tubular injury after major surgery is a result of complex interaction between baseline predisposition, haemodynamic disturbances, nephrotoxic insults and inflammatory responses. Inflammatory mechanisms play a central role, causing both direct cellular injury and inflammation-induced microcirculatory dysfunction contributing to local tissue ischaemia.

Thus, AKI is often one expression of the inflammatory processes that underlies general multi-organ dysfunction in critical illness. Tissue ischaemia is likely to play an important role in the initiation of perioperative AKI; however, renal injury may persist because of ischaemia-induced inflammation and local alterations in microvascular perfusion. Preglomerular resistance may in turn be increased in response to tubular injury, reducing renal perfusion that is independent of systemic haemodynamics. Thus, once established, these processes may not be readily reversed by manipulation of the systemic circulation aimed at maximising global renal oxygen delivery. Recognition of stage in the pathophysiology of AKI is therefore essential in selecting appropriate likely clinical progress and appropriate management (Figure 3).

PREOPERATIVE: ASSESSMENT AND PLANNING

Preoperative assessment should aim to identify those at greatest risk of AKI, allowing pre-optimisation and planning for higher level postoperative care and monitoring in the most vulnerable. Risk factors can be divided into patient, operative, and pharmacological factors (Table 3). Although many patient risk factors are unmodifiable, efforts should be made to optimise cardiorespiratory status,

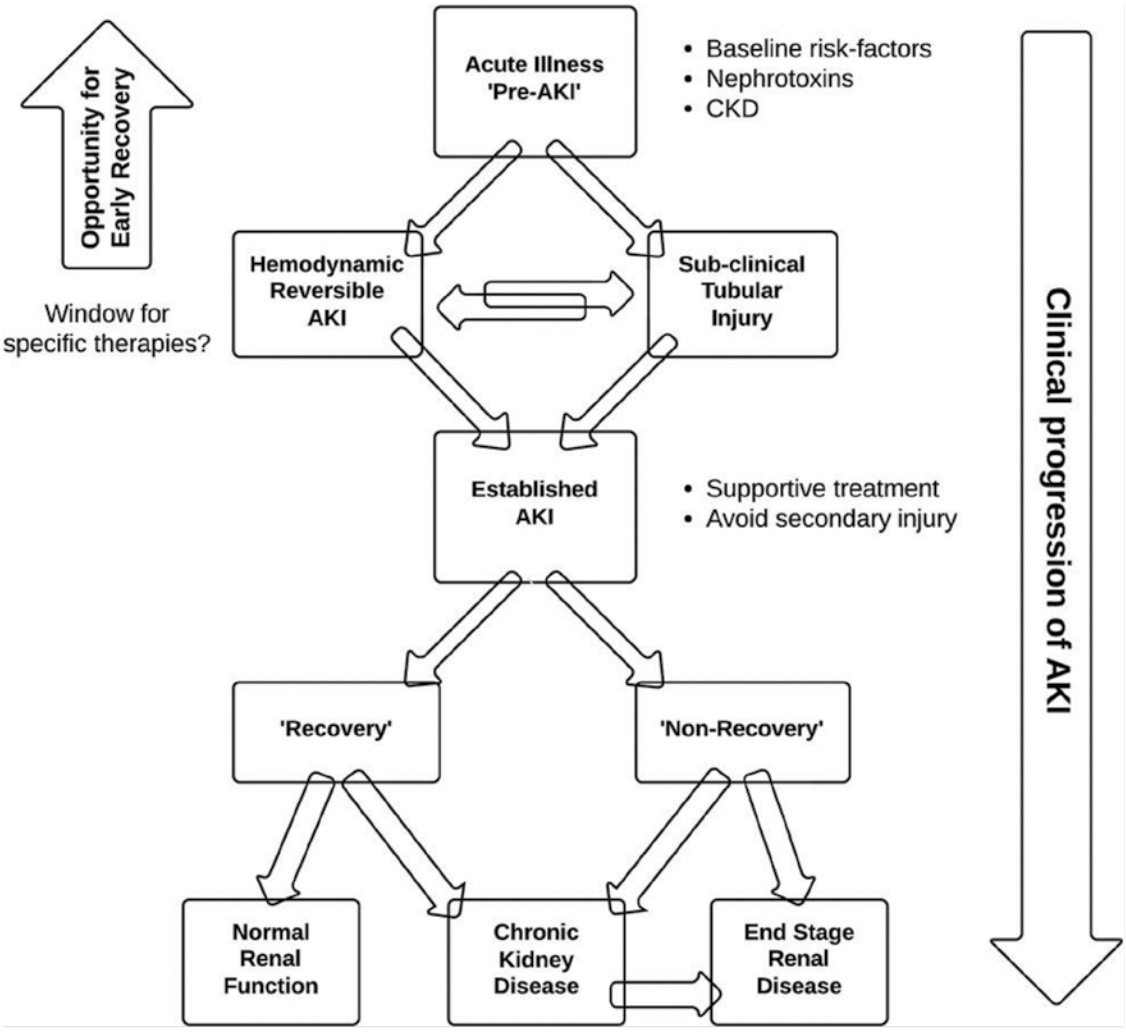

Figure 3. *Clinical course of AKI. Initiation of AKI can involve haemodynamic changes in GFR, subclinical tubular injury or both processes occurring simultaneously. A short window may exist when specific therapy might reverse AKI; however, this treatment may need to be tailored to the nature of the injury. Recovery from established AKI takes days to weeks; the emphasis in this case should be on supportive therapy and the avoidance of secondary renal injury that may result in non-recovery of renal function or CKD. Reproduced with permission from Prowle JR. Acute kidney injury: an intensivist's perspective.* Pediatric Nephrology *2014;* ***29****: 13–21.*

Table 3. *Risk factors for perioperative AKI*

Patient	Operative	Pharmacological
Age	Emergency surgery	Non-steroidal anti-inflammatory agents
Male sex	Cardiac surgery	Angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers
CKD	Liver transplant surgery	
Chronic cardiac failure	Vascular surgery	Antibiotics (aminoglycosides, glycopeptides, etc.)
Hypertension	Intraperitoneal surgery	Immunosuppressive drugs (calcineurin inhibitors)
Chronic liver disease	Duration of surgery	Hydroxyethylstarch solutions
Diabetes mellitus	Major haemorrhage	Radiological contrast
Sepsis	Blood transfusion	
Limited cardiorespiratory reserve	Intraoperative hypovolaemia and hypotension	

nutrition and glycaemic control and to minimise nephrotoxin exposure. Cardiopulmonary exercise testing can be used to better define cardiorespiratory reserve to aid risk stratification. Those with known CKD are at highest risk for AKI and require most careful attention to arterial pressure and fluid balance. The need for nephrotoxic medication, such as NSAIDs, should be balanced against risk of AKI and such medication should be avoided in patients with significant risk factors. Antibiotics with nephrotoxic properties, such as aminoglycosides, should be judiciously considered, taking into account the degree and likelihood of microbial contamination or active infection and likely sensitivities to the antibiotics in question.

Sepsis is the leading cause of AKI in the ICU and concerns about nephrotoxicity should not prevent adequate treatment of infection, providing dosing and monitoring for level of renal function is appropriate. The need for regular antihypertensive medication in the perioperative period should also be reviewed considering the likelihood of postoperative vasodilatory hypotension and additional risk factors such as epidural anaesthesia. In particular, angiotensin-converting enzyme inhibitors and angiotensin II receptor blockers will selectively reduce glomerular perfusion pressure and systemic arterial pressure. Although clinical trials showing a clear benefit of omission of these agents during the perioperative phase are lacking, it is suggested that for high-risk patients and those with limited cardiovascular reserve, they should not be given on the day of surgery and not recommenced until after recovery from the acute effects of surgery.

PERIOPERATIVE MANAGEMENT

Haemodynamic management and fluid therapy

Targeted approaches to perioperative haemodynamic management have been shown to improve patient and renal outcomes after high-risk surgery and we suggest that goal-directed perioperative fluid management should be considered in patients deemed at high risk of AKI and all patients undergoing high-risk surgery. Such goal-directed therapy (GDT) strategies involve titrating fluid boluses and/or inotropic drugs to endpoints such as cardiac output (as provided by oesophageal Doppler, pulse contour waveform analysis or dilutional techniques) or markers of end-organ perfusion (such as arterial lactate).

Adequate monitoring of fluid resuscitation is essential in at-risk patients as there is often a fine balance to be met between resuscitating to achieve an adequate cardiac output (to prevent renal ischaemia) and avoidance of fluid overload, which is associated with adverse postoperative outcomes. Several lines of evidence suggest that fluid overload may worsen AKI,[7] decrease survival in those developing AKI and is associated with impaired recovery of renal function in patients surviving critical illness.[8] Timing of fluid resuscitation may also be crucial and experimental evidence suggests that early compared with late systemic resuscitation in systemic inflammatory states reduces renal inflammation and improves microvascular perfusion.[9] Therefore, GDT protocols may afford the best method of minimising risk of hypovolaemia, delayed resuscitation and fluid overload. A recent meta-analysis not only demonstrated a reduction in AKI with the use of perioperative GDT, but also showed that overall, the amount of fluid given in the GDT group was similar to the non-GDT group.[10] This suggests that the timing and appropriate targeting of fluid therapy is the important factor and is unlikely to contribute to fluid overloaded states.

Composition of resuscitation fluid remains an area of controversy. Evidence of increased harm with starches and lack of clear benefit compared with crystalloids or albumin led to its withdrawal in June 2013. However, there is currently no clear consensus on superiority of albumin or crystalloids. For crystalloids, there is evidence that balanced salt solutions should be given in preference to 0.9% saline, which has been associated with development of hyperchloraemic acidosis, decreased renal blood flow (RBF) and increased risk of AKI.[11]

Vasopressors

Maintaining an adequate mean arterial pressure (MAP) is essential to preserving renal function, both to ensure adequate renal perfusion pressure and to maintain the transglomerular pressure gradient for ultrafiltration. Hypotension related to systemic vasodilation, as a consequence of systemic inflammatory response to surgical trauma or sepsis, or the effects of medication and neuroaxial block is common in postoperative settings. Vasodilatory hypotension is unlikely to respond to fluid therapy and over-reliance on IV fluids in these settings is likely to lead to prolonged hypotension and fluid overload.

While vasoconstrictors have historically been regarded as potentially harmful to an ischaemic kidney, most available evidence favours moderate vasopressor use in vasodilatory shock. The use of noradrenaline has been shown to improve RBF, GFR and urine output in experimental models of septic AKI and clinical settings. This is because systemic vasoconstrictors have a larger positive effect in increasing renal perfusion pressure than a negative effect caused by increases in renal vascular resistance. Vasopressor management in AKI requires consideration of what MAP is normal for any individual and higher levels may need to be targeted in the elderly and chronically hypertensive. It is difficult to make specific recommendations; however, increasing MAP up to 75 mmHg has been shown to increase renal oxygen delivery and GFR during post-cardiac surgery AKI, while higher targets did compromise renal perfusion in some.[12]

Other specific therapies

There is no evidence that renal vasodilators prevent the onset or halt the progression of AKI in clinical settings. In particular, a large randomised multicentre trial demonstrated that low-dose dopamine is ineffective in the treatment of early AKI.[13] Such agents are not recommended outside clinical trial settings.

The use of diuretics should be limited to controlling fluid balance and preventing fluid overload. Although diuretics may improve urine output, there is no evidence that they reduce the onset of AKI or alter GFR. Inappropriate diuretic use risks hypovolaemia and additional renal injury.

There is also insufficient evidence to support the use of atrial natriuretic peptide, nesiritide (recombinant human β-natriuretic peptide) or theophylline in the prevention or treatment of AKI.

AKI IN SPECIFIC PERIOPERATIVE SETTINGS

Cardiac surgery

Up to 50% of high-risk patients undergoing cardiac surgery with cardiopulmonary bypass (CPB) develop some degree of postoperative AKI. Cardiac surgery-associated AKI involves several synergistically injury pathways including ischaemia–reperfusion injury, exogenous and endogenous toxins, inflammation, oxidative stress and vasodilation. The use of a CPB pump has been associated with elevation in levels of systemic inflammatory mediators and length of time on CPB is a well-recognised risk factor for the development of AKI. Oxido-inflammatory changes during CPB can be further exacerbated by haemolysis in the extracorporeal circuit with release of free haemoglobin into the circulation. Haem-induced oxidant injury is likely to be a consequence of lipid peroxidation leading to the formation of potent renal vasoconstrictors and by direct cellular injury.

Thus, in common with most forms of AKI, cardiac surgery-associated AKI is multifactorial and management involves recognition of risk, early diagnosis, and supportive haemodynamic therapy. However, there are specific nephrotoxic features of CPB surgery, and some evidence suggests that 'off-pump' surgery, where feasible, is associated with lower risk of AKI.[14]

Endovascular surgery

Interventional procedures such as endovascular aortic repair are associated with specific risk of AKI. Mechanism of renal injury is again multifactorial with mechanisms including contrast-induced AKI (CI AKI), guidewire embolisation of atheromatous material from major vessels, perioperative hypotension and inflammation.

CI AKI can occur in as many as 25% of patients with pre-existing renal impairment or those exposed to other major risk factors. Postulated mechanisms of contrast toxicity include increased systemic vasoconstriction, decreased local prostaglandin and nitric oxide-mediated vasodilatation and a direct toxic effect on renal tubular cells. Current consensus recommendations are to use the lowest possible dose of iso- or hypo-osmolar contrast. In order to limit the cumulative dose of contrast at the time of surgery, preparative imaging should be done as far in advance as possible.

Avoidance of hypovolaemia and adequate hydration with isotonic crystalloid has been proven to reduce the risk of CI AKI. While sodium bicarbonate has theoretical benefits over isotonic saline, evidence of clinical superiority is lacking. A suggested fluid regime is $3\,mL\,kg^{-1}$ isotonic crystalloid (0.9% saline, buffered solutions or isotonic sodium bicarbonate) 1 hour before exposure, followed by $1\,mL\,kg^{-1}\,h^{-1}$ post exposure for 6–24 hours. Prophylactic fluid therapy remains the only proven intervention for the prevention of CI AKI and there is currently insufficient evidence to recommend the use of theophylline, fenoldopam or prophylactic haemodialysis or haemofiltration.

Evidence for the use of N-acetylcysteine for the prevention of CI AKI is neither consistent nor overwhelming, and recent guidelines produced by NICE[15] and the UK Renal Association, British Cardiovascular Intervention Society and the Royal College of Radiologists[16] suggest that there is no convincing benefit for prescribing oral or IV acetylcysteine or any other pharmacological agents to prevent CI AKI.

CONCLUSIONS

AKI is associated with significant perioperative morbidity and mortality but is complex to diagnose and lacks evidence-based clinical interventions. Preventative management relies on identification of patients at risk, avoidance of nephrotoxins, optimisation of haemodynamics (including use of GDT) and assiduous monitoring during the period of risk. Current investigations for AKI have significant limitations and diagnosis is often late and imprecise. Once AKI is overt, the immediate clinical course may be unalterable and emphasis should be placed on best supportive care and avoidance of harm, including iatrogenic fluid overload, while recovery occurs.

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Update in
Anaesthesia

Anaesthetising the malnourished patient

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Definitions

Malnutrition – the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth, maintenance and specific functions.

Undernourishment – consuming less than the recommended minimum number of calories required for growth whilst performing light exercise. The World Food Programme's recommended food calorie intake per day is 2100 kcal per person. Additional calories are required when pregnant and if breast feeding.[1]

Starvation – a severe deficiency in calories, vitamins or protein.

Inanition – the symptoms and effects of starvation.

Cachexia – excessive weight loss in the context of on-going disease, usually with disproportionate muscle wasting.[2,3]

Severe malnutrition – multisystem disorder affecting every cell, organ and system. World Health Organization (WHO) guidelines defined as severe wasting (<70% weight for height or <3 standard deviations) with or without symmetrical oedema (see Table 1).[4]

INTRODUCTION

There are an estimated 923 million undernourished people worldwide according to 2008 estimates. This number is decreasing, but malnutrition remains a major problem, and one frequently encountered in the health care setting of developing countries.[5] Malnutrition is thought to contribute to 5 million of the 10.6 million infant deaths that occur in the world annually.[6] Growth retardation and inability to fight disease cause significant long-term morbidity in survivors.

Children are at particular risk, with an estimated 50.6 million malnourished children < 5 years worldwide. Among hospitalised children, the mortality rate is 30–50% (World Health Organization).

Malnourishment is also a problem for the anaesthetist working in the western world, with 25–40% of hospital inpatients in the USA being malnourished, only half of whom are identified by medical staff.[7] Aside from inadequate dietary calorie intake, a variety of other causes of malnutrition must be considered by the anaesthetist in the preoperative assessment of patients.

AETIOLOGY

The basic cause of malnourishment is an imbalance between energy intake and energy expenditure. There are a variety of causes, which can broadly be divided into patient factors and environmental factors (Table 2).

CLASSIFICATION

Protein–energy malnutrition (PEM) is an umbrella term covering the conditions of kwashiorkor, marasmus and kwashiorkor–marasmus in combination. These are WHO-classified conditions predominantly affecting young children at weaning age.

Kwashiorkor

- A term first coined in 1935 translated from the Ga language meaning 'the sickness the baby gets when the new baby comes'.[8]
- A syndrome caused by severe protein deficiency despite overall energy intake that is adequate. Characterised by irritability, anorexia, oedema and ulcerating skin lesions. Abdominal distension, fatty liver and immune deficiency also occur (see Table 1).[3]
- Cell membrane dysfunction leads to potassium and water leak from cells, causing oedema and fluid shifts.

Key points

Malnutrition is a significant problem worldwide and will be faced by all anaesthetists working in developing countries.

Anorexia nervosa and malnutrition in Western countries has a high mortality rate. Patients are at increased risk if not identified and managed promptly.

Malnutrition is a whole-body disorder affecting all systems, organs and cells.

All patients who are malnourished should be treated as though they have a full stomach.

Careful adjustment of drug dosing and an understanding of the pharmacokinetics specific to the malnourished patient are vital.

Sean Edwards
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Table 1. *Waterlow classification of malnutrition*[9]

Degree of protein–energy malnutrition	Stunting (% height for age)	Wasting (% weight for age)
Normal (grade 0)	> 95	> 90
Mild (grade 1)	87.5–95	80–90
Moderate (grade 2)	80–87.5	70–80
Severe (grade 3)	< 80	<70

Table 2. *Categorising causes for malnutrition*

Category	Causes
Economic/environmental	inability to buy food/poverty
	Food scarcity
	Access issues (poor infrastructure)
	Natural disasters
	Civil war
	Erratic weather patterns (poor yields)
Psychiatric	Anorexia
	Bulimia
	Depression
	Social isolation
	Alcohol abuse
Incapacitation	ICU patients/coma
	Burns victims
	Cardiac cachexia
	Chronic obstructive pulmonary disease
Malabsorption	Coeliac disease
	Short bowel syndrome
	Hyperemesis
	Intestinal worms
Physical	Cleft palate/lip/maxilla[10]
	Facial deformity
	ENT or maxillofacial surgery
	Poor dentition

- Profound hypokalaemia and hypophosphataemia are of most importance to the anaesthetist. These are due to cellular leakage; whole body sodium is elevated.
- The liver's inability to process fats is manifested as intracellular fat deposition and fatty liver.
- Xerophthalmia, a severe vitamin A deficiency resulting in conjunctival dryness, corneal dryness, ulceration and ultimately blindness if left untreated, is also recognised.

Marasmus

- Named from the Greek *marasmos* – decay or wasting.
- Extreme form of malnutrition classified as body weight < 60% of expected.
- Condition caused by overall lack of dietary calorie intake and energy deficit.
- Patients appear emaciated with muscle wasting and loss of subcutaneous fat.

PATHOPHYSIOLOGY

Catabolism and the starvation response

The body exhibits an adaptive 'starvation response' to prolonged inadequate calorie intake. This is initially focused on mobilising energy stores to provide glucose and later ketones as an energy substrate for the brain and central nervous system. The starvation response can broadly be divided into three main stages, as outlined in Table 3.

When considering the pathological effects of prolonged starvation it is useful to classify the problems using a systems-based approach (Table 4).[11] Starvation is a 'whole body' response to inadequate calorie intake that is partly adaptive and partly maladaptive. Cachexia is weight loss as a manifestation of underlying physical disease, cardiac disease, chronic obstructive pulmonary disease (COPD) malignancy and chronic renal failure being the major causes. Inflammatory mediators, especially cytokines, are thought to play a role in the excessive weight loss associated with these conditions.[12]

Refeeding syndrome

Refeeding syndrome describes the metabolic alterations that result from rapid nutrition repletion in severely malnourished patients. It is thought to occur in 6–10% of malnourished patients who are given nutrition in hospital. Severity increases in relation to severity of pre-existing malnourishment status.

Hyperinsulinaemia following commencement of nutrition leads to decreased gluconeogenesis and decreased anaerobic metabolism. Rebound hypoglycaemia can easily occur if blood sugar levels are not checked regularly. Hyperinsulinaemia results in rapid movement of extracellular phosphate, potassium and magnesium into the intraceullar compartment, which can cause dangerous spikes in serum electrolyte concentrations (especially potassium). Low extracellular phosphate levels reduce ATP levels intracellularly, and 2,3-diphosphoglycerate (2,3-DPG) levels in erythrocytes are also reduced.

Clinical features include arrhythmias and systolic heart failure. Increased cardiac output, plasma volume and basal metabolic rate can overwhelm the ventricle, leading to congestive cardiac failure. Central nervous system effects include seizures, delirium and coma.

Table 3. *Phases of the starvation response*

Phase	Details	Timing
Glycogenolytic	70–100 g of glycogen stored in the liver and a further 400 g stored in the muscles is mobilised as an energy substrate	First 24 hours (early)
Gluconeogenic (early < 24 hours)	Insulin levels fall in response to low glucose and amino acid levels, glucagon levels rise and lipolysis occurs in the liver	Up to 24 hours
	Glucose forms from glycogen due to lower insulin levels.	
Gluconeogenic (late)	After 24 hours all new glucose is derived from:	Beyond 24 hours (Intermediate)
	amino acids (alanine being the most important)	
	glycerol (from adipose tissue)	
	lactate (from erythrocytes via the Cori cycle)	
	This coincides with a rise in plasma glucagon concentration and continued insulin suppression	
	Increased catecholamines and cortisol mobilise fat stores, increasing plasma free fatty acids	
	Gluconeogenesis declines after 3–4 days as the body adjusts to mobilise energy from fat stores (fully adjusted by 2 weeks)	
Ketogenic	Ketone bodies gradually replace glucose as the fuel source for the brain and nervous system up to a maximum of 50%	Up to 2 weeks (and beyond)
	Ketone body formation by the liver is maintained	
	Other tissues (cardiac and skeletal muscle) obtain energy from free fatty acids	
	In this phase gluconeogenesis is reduced as a protein-sparing mechanism. This occurs at 10 days via reduction in glucagon. Initial protein catabolism = 70 g day^{-1}, reducing to 20 g day^{-1} by week 3	

To avoid refeeding syndrome, 5 kcal kg^{-1} day^{-1} is recommended in a deliberate under-delivery of calories in the early stages of refeeding. This should be coupled with judicious measurement of serum electrolytes on a daily basis with early correction of abnormalities as they occur. Input from a specialist dietitian and early identification of the patient at risk of refeeding syndrome are of the utmost importance.

The WHO recommends a three-phase refeeding protocol for patients at risk of refeeding syndrome:

1. rapid resuscitation phase
2. stabilising phase
3. weight gain and rehabilitation phase.

PRACTICAL TIPS

Preoperative assessment

History

History may be difficult to elicit in some patients, especially those with underlying psychiatric disorders. Aim to quantify overall daily calorie intake, as well as ascertaining whether the diet is balanced or lacking in crucial micronutrients. Specific questions about laxatives, amphetamines and diuretic use as well as menstrual cycle are useful in anorexic patients.

Examination

A full examination is essential with particular attention to the following features:

- thin, cachectic or wasted appearance – sunken eyes, prominent clavicles
- oedema and abdominal swelling, which can mask overall malnorished state in kwasiokor patients
- hydration status – dry skin and mucous membranes, dry tongue, decreased skin turgor
- orange tinged palms and soles as evidence of carotenaemia in anorexia nervosa
- lanugo hair
- amenorrhoea in females
- heart murmur
- hypotension.

The European Society for Clinical Nutrition and Metabolism (ESPEN) suggests that severe undernutrition is present if one of the following is present:[13]

- weight loss >10–15% within the past 6 months
- body mass index < 18.5
- subjective global assessment grade C (severely malnourished)
- serum albumin <3 g L^{-1} (in the absence of hepatic or renal dysfunction).

Additional tools

- Nutritional Risk Assessment Scale (NRAS).[16]
- Triceps skinfold thickness or mean arm circumference.
- body mass index.

Table 4. *Body systems affected by malnutrition*

System	Features
Central nervous system	Impaired mental ability
	Mental depression
	Depressed cognitive function
	Fatigue and generalised weakness
Musculoskeletal	Muscle mass and strength reduced
	Histologically confirmed myopathy in severe anorexia nervosa patients
	Reduced bone mass, osteopenia and osteoporosis with secondary fractures
	Impaired thermoregulation
	Impaired wound healing
Cardiovascular	Reduction in cardiac output and blood pressure and bradycardia
	Increased risk of arrhythmia due to vitamin and electrolyte disturbance
	Mitral valve prolapse (poorly understood? due to weak and thin ventricular wall)
	Loss of cardiac muscle mass with associated reduced left ventricular function and ejection fraction (consider echocardiography in anorexic patients)
	Increased vagal tone
	Peripheral vasoconstriction
	Sinus arrest and wandering atrial pacemakers
	ECG changes
	Prolonged QTc
	ST depression and T-wave inversion[14]
Respiratory	Reduced respiratory muscle strength and function
	Spontaneous pneumothorax
	Pneumomediastinum from persistent vomiting
	Decreased respiratory compliance (due to decreased elasticity of lung tissues)
Renal	Reduced glomerular filtration rate
	Total body water proportionally higher
	Proteinuria
	High urea due to dehydration
Gastrointestinal	Decreased enteral feeding leading to gut atrophy, bacterial translocation and impaired immune function (due to larger gaps between enterocytes)
	Oesophagitis and Mallory–Weiss tear from purging
	Gastric dilatation
	Paradoxical decrease in gastric emptying time
Micronutrient disturbances	Vitamin A insufficiency – blindness (xerophthalmia due to corneal ulceration is the leading cause of childhood blindness worldwide), immunosuppression[12]
	Reduced iron, ferritin and iron deficiency anaemia
	Folic acid and zinc levels may also be low
Electrolyte disturbances	Hypokalaemia (due to repeated purging and vomiting)
	Hypocalcaemia = prolonged non-depolarising muscle relaxation action. Can lead to tetany but low K^+ prevents this (rapid K^+ replacement can precipitate it though)
	Hypoglycaemia and hypoglycaemic coma
	Metabolic alkalosis (less common in malnutrition, more likely in patients who purge)
	Increased cortisol and corticotrophin-releaseing hormone levels with blunted response

Continued on next page

Table 4. *Body systems affected by malnutrition (continued)*

System	Features
Haematological	Leucopenia. Can be graded using Common Terminology Criteria for Adverse Events: < 1.2 = grade 3 < 2.8 = grade 2 < 3.0 = grade 1 Further drop due to stress response can occur due to inability to produce leucocytes Often normal immune function until 50% drop in normal expected body weight. Elevated liver transaminases Anaemia (often mild, due to bone marrow hypoplasia) Pancytopenia
Pharmacological	Delayed or reduced absorption of drugs Hypoalbuminaemia increases free fraction of drugs, decreased protein binding occurs[15] Prolonged treatment with non-depolarising muscle relaxants Lower total body mass means reduced drug doses required and lowered thresholds for toxicity Neostigmine, edrophinium and catecholamines can cause life-threatening arrhythmias[14]

Table 5. *General principles for routine care of malnourished patients (extracted from WHO nutritional guidelines)[7]*

Goal	Description
Prevent hypoglycaemia	50 mL of 10% glucose (one heaped teaspoon of sugar in 70 mL of water) orally or bynastrogastric tube If lethargic/fitting/unconscious, 5 mL kg^{-1} 10% dextrose IV then 50 mL 10% dextrose orally or by nasogastric tube Prevent relapse with 2-hourly feeds
Prevent hypothermia	If axillary temperature is < 35ºC or rectal temperature < 35.5ºC, rewarm until temperature > 36.5ºC. Consider skin-to-skin, clothing, heaters, wrapping head. Start feeding
Treat and prevent dehydration	*Do not treat with IV fluids unless shocked. Low blood volume + oedema can be exacerbated by IV fluids* Administer rehydration salts, 5 mL kg^{-1}, orally or by nasogastric tube Assess for tears, fontanelle, skin turgor and mouth moistness Beware of overhydration as evidenced by raised respiratory rate or heart rate
Correct electrolytes	Use caution K^+ 3–4 mmol kg^{-1} day^{-1} Mg^{2+} 0.4–0.6 mmol kg^{-1} day^{-1}
Identify and treat infection	Normal signs such as raised temperature may be absent in malnourished children Give broad-spectrum antibiotics and metronidazole, which helps heal bowel mucosa
Correct micronutrient deficiencies	Wait 2 weeks before administering iron Correct vitamin A deficience immediately, first checking for eye signs (corneal clouding or ulceration) Administer multivitamins and folic acid for 2 weeks Consider zinc if evidence of skin desquamation or ulceration Transfuse if Hb < 4 g dL^{-1} or if compromised and < 6 g dL^{-1}
Cautious refeeding	Homeostatic capabilities will be blunted so feeding should be commence cautiously Aim for >10 g $kg–^{1}$ day^{-1} weight gain Consider refeeding achieved when < 1 SD or > 90% weight for length
Emotional support	Emotional and psychological support should be provided to parents and patient.

Investigations

- Bloods – full blood count (FBC), creatinine and electrolytes, liver function tests, calcium, phosphate, magnesium, glucose, transferrin, albumin.[17]
- Urinalysis for proteinuria and ketonuria.
- ECG for cardiovascular complications or evidence of electrolyte imbalance.
- Where available echocardiography can be considered in selected patients in whim a murmur is heard or who exhibit signs of cardiac failure.

Preoperative optimisation (see Table 5)

- Adequate hydration and correction of electrolyte abnormalities for emergency cases.
- Elective cases with albumin $< 34\,g\,dL^{-1}$ or lymphocyte count <1400 should have dietary problems corrected prior to major surgery.[17]
- 7–10 days of preoperative parenteral nutrition has been shown to improve outcomes in malnourished patients[15,18]

Perioperative management

Induction

Adequate rehydration prior to induction is essential to avoid cardiovascular collapse. Be wary of IV hydration in oedematous children. Malnourished patients are at increased risk of aspiration due to gastric distension and delayed gastric emptying so consider inserting a nasogastric tube prior to intubation and have a low threshold for rapid sequence induction with cricoid pressure. Consider an antacid and a prokinetic prior to induction.

Intraoperative care

Malnourished patients are at high risk of intraoperative hypothermia. Make efforts to keep the patient warm with warmed IV fluids, patient warmer, heat and moisture exchange (HME) filter and careful monitoring of perioperative core temperature. Careful positioning is paramount to avoid nerve compression as reduced cushioning and muscle mass are common. Pressure-related necrosis or fractures due to careless posturing are also recognised in the underweight population.

Consideration of drug dosing, bearing in mind reduced total body mass, albumin concentration and volume of distribution, can avoid toxicity. Non-depolarising muscle relaxants should be administered with the use of a nerve stimulator to avoid dosing errors and a partial reversal scenario. Smaller initial doses are required as electrolyte abnormalities can potentiate their actions. Avoid reversal of neuromuscular blockade where possible, allowing agents to wear off spontaneously as this increases the risk of arrhythmias.

Hyperventilation should be avoided as this can further lower potassium levels, lowering the threshold for life-threatening arrhythmias. Halothane should be avoided for the same reason given its increased potential to cause arrhythmias. Given the potential for cardiovascular instability and reduced cardiac output state the anaesthetist should have a low threshold for invasive cardiac monitoring. The incidence of intraoperative arrhythmias has been reported to be as high as 16–62%.[14]

Postoperative care

There is a high possibility of difficult extubation due to impaired respiratory muscle function and impaired upper airway reflexes in the severely malnourished patient. Aim to extubate the patient when he or she is fully awake and responding to commands, if feasible.[19]

Early enteral feeding has been shown to be beneficial. Be wary of hypoglycaemia in the immediate postoperative period as the stress response to surgery can deplete glucagon stores. Cautious glucose replacement is required as hyperinsulinaemia following a glucose bolus can result in refractory hypoglycaemia immediately afterwards. The stress response results in catabolism of fat, glycogen and protein, resulting in raised levels of glucose, free fatty acids and amino acids in the serum initially, which in turn raises insulin levels and makes the patient vulnerable to sudden hypoglycaemia.

CONCLUSION

Anaesthetising patients who are malnourished calls for a considered and delicate approach. An in-depth pre-operative assessment looking for the cardinal signs of malnutrition and assessing for severity is crucial, as is with the institution of optimising measures if time allows.

When dealing with malnourished patients, presenting for non-elective surgery, have a low threshold for invasive cardiac monitoring, correct all electrolyte abnormalities promptly and be wary of respiratory compromise on extubation. Treat all malnourished patients as if they have a full stomach as the aspiration risk is high in this cohort, and have a low threshold for post-operative care in an intensive care setting if your institution allows this. Be vigilant for hypoglycaemia in the postoperative period as this is easily treated but can be life-threatening.

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Update in
Anaesthesia

Antiemetic drugs: pharmacology and an overview of their clinical use

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Summary
This article describes the pharmacology underlying our commonly used antiemetics. The physiology of nausea and vomiting is outlined with practical advice on use of antiemetic drugs to prevent and treat postoperative nausea and vomiting.

INTRODUCTION

Nausea and vomiting are feared and frequently very distressing symptoms that have multiple triggers including drugs, motion, pregnancy, fear, vestibular disease, migraine and gastrointestinal pathology. Postoperative nausea and vomiting (PONV) is one of the most common causes of patient dissatisfaction after anaesthesia. Untreated, PONV occurs in approximately 30% of the general surgical population and up to 70–80% of high-risk surgical patients. The adverse effects of PONV include distress, increased pain, wound dehiscence and bleeding, as well as risk of aspiration of gastric contents. If protracted, PONV may lead to electrolyte imbalance and dehydration. Such adverse consequences prolong recovery and have the potential to delay discharge from hospital, leading to increased health care costs.

PHYSIOLOGY OF THE VOMITING CENTRE

The vomiting centre coordinates vomiting and is composed of a collection of effector neurones in the medulla. This collection projects to the vagus and phrenic nerves and also to the spinal motor neurones supplying the abdominal muscles, which together bring about the vomiting reflex.

The vomiting centre receives afferent impulses from the chemoreceptor trigger zone (CTZ), vestibular apparatus, cardiovascular and abdominal afferents (via the vagus nerve), peripheral pain pathways and the limbic cortex (Figure 1). The CTZ is situated in the area postrema, on the lateral walls of the fourth ventricle, outside the blood–brain barrier (BBB). It is rich in dopamine (D_2) and serotonin (5-hydroxytryptamine, 5-HT_3) receptors. Drugs (e.g. opioids) and neurotransmitters (e.g. dopamine, noradrenaline, acetylcholine, 5-HT) can stimulate the CTZ. Motion sickness is primarily a central nervous system response mediated by the vestibular apparatus. Acetylcholine and histamine receptors are found in the vestibular centre. Acetylcholine is important in neural transmission from the vestibular apparatus. The limbic system is associated with expression of mood, emotions and feelings, as well as memory recall. Anxiety, fear and other emotions may play a role at this site in the perception of nausea and vomiting.

ANTIEMETIC AGENTS

The treatment of nausea and vomiting aims to antagonise the afferent supply to the vomiting centre. Antiemetic drugs can be classified according to the receptor at which they act:

- dopamine antagonists
- anticholinergics
- antihistamines
- serotonin antagonists
- miscellaneous.

DOPAMINE ANTAGONISTS

The CTZ is rich in dopamine receptors; hence most drugs that antagonise D_2 receptors have antiemetic properties. The dopamine antagonists used clinically as antiemetics can be divided into three groups: phenothiazines, butyrophenones and benzamides.

Phenothiazines

Phenothiazines are most commonly used as antipsychotic drugs and have a limited role in the treatment of PONV.

Chlorpromazine

Chlorpromazine is available as a tablet, syrup or straw-coloured solution for injection. It is used to prevent and treat nausea and vomiting in palliative care patients in whom other agents have been unsuccessful. It is also used in schizophrenia for its sedative properties and for the treatment of intractable hiccough. Chlorpromazine antagonises D_2, muscarinic, noradrenergic (α_1 and α_2), histaminergic (H_1) and 5-HT_3 receptors. Blockade of D_2 receptors results in an increased threshold for vomiting at the CTZ. Central nervous system effects include sedation, extrapyramidal effects and, rarely, neuroleptic malignant syndrome. Cardiovascular effects include negative

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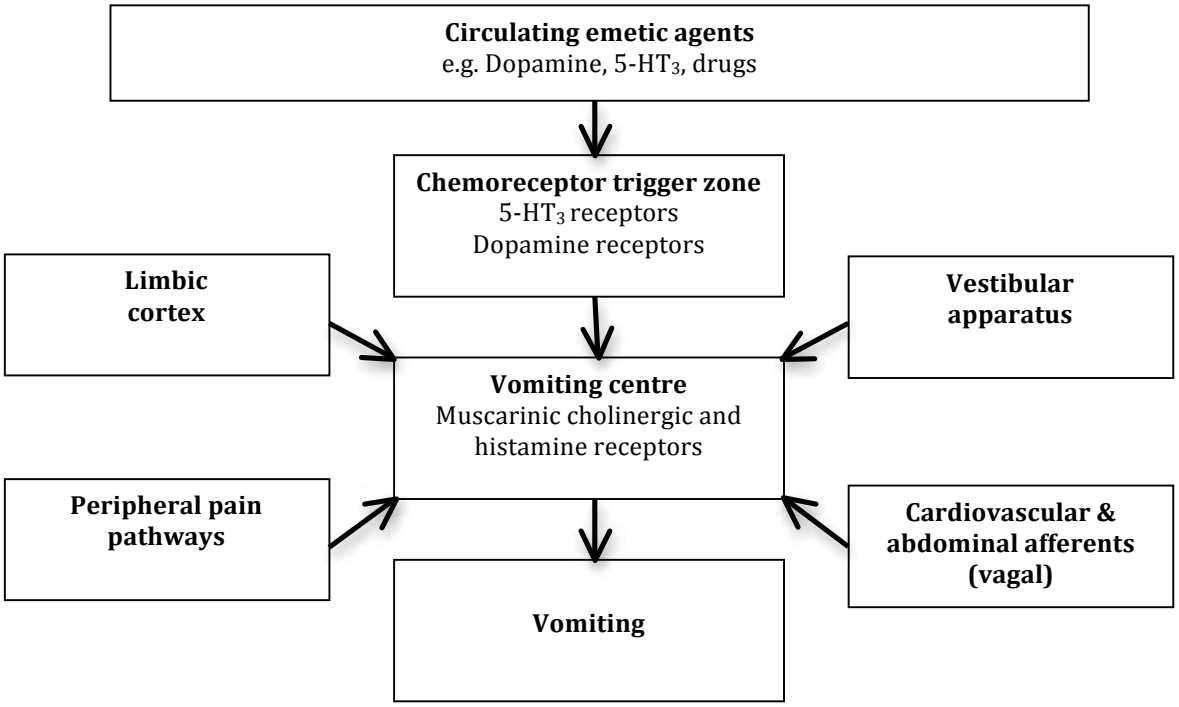

Figure 1. *Pathways involved in the vomiting reflex*

inotropy, peripheral vasodilatation, hypotension and increased heat loss. Gastrointestinal effects include increased appetite, decreased salivation and gastric secretions. Other recognised side-effects are anticholinergic effects, cholestatic jaundice, agranulocytosis and haemolytic anaemia. Chlorpromazine is usually given parenterally to avoid extensive first-pass metabolism; it is excreted in the urine and bile.

Prochlorperazine

Prochlorperazine is available as tablets, syrup, suppositories and a clear, colourless solution for injection. It is mainly used as an antipsychotic and for the treatment of PONV and vertigo. It antagonises central D_2 receptors; high doses have an inhibitory effect at the vomiting centre. It has a similar side-effect profile to chlorpromazine; however, extrapyramidal reactions are more commonly seen, especially in children. In contrast to chlorpromazine, it has milder sedative and anticholinergic effects. Oral bioavailability is low due to extensive first-pass metabolism. It is active within 10–20 minutes of intramuscular (IM) administration and its effects last 3–4 hours.

Butyrophenones

Droperidol

Droperidol is available as tablets, syrup and as a clear solution for injection. It is the only butyrophenone used in anaesthesia; however, its use has declined because it has been associated with cases of QT interval prolongation. It was previously commonly used in the prevention and treatment of PONV, for neuroleptanaesthesia and in the control of mania. Droperidol antagonises central dopamine receptors at the CTZ and its side-effect profile is similar to that of the phenothiazines. Sedation is more pronounced and the incidence of extrapyramidal effects increases at higher doses. It can cause a distressing 'locked-in syndrome'. Cardiovascular effects include hypotension resulting from peripheral α-adrenergic blockade. It has good absorption following IM administration and is 90% protein bound in the plasma. Droperidol is metabolised by the liver and excreted in the urine.

Domperidone

Domperidone is available as tablets, suspension and suppositories. The intravenous (IV) preparation was withdrawn following association with serious arrhythmias. It antagonises peripheral dopaminergic receptors, resulting in increased gastrointestinal motility and tone. It is used for the symptomatic treatment of nausea and vomiting, particularly following chemo- and radiotherapy. It does not cross the BBB; thus, it is less likely to cause sedation and extrapyramidal effects. It can increase prolactin levels and may cause galactorrhoea and gynaecomastia.

Benzamides

Metoclopramide

Metoclopramide is available as tablets, slow-release capsules, syrup and a clear, colourless solution for injection. It acts primarily by antagonising dopamine receptors at the CTZ, but is also a weak antagonist at 5-HT_3 receptors. It also acts a prokinetic, increasing gastric emptying and oesophageal sphincter tone. In addition, metoclopromide also has an antagonistic action on serotonin receptors and this may contribute to some of its antiemetic properties. It is used for the symptomatic treatment of nausea and vomiting, digestive disorders, migraine and postoperative gastric hypotonia. It appears to be most effective for PONV if 20 mg is given at the end of anaesthesia

rather than at induction. Metoclopramide crosses the BBB and can precipitate extrapyramidal effects up to 72 hours after administration. Such effects are more common in young females. Sedation is noted more often with long-term administration. Cardiovascular effects include hypotension, tachycardia and bradycardia following rapid IV administration. Metoclopramide is rapidly absorbed orally, is conjugated in the liver and excreted in the urine.

ANTICHOLINERGICS

Anticholinergics are effective antagonists at the muscarinic receptors; they have minimal activity at the nicotinic acetylcholine (Ach) receptors, found in autonomic ganglia and the neuromuscular junction. Naturally occurring tertiary amines such as atropine and hyoscine are able to cross the BBB; their central effects include sedation, amnesia, antiemesis and the central anticholinergic syndrome. Atropine is not used to treat PONV because of its cardiovascular effects. Glycopyrrolate is a synthetic quaternary amine that is unable to cross the BBB and therefore has no centrally mediated effects.

Hyoscine

Hyoscine is an ester of tropic acid and scopine. It is a racemic mixture in which only L-hyoscine is active. Hyoscine butylbromide is presented as a clear solution for IV, IM and subcutaneous (SC) injection. It can also be administered orally and via transdermal patch. It competitively antagonises ACh at muscarinic receptors. It is used in the prophylaxis of motion sickness and, when administered together with an IM opioid, has been shown to reduce PONV. In addition, hyoscine decreases muscle tone (anti-spasmodic) and gut secretions, which may contribute to its antiemetic effect. Other effects include sedation, initial tachycardia followed by bradycardia, decreased bronchial secretions, mild bronchodilatation and respiratory stimulation. At toxic levels it can cause central anticholinergic syndrome, characterised by excitement, ataxia, hallucinations and behavioural abnormalities. It can precipitate porphyria in susceptible patients. Absorption of hyoscine following oral administration is poor; it is absorbed well following SC and IM administration and is most effective in reducing PONV by such routes. It undergoes extensive metabolism by liver esterases and 2% is excreted unchanged in the urine and 5% in the bile.

ANTIHISTAMINES

Cyclizine

Cyclizine is a piperazine derivative, and is available as tablets or as a clear, colourless solution for IV or IM injection. It is used as to treat motion sickness, radiotherapy-induced emesis, PONV and opioid-induced emesis and for symptom control in Ménière's disease. It is a histamine (H_1) antagonist but also has anticholinergic properties that contribute to its antiemetic properties. Side effects include tachycardia, drowsiness, blurred vision and pain on injection.

SEROTONIN (5-HT_3) ANTAGONISTS

Ondansetron

Ondansetron is a synthetic carbazole, and is availabe as tablets, a suppository or a clear solution for slow IV injection. It is widely used in the management of nausea and vomiting induced by chemo- or radiotherapy as well as in the perioperative period. It is ineffective for vomiting induced by motion sickness or dopamine agonists. The activation of 5-HT_3 peripherally and centrally appears to induce vomiting. Chemo- and radiotherapy may cause the release of 5-HT from enterochromaffin cells. Peripheral 5-HT_3 receptors in the gut are then activated and stimulate vagal afferent neurones that connect to the vomiting centre via 5-HT_3 receptors. Ondansetron is a highly selective antagonist at 5-HT_3 receptors both centrally and peripherally. Side-effects include headache, constipation, flushing and bradycardia and in higher doses it may cause QT interval prolongation. It undergoes significant hepatic metabolism and the dose should be reduced in patients with hepatic impairment.

Granisetron

Granisetron is available in tablet form and as a solution for slow IV injection. Granisetron is a serotonin antagonist that is similar to ondansetron and is licensed for use in PONV.

MISCELLANEOUS

Dexamethasone

Dexamethasone has been shown to be useful in the treatment of PONV and for nausea and vomiting related to chemotherapy. Its mode of action is unclear but may be due to a reduction in the release of arachidonic acid, reduced turnover of 5-HT or decreased permeability of the BBB. Caution should be exercised in diabetic patients owing to its negative effects on glycaemic control.

Acupuncture

A Cochrane review has shown acupuncture to be effective in the prevention of PONV.[1] The acupuncture site is Pericardium 6: 4 cm proximal to the distal wrist skin crease, between the flexor carpi radialis and palmaris longus tendons. Acupuncture should be performed on awake patients and is free from side-effects.

Cannabinoids

Nabilone is a synthetic cannabinoid with antiemetic properties. Its acts on the CB_1 and CB_2 cannabinoid receptors and is used to treat chemotherapy-induced nausea and vomiting. Side-effects include drowsiness, dizziness, dry mouth, psychotic reactions, hypotension and tachycardia.

Propofol

Total IV anaesthesia using a propofol infusion avoids exposure to volatile anaesthetic agents and dramatically reduces the incidence of PONV. Propofol appears to exhibit inherent antiemetic activity and

when administered in subhypnotic doses to postoperative patients and patients undergoing chemotherapy it results in a significant reduction in nausea and vomiting. The mechanism for this effect has not been fully elucidated.

CLINICAL MANAGEMENT OF PONV

Risk factors for PONV

Administering antiemetic drugs to all patients regardless of risk would expose many patients to unwanted side effects and is not a cost effective strategy. To reduce the incidence of PONV, prophylactic antiemetic regimens should be tailored to groups of patients where risk factors are present (Table 1).

Data from large studies investigating risk factors for PONV have been used to create risk scores that attempt to predict the likelihood of a patient developing PONV. The most commonly used is the Apfel simplified score (Table 2).[2]

Efficacy

When comparing different antiemetics and the evidence for and against their use, it is helpful to determine the number needed to treat (NNT), or the number of patients who must be exposed to a particular intervention in order for one patient to benefit over receiving placebo or no treatment (Table 3). Studies have shown that high-risk patients are best managed with a combination of agents rather than just agent in isolation.

Table 1. *Risk factors for postoperative nausea and vomiting*

	Odds ratio	Effects
Patient factors		
Female gender	3	
Non-smoker	2	
History of motion sickness or PONV	2	
Young age		Increased incidence in younger patients
Anaesthetic factors		
Intra- and postoperative opioid use		Dose dependent. Delays gastric emptying, causes bowel distension and triggers vomiting reflex
Volatile anaesthetics	2	Dose dependent
Nitrous oxide	1.4	Small increase in risk although not proven in children
Prolonged anaesthesia		Prolonged exposure to emetogenic stimuli
Surgical factors		
Gynaecological surgery		Less reliable data on impact of type of surgery on PONV risk
ENT surgery		
Squint surgery		
Thyroid surgery		
Laparoscopic procedures		
Severe pain		

Table 2. *Apfel simplified score*

Risk factor	Female gender
	Non-smoker
	Prior history of PONV or motion sickness
	Postoperative opioid use
Incidence based on number of risk factors	0 – 10%
	1 – 21%
	2 – 39%
	3 – 61%
	4 – 78%

Table 3. *Number needed to treat for common prophylactic antiemetics*

Antiemetic agent	NNT for prevention of PONV (0–24 hours)
Droperidol	5
Metoclopramide	
10 mg	30
25 mg	16
50 mg	1
Ondansetron	6–7
Dexamethasone	4
Propofol (total IV anaesthesia)	5

Figures taken from Gan and Diemunsch et al.[3] See paper for full references

Clinical strategies

The use of antiemetic drugs for prophylaxis should be guided first by the presence of risk factors and second by consideration of potential morbidity arising from PONV.

The presence of two or more of the risk factors described above correlates with a high risk of PONV, and this group of patients are likely to benefit from prophylactic use of antiemetic drugs. The physical implications of retching and vomiting may result in additional morbidity following procedures on the upper gastrointestinal tract such as hiatus hernia repair, and for this population prophylaxis continuing into the early postoperative period is advised.

The choice of which antiemetic agents to administer depends largely on the potential side-effects, drug availability and personal preference. Low-risk patients usually do not require prophylactic antiemetics and should be prescribed rescue therapy if necessary. High-risk patients will benefit from a multimodal approach combining avoidance of any modifiable risk factors (including consideration of total IV anaesthesia strategy) as well as combination antiemetic drug therapy.

First-line agents typically include dexamethasone and ondansetron ,which can be given together intraoperatively with additional antiemetics prescribed 'as required' for the postoperative period.

SUMMARY

The complex physiology of vomiting means that there are multiple pathways that can be targeted when attempting to prevent and treat PONV. The choice of antiemetic drug should be tailored to the individual patient's needs and an awareness of the pharmacological actions when choosing an antiemetic is essential to improve effectiveness and reduce undesirable side-effects.

Use of a risk scoring system allows for quantification of the risk of PONV, and many advocate prophylactic antiemetic use when there are two or more risk factors present. Administering prophylactic antiemetics to low-risk patients is of questionable value because the NNT approaches the number needed to harm (NNH) in many cases. Rescue strategies for those with established nausea and vomiting should include the use of an antiemetic from a different class to those already administered.

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Update in
Anaesthesia

Neck of femur fracture: perioperative management

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Summary

Surgical repair of hip fractures should occur within 48 hours of hospital admission.

Surgery is the best analgesia for a hip fracture.

The value of investigations needs to be carefully weighed against the risk of delaying surgery further.

Patients with hip fracture require multidisciplinary care

Audit projects are required for quality improvement.

INTRODUCTION

Several large systematic reviews of neck of femur fracture (NOF) surgery have demonstrated that operative delay beyond 48 hours results in increased morbidity and mortality.[1–3] Surgery beyond the 48-hour period has been shown to more than double the risk of postoperative complications such as pneumonia, urinary tract infections, deep vein thrombosis and pulmonary embolism,[4] whilst earlier surgery results in reduced mortality and postoperative complications.[5]

Reasons for operative delay can be grouped into system-based or medical-based delays. System-related delays include waiting for routine medical consultations or the unavailability of operating rooms or surgeons. Medical delays include stabilisation of medical problems such as unstable blood sugar levels in diabetic patients or reversing anticoagulation.

Timely surgery for NOFs presents a challenge for health care systems as it involves large numbers of elderly patients with significant comorbidities.[6] To manage this complexity, a protocol-driven and multidisciplinary approach is ideal. This article is largely based on the recently released Association of Anaesthetists of Great Britain and Ireland (AAGBI) guidelines regarding NOF surgery.[7] They are unique because they are specifically directed towards helping anaesthetists manage patients with hip fracture.

FACILITIES AND SERVICES REQUIRED

Multidisciplinary management

A multidisciplinary group could include general practitioners, community nurses, emergency staff, bed managers, orthopaedic nursing staff and surgeons, anaesthetists, orthogeriatricians, physiotherapists, occupational therapists, social workers, rehabilitation services and trauma coordinators.

Planned care pathways

Patients with a hip fracture who arrive in the emergency department should have a planned care pathway which includes prioritised anaesthetist and orthopaedic reviews as well as instructions on the management of preoperative issues such as fasting and anticoagulation. The pathway should also include prompt notification of bed managers and trauma coordinators to reduce the risk of delay.

Trauma coordinators

Trauma coordinators can reduce preoperative delays, facilitate interdisciplinary communication and start discharge planning. Together with multidisciplinary trauma meetings in the morning before the start of operating lists, they can effectively reduce delays.

Protected trauma lists

These are separate from general emergency lists and should be provided daily. The AAGBI recommends that hip fracture surgery should be prioritised over all other cases other than life- or limb-threatening trauma.

Consultant-delivered service

The AAGBI recommends that patients with hip fracture be anaesthetised and operated on by consultants with clinical experience in treating the unwell, older patient in order to reduce operative time and poor surgical outcomes.

Operating department

Room temperature should be between 20 and 23 ºC with a humidity of 50–60%. A dedicated radiographer will help reduce delay. An adequate stock of surgical implants, consumables and instruments should also be prepared.

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PREOPERATIVE MANAGEMENT

Analgesia

Surgical fixation is the best analgesic in hip fractures. Start with simple analgesics such as paracetamol and progress to opioids only after urea and electrolytes have been checked. Regional analgesia using nerve blocks or field blocks (such as the fascia iliaca block) offers effective preoperative pain relief and reduces the risk of opioid-induced side-effects.[8]

Preoperative assessment

Seventy per cent of patients with a NOF will have an American Society of Anesthesiologists (ASA) score of 3–4, making preoperative assessment by an anaesthetist mandatory.[9] Thirty-five per cent will have one comorbidity, 17% will have two and 7% will have three or more.[10] The most common comorbidities are cardiovascular disease (35%), respiratory disease (14%), cerebrovascular disease (13%), diabetes (9%), malignancy (8%) and renal disease (3%).[10] The anaesthetic assessment allows for planning of anaesthetic technique, assessment and communication of perioperative risk, and preoptimisation.

Early input from orthogeriatricians is also recommended. Orthogeriatric input can identify patients at increased risk of perioperative morbidity and mortality, help optimise patients before surgery and facilitate the commencement of early rehabilitation and discharge planning.

Routine preoperative investigations

Full blood count and group and hold

Preoperative anaemia is present in 40% of patients. The AAGBI suggests the use of a higher blood transfusion trigger in the elderly, such that in the case of patients with Hb < 90 g L^{-1} (or Hb < 100 g L^{-1} with a history of ischaemic heart disease), two units of blood should be transfused.

Leucocytosis and neutrophilia are common and may present a reaction to trauma rather than infection. A platelet count of less than 80×10^9 L^{-1} is a relative contraindication to neuraxial anaesthesia and a count less than 50×10^9 L^{-1} will usually necessitate a platelet transfusion.

Urea and electrolytes

Hyper- and hypokalaemia, as well as hyponatraemia, are common.

Coagulation studies

Request coagulation tests only if clinically required.

Electrocardiography (ECG)

ECG is required in all patients with a NOF.

Chest X-ray (CXR)

CXR is not necessary for all patients but may be useful in those with pneumonia or heart failure.

Common comorbidities

Atrial fibrillation (AF)

Patients in AF should ideally have a ventricular rate less than 100 beats per minute. Exacerbants such as electrolyte abnormalities or sepsis should be treated.

Anticoagulation

Aspirin should be withheld during inpatient stay unless indicated for unstable angina or stroke. In those on clopidogrel, surgery should not be delayed and prophylactic platelets are not necessary. The AAGBI suggests generally not stopping clopidogrel on admission, especially in patients with drug-eluting stents. This suggestion may differ to the practice at your hospital. Hence, an individual approach balancing the risks of interrupting clopidogrel therapy will need to be tailored to each patient. Hospital guidelines regarding the perioperative management of warfarin should be followed.

Aim for an international normalised ratio (INR) of less than 2 for surgery and less than 1.5 for neuraxial anaesthesia. Use vitamin K or, where available, four-factor prothrombin complex concentrates (Beriplex, Octaplex) to reverse warfarin if necessary. Perioperative cover with heparin is usually required. Warfarin should be recommenced 24 hours after surgery.

If unsure about the management of anticoagulation, advice from a haematologist should be sought promptly.

Chest infection

Chest infections require prompt antibiotics and the AAGBI recommends proceeding to surgery under regional anaesthesia if possible.

Diabetes

Hyperglycaemia is not a reason to delay surgery unless the patient is ketotic and/or dehydrated. Hospital guidelines concerning the perioperative management of diabetes should be followed.

Heart murmur

There is debate regarding the postponement of surgery pending echocardiography in the light of unrecognised aortic stenosis. The majority of clinicians favour proceeding to surgery with modification of their techniques towards general anaesthesia and invasive blood pressure monitoring.

Echocardiography may be indicated in order to:

1. establish left ventricular function if the patient is breathless at rest or on low-level exertion
2. investigate severity of an ejection systolic murmur heart in

the aortic area, particularly if two or more of the following are present:

a. unexplained syncope or presyncope
b. slow rising pulse
c. absent second heart sound
d. left ventricular hypertrophy on ECG without hypertension.

Implantable cardioverter defibrillators (ICD) and pacemakers

With both devices there are risks of perioperative failure and of unipolar diathermy resulting in delivery of an arrhythmogenic shock to the myocardium. The AAGBI recommends early consultation with a cardiologist to identify the specific type of device and to develop a plan for intraoperative management.

INTRAOPERATIVE MANAGEMENT

Anaesthetic choice

There is little evidence to support the use of one anaesthetic technique over another for patients undergoing hip fracture surgery. Anaesthetists tend to use the technique that they are familiar with. Approximately half of anaesthetists use neuraxial anaesthesia and the rest use general anaesthesia. The AAGBI recommends that peripheral nerve blockade always be considered whether a spinal or general anaesthesia is used.

Neuraxial anaesthesia

The AAGBI recommends the use of either spinal or general anaesthesia but not a combination of the two as the latter is associated with falls and hypotension. Lower doses of intrathecal bupivacaine (< 10 mg) may reduce associated hypotension. Intrathecal fentanyl is preferred to morphine as it is associated with less respiratory and cognitive depression.

General anaesthesia

It is recommended that reduced doses of intravenous induction agents be administered. Inhalational induction is generally well tolerated by the elderly and may facilitate a haemodynamically stable induction. There remains debate about whether mechanical ventilation is preferable to spontaneous.

Peripheral nerve blockade

Peripheral nerve blockade can reduce postoperative analgesia requirements. Blockade of the femoral, obturator and lateral cutaneous nerve of the thigh can provide adequate analgesia. The psoas compartment block/lumbar plexus block is the most reliable method of blocking all three. Femoral nerve blocks do not reliably block all three nerves but can reduce postoperative analgesia requirements and be more easily placed with ultrasound guidance. The fascia iliaca block is an alternative technique that covers all three nerves and requires a similar level of skill to the femoral nerve block.

Table 1 describes possible reasons why a delay in surgery may be justified.

Monitoring

Have a low threshold for obtaining further monitoring equipment for this patient group (see Table 2).

Table 1. *Acceptable and unacceptable reasons for delaying surgery in hip fractures*

Unacceptable	Acceptable
Lack of facilities or theatre space	Hb < 80 g dL^{-1}
Awaiting echocardiography	Na^+ < 120 or >150 mmol L^{-1}
Unavailable surgical expertise	K^+ < 2.8 or > 6.0 mmol L^{-1}
Minor electrolyte abnormalities	Uncontrolled diabetes
	Correctable cardiac arrhythmias with a ventricular rate >120 bpm
	Chest infection with sepsis
	Reversible coagulopathy

Table 2. *Minimum and optional monitoring*

Minimum	Optional
Anaesthetist present	Invasive blood pressure monitoring
Pulse oximetry	Cardiac output monitoring (e.g. oesophageal Doppler-guided fluid therapy)
Capnography	Bispectral index (BIS)
ECG	Cerebral oxygen saturation
Non-invasive blood pressure monitoring	
Point-of-care Hb (e.g. Hemocue®)	

Supplemental pain relief

Opioids and non-steroidal anti-inflammatory drugs should be used with caution (Table 3). Codeine should not be used because its variable pharmacokinetics make its efficacy and safety difficult to predict in an individual.[7] Paracetamol should be given in the perioperative period.

Thromboprophylaxis

Low-molecular-weight heparin should be administered on the evening before surgery to patients on the daytime trauma lists. This precaution allows for an appropriate window of time to minimise the risk of bleeding related to neuraxial anaesthesia. Thromboprophylactic stockings or intermittent calf compressors should be used intraoperatively. Regional anaesthesia, prompt surgery and early mobilisation will also reduce the risk of deep vein thrombosis.

Antibiotics

Administer within 1 hour prior to skin incision. Follow your hospital's antibiotic protocols.

Pressure care

Elderly patients should be positioned to avoid pressure sores if possible.

Thermoregulation

Active warming techniques should be used as elderly patients are prone to intraoperative hypothermia.

Intravenous fluids

Many patients are hypovolaemic from fasting prior to their surgery. Preoperative intravenous fluids should be prescribed.

POSTOPERATIVE MANAGEMENT

Nursing

These patients should ideally be in a ward with a nurse to patient ratio of 1:4.

Analgesia

As the peripheral nerve blockade wears off, administer paracetamol regularly with carefully prescribed opioid analgesia as required.

Hypoxia

Supplemental oxygen should be provided in the first 24 hours after the operation. Early mobilisation will improve oxygenation and respiratory function.

Fluid balance

Hypovolaemia is common postoperatively, and oral fluid intake should be encouraged and intravenous fluids avoided if possible.

Urinary tract infections (UTI)

UTIs are common and urinary catheters should be removed as soon as possible to reduce the risk of infection. Early mobilisation will also reduce the risk of UTIs.

Postoperative confusion

Cognitive dysfunction or an acute confusional state occurs in 25% of patients with hip fracture.[11] This can interrupt management and rehabilitation.Physicians specialised in the care of the elderly should be involved. Haloperidol or lorazepam should be used only for short-term symptom control. An underlying cause of the acute confusion should be sought and treated.

Malnutrition

Many patients with hip fracture are malnourished on admission to hospital. Dietitians should be involved and nutritional supplements should be provided.

Rehabilitation

Rehabilitation aims to return the patient to their pre-morbid level of activity. Rehabilitation should start as early as possible and be coordinated with an orthogeriatrician.

WEBLINKS

1. Sample patient information sheets regarding hip fractures which can be modified to suit your specific hospital: http://docroncheung.blogspot.com.au/2013/04/sample-patient-informationleaflets-on.html
2. Information and tutorial on the fascia iliaca block: http://neuraxiom.com/fascia_iliaca_block.html

Table 3. *AAGBI recommendations for supplemental pain relief*

Yes	Caution	No
Paracetamol	Non-steroidal anti-inflammatory drugs Opioids	Codeine

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Update in
Anaesthesia

Ebola – critical care considerations

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Summary

Although the threat of imported cases to the UK and other international countries is low, there remains the distinct possibility that further cases may occur.

Consider Ebola virus disease (EVD) as a differential diagnosis in anyone with a positive exposure history and recent fever ≥37.5°C.

If deemed at risk, immediate isolation in a ward-level bed and discussion with local infectious disease service is paramount.

Diagnostic tests may take up to 8 h to receive a result.

EVD has a high mortality but survival outcomes improve with aggressive supportive care with intravenous fluid and electrolyte replacement.

Local escalation policies should be pre-agreed and followed.

All confirmed EVD cases should be transferred to a specialist High Level Isolation Facility for further management.

INTRODUCTION

Ebola virus disease (EVD), previously known as Ebola haemorrhagic fever, is a rare, life-threatening viral illness caused by infection with one of the Ebola virus strains. The most recent epidemic of EVD, beginning in March 2014, has been the largest recorded outbreak, in terms of both geographical spread and case numbers. It has affected multiple countries in West Africa, amongst which the most affected are Guinea, Liberia and Sierra Leone. In late July the World Health Organization (WHO) declared the outbreak a 'Grade 3 emergency response' and, later, in early August, a 'Public health emergency of international concern'.

Cases have been reported in Nigeria, Senegal, Mali, the USA, Spain and the UK. The management of EVD raises a number of practical, logistic and ethical issues. This article aims to discuss the management of suspected and confirmed cases of EVD from a critical care perspective. It is based on recent publications from WHO, the Centers for Disease Control and Prevention (CDC), Public Health England (PHE) and the North of England Critical Care Network (NoECCN).

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HISTORY

EVD is caused by the genus *Ebolavirus*, which is part of the Filovirus family. Filoviruses can cause severe haemorrhagic fever in human and non-human primates. Four of the five known species of *Ebolavirus* can cause disease in humans: Zaire, Sudan, Tai Forest and Bundibugyo. The fifth species, Reston, has caused severe illness only in non-human primates.[1]

Ebola was first discovered in 1976 in almost simultaneous outbreaks occurring in the Democratic Republic of Congo near the Ebola River, from which the disease takes its name, and in South Sudan. The disease then disappeared after 1979 and did not reappear again until 1994 in Gabon. Since 1994 sporadic outbreaks have been occurring with increasing frequency.[2]

CURRENT EPIDEMIOLOGY

The current (2014) epidemic is caused by the Zaire species. It is by far the most widespread and intense outbreak recorded and, as of 6 February 2015, a total of 22,495 clinically compatible cases of EVD,

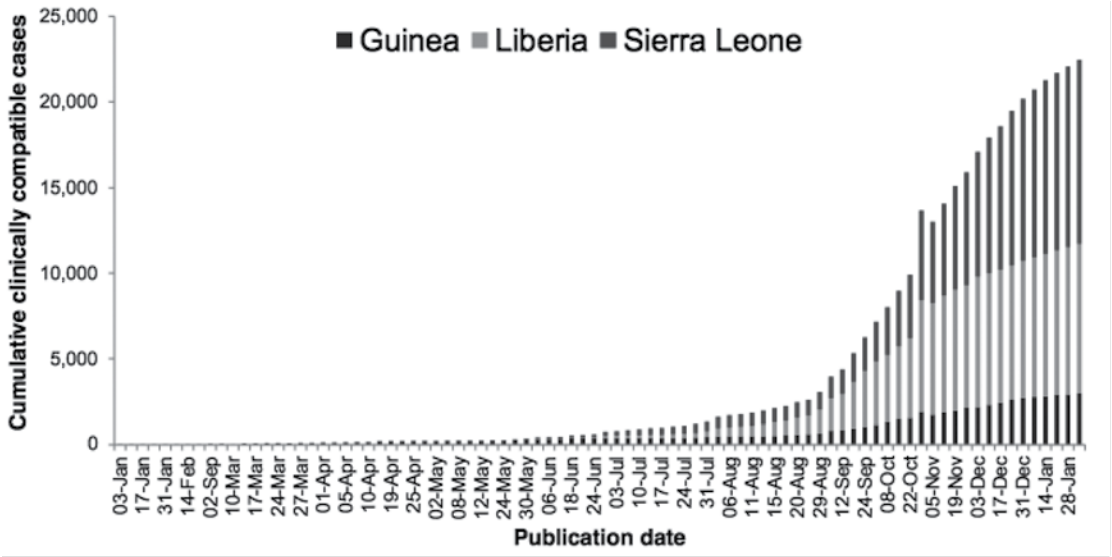

Figure 1. *Cumulative clinically compatible cases in Guinea, Liberia and Sierra Leone as of 4 February 2015*[3]

including 8981 deaths, have been reported globally (Figure 1). This number is believed to be an under-representation, as many cases will be cared for outside the hospital setting.

At present, there have been six non-medically repatriated cases of EVD diagnosed outside Africa: three imported cases (one in the UK and two in the USA) and three incidents of local transmission to health care workers (one in Spain and a further two in the USA). With regard to medically repatriated cases, a total of 18 patients with confirmed have been evacuated from Africa. Of these, 14 have been discharged from hospital and four have died.

The Zaire species of *Ebolavirus* is one of the most virulent human pathogens known. The overall case fatality rates in the three intense transmission countries (Guinea, Liberia and Sierra Leone) are estimated to be as high as 71% whilst, among those hospitalised, mortality rates are slightly lower, at 60%. The mortality rate is seen to fall further in EVD cases being treated outside of Africa, at approximately 20%.

The risk of further EVD cases being imported to Europe and the USA is still considered to be very low because robust monitoring and surveillance measures are in place. However, there remains a distinct possibility that additional cases may occur in the upcoming months, giving rise to concerns for the impact this may have on national health services.[3]

PATHOGENESIS

The natural reservoir of Ebola virus has not yet been identified. The first human case in an outbreak occurs through contact with the body fluids of an infected animal. Person-to-person transmission then follows through:

- direct contact with blood or body fluids (including but not limited to urine, saliva, faeces, vomit, breast milk, semen and sweat) of an infected individual
- contact with objects contaminated with infected fluids in the absence of strict infection control measures.

Traditional burial practices in West Africa, where mourners have direct contact with the bodies of the deceased, have significantly driven the transmission of EVD. Transmission via sexual contact with a convalescent case is also possible as the virus is present in semen and vaginal fluids for up to 3 months after recovery.[2]

Infection begins once the virus gains entry through unprotected mucous membranes, breaks in skin integrity or via the parenteral route. There is no evidence of transmission of EVD through intact skin or through small droplet spread, such as coughing or sneezing. The virus migrates to regional lymph nodes and subsequently disseminates to the liver, spleen and adrenal glands, affecting a number of target cells, including monocytes, macrophages, dendritic cells, endothelial cells, fibroblasts, hepatocytes, adrenal cortical cells and epithelial cells.

Although not infected by Ebola virus, lymphocytes undergo apoptosis, resulting in decreased lymphocyte counts and an altered immune response by modulation of gene expression. An early antibody response and high lymphocytic count during the infection are associated with survival. Hepatocellular and adrenocortical necrosis occur, causing coagulopathy and shock from impaired steroid synthesis respectively.

Ebola virus appears to induce cytokine and other proinflammatory mediator release with subsequent loss of vascular integrity and coagulation defects ultimately resulting in multiorgan failure and shock.[4] The pathogenesis of shock is multifactorial and includes fluid loss, fluid sequestration, coagulopathy and sepsis due to secondary infections.

CLINICAL PRESENTATION

Patients with EVD will develop symptoms within 21 days of infection and any symptoms following this period will not be due to Ebola virus. The onset of symptoms typically occurs after an incubation period of approximately 9–11 days. Table 1 outlines the symptoms of EVD. Such non-specific symptoms can be easily mistaken for those of other infectious diseases such as malaria or typhoid fever, or with any other viral or bacterial infection, so a comprehensive travel and exposure history must be obtained.

Patients with fatal disease typically develop more severe clinical signs early during infection and usually succumb to the disease between days 6 and 16. In less severe cases, patients have fever for several days and improve around day 6. Risk factors associated with a poor outcome in the affected West African countries are shown in Table 2.[5]

INFECTION CONTROL

Prior to isolation, if the patient has been in a public area, the hospital lead for infection control and the local health protection team must be notified, and the area cornered off and decontaminated. All staff and members of the public who may have come into physical contact with the patient or body fluids should be assessed.

Table 1. *Early and late signs and symptoms of Ebola virus disease*[5]

Early	Late
Fever	Severe watery diarrhoea
Rash (maculopapular)	Vomiting
Sore throat	Abdominal pain
Myalgia and arthralgia	Petechiae
Malaise	Hypovolaemic shock
Severe headache	Haemorrhagic manifestations, e.g. mucosal or gastrointestinal

Table 2. *Risk factors associated with a poor outcome in West African countries*[5]

Age > 45 years
Unexplained haemorrhage
Associated symptoms such as:
• chest pain
• shortness of breath
• headache
• confusion and convulsions

Infection control measures are a critical part of clinical management. Person-to-person transmission of Ebola virus requires direct contact with body fluids (e.g. blood, faeces or vomit) from a person who has developed symptoms. Therefore, in a secondary care setting, the rapid identification and subsequent isolation of high-risk patients is paramount. The patient should be isolated in a single room with an adjacent contained space to be used for the removal of personal protective equipment (PPE) and waste disposal.

Only staff trained in the correct use of PPE should have patient contact. Staff should attend the patient in pairs with a third member in the relevant PPE outside the room to assist as required. A fourth member of staff should act as a safety officer, ensuring correct PPE use and adherence to local protocols for the safe donning and doffing of PPE.[6]

The use of PPE is mandatory, and guidance from the CDC sets out protection standards for dealing with suspected cases of EVD. Recommended PPE includes the following:

- hand hygiene with soap and water or an alcohol based hand rub
- single-use double gloves with extra-long cuffs
- fluid-resistant single-use coveralls extending to the mid-calf
- fluid-resistant single-use aprons if patients have vomiting or diarrhoea
- respiratory protective equipment (RPE) to reduce the risk of aerosol spread such as:
  - powered air-purifying respirator (PAPR) with a full face shield, helmet or headpiece
  - N95 or higher respirator in combination with disposable surgical hood extending to shoulders and single-use full face shield.[7]

Note that the above are recommendations and that individual facilities may elect to use PPE that varies from that outlined depending on local resources.

The key to effective and safe use of any PPE is through consistent implementation by repeated training and practice. Facilities should standardise the PPE in use and provide clear written protocols to avoid the risk of contamination.[7]

CLEANING AND WASTE MANAGEMENT

Contaminated equipment or surfaces should be cleaned and disinfected in a timely manner using standard hospital disinfectants (e.g. 0.5% chlorine solution). Contaminated material must be immediately segregated at the point of generation, sealed in appropriately labelled containers and destroyed within 24 hours. The preferred method of waste disposal is autoclaving with the contents appropriately disposed of in a designated pit.

Handling of human remains should be kept to a minimum. Appropriately trained personnel must use full PPE when handling the remains of a suspected or confirmed case of EVD. The body should be placed in a leak-proof double bag, with the surface of each body bag being decontaminated with a suitable disinfectant. The body should immediately be transported to the mortuary or the cemetery and buried promptly. Spraying, washing or embalming of remains in preparation for burial should be discouraged.

Owing to the highly infectious nature of the remains, post-mortem examinations should be limited to essential evaluations only and, again, must be carried out by trained personnel wearing full PPE.[8]

DIAGNOSIS

The diagnosis of EVD should follow a step-wise approach comprising a comprehensive history, physical examination and relevant investigations. A high index of suspicion of EVD should be present when faced with any individual manifesting the signs and symptoms detailed above along with a positive exposure history.

Current practice in the UK is based upon recent guidelines published by the College of Emergency Medicine. patients are suspected to be at high risk of EVD if:

1. they have travelled from one of the affected areas (currently Guinea, Liberia and Sierra Leone) *or* have had contact with an individual with EVD within the previous 21 days, *and*
2. they have a fever (≥ 37.5°C) or history of fever in the past 24 hours.[6]

However, as the symptoms of EVD are non-specific and may mimic those of other diseases, a definitive diagnosis can be made only by using specific laboratory diagnostic tests including enzyme-linked immunosorbent assay (ELISA) testing, polymerase chain reaction (PCR) and virus isolation.

Ebola virus can be detected in serum samples only after the onset of symptoms, when the viral load is increasing. Diagnostic tests are usually performed on samples of serum and EDTA-treated blood and/or urine. In the UK, samples are sent to the Rare and Imported Pathogens Laboratory (RIPL) in Wiltshire, England. In addition to EVD, all samples are tested for other potential causes of fever that the patient may have been exposed to, including, but not limited, to Marburg virus disease, Dengue fever and malaria.

For urgent samples, results may be available within 7–8 hours of sample receipt. Positive results are immediately telephoned to the referring clinician to aid in the timely patient management, infection control and public health response.[9] It may take up to 3 days after the onset of symptoms for the virus to reach detectable levels. It is therefore essential, following an initial negative sample, to send a second sample for testing after at least 48 hours owing to the possibility of a false-negative result.[10]

Other supplementary laboratory investigations include haematological and biochemical tests. Findings may demonstrate low white blood cell counts followed later by elevated neutrophils. Serum amylase and hepatic transaminases may be raised, reflecting pancreatic and hepatic involvement. Blood coagulation tests may demonstrate a picture consistent with DIC such as prolonged prothrombin time (PT) and partial thromboplastin times (PTT), elevated fibrin degradation products and thrombocytopenia.[5]

MANAGEMENT

The increasing international response to the current outbreak has meant that a large number of international health care and military staff have been deployed to aid countries where transmission is widespread. Such workers have been identified as being at obvious risk of EVD, and the CDC and other national agencies have issued guidance for the monitoring, surveillance and, if indicated, escalation plans for returning staff based on their exposure risk.[11]

Individuals with suspected EVD are likely to initially present to a peripheral hospital so acute health services should have local management protocols in place. Discussion with infectious disease clinicians will help determine whether transfer to a high-level infection unit (HLIU) is indicated.

In peripheral hospitals, it is recommended that cases be managed with the best available PPE, in a ward-level isolation room rather than a critical care setting. The decision to escalate or de-escalate care should be made on a case-by-case basis, taking into consideration the potential risks to the patient and staff. This decision-making process raises many ethical and practical issues so must be based on agreement between at least two local consultants (such as emergency department and critical care consultants) and advice from an infectious disease consultant.

In confirmed cases, a number of key teams are alerted including the outbreak control team, public health and senior government officials, and the clinical team at the nearest HLIU.[12] Currently there is no licensed treatment or vaccine for EVD and the mainstay of treatment is primarily supportive. Care focuses on the early detection and supportive care of complications such as hypoxia, hypovolaemia, electrolyte and coagulation abnormalities, septic shock, multiorgan failure and disseminated intravascular coagulation (DIC). This standard supportive care should be provided by the hospital concerned within the limitations of the strict infection control measures.

Monitoring

The monitoring of patients' vital signs, fluid balance and neurological status through non-invasive means (e.g. pulse oximetry, heart monitor, non-invasive blood pressure) should be carried out on a frequent basis guided by the patient's clinical condition. Accurate documentation of fluid balance may be difficult particularly in the setting of vomiting and diarrhoea; therefore, hourly monitoring of urine output via a Foley catheter and urometer is essential.

If available, invasive arterial blood pressure monitoring should be considered in those with haemodynamic instability requiring vasopressor support or when frequent blood samples are being taken. Insertion of a central venous line (CVL) solely for central venous pressure (CVP) monitoring is not recommended and in general the use of any form of invasive monitoring should be limited to reduce the risk of exposure to health care staff.

Airway management and ventilation

Respiratory involvement is not a common feature of EVD, although in severe cases respiratory failure may occur. Airway management may otherwise be required to protect the airway from aspiration in those with reduced level of consciousness or upper gastrointestinal haemorrhage.

The CDC strongly recommend that aerosol-generating procedures such non-invasive ventilation, bronchoscopy, sputum induction, intubation and extubation and open suctioning of airways be avoided if at all possible. In addition, ventilatory support has yet to demonstrate a significant improvement in survival rates and therefore may not be offered depending on local protocol.

If ventilatory support is to be offered, the Canadian Critical Care Society recommends early intubation with traditional mechanical ventilation in a negative pressure isolation room by highly experienced clinicians wearing appropriate PPE.[13]

Cardiovascular support and intravenous access

Careful attention to intravascular volume status and aggressive administration of fluids and electrolytes (with a special focus on potassium, calcium and bicarbonate supplementation) constitutes the first step in a series of supportive care interventions. In the non-critically ill patient this should be achieved via the oral route.

Intravenous access is required in those unable to tolerate the oral route or in the presence of haemodynamic instability. Hartmann's or Ringer's lactate has been suggested as the fluid of choice for volume replacement. Large-bore peripheral intravenous (IV) access is suitable for those with milder disease with central venous access required for those needing IV electrolyte replacement or with poor peripheral access. In the event of the need to establish central venous access, the risk of injury and exposure can be minimised by having an experienced clinician conduct the procedure under ultrasound guidance. Needle-less systems may be used to avoid sharps injuries and the use of non-suture securing devices is advocated.

Cardiovascular support with vasopressors may be indicated, these may be administered via either the peripheral or central route depending on local protocol. Vigilance must be taken with fluid replacement as with the systemic inflammatory response and loss of vascular integrity, profound third space losses have been observed. The correction of haematological and coagulation abnormalities with blood products may also be necessary.[13]

Renal support

Renal failure is common in severe cases. Dialysis for renal failure is considered a high-risk intervention for health care staff and the Royal Free Hospital in London has therefore ruled out offering this. In the USA, however, the CDC recommend that the care of patients with EVD should be undertaken in a hospital with the capacity to perform continuous renal replacement therapy (CRRT). This highlights the importance of regional and national guidelines in outlining clear escalation and management policies.[14]

Symptom management

Symptoms control is a significant component of EVD management (Table 3).

Antibiotics and experimental therapies

The treatment of secondary bacterial infections and use of broad-spectrum antibiotics has been suggested in patients with evidence of septic shock and secondary infection. The early discontinuation of antibiotic therapy should be considered if microbiology results and other investigations do not reveal bacterial superinfection. Other management options may include the early utilisation of

Table 3. *Symptoms of EVD and the appropriate management*[12]

Symptom	Management
Pain	Opiates titrated to effect e.g. fentanyl, morphine
Fever	Paracetamol (max. 4 g per 24 hours), lower dose in hepatic dysfunction
	Non-steroidal anti-inflammatory drugs should be avoided because of their platelet inhibition and renal effects
Dyspnoea	Supplemental oxygen
Seizure	Airway management. Benzodiazepines. Laboratory investigations (Na^+, glucose). CT of the head if focal signs are present
Nausea and vomiting	Antiemetics. Consider nasogastric tube and suction
Poor oral intake	Where available, delayed total parenteral nutrition if enteral not tolerated
Agitation	Haloperidol

experimental monoclonal antibody therapy such as ZMapp (Mapp Biopharmaceuticals Inc, San Diego, CA, USA). The clinical benefit of ZMapp remains unproven and further trials are required to assess efficacy. Beyond Zmapp, the development and testing of other antiviral therapies and experimental vaccines is also picking up pace.[5,15]

Patients who make a successful recovery from EVD develop antibodies that last for at least 10 years. It is not known if people who recover are immune for life or if they can become infected with a different strain of *Ebolavirus*.[5]

PAEDIATRIC CONSIDERATIONS

There are additional issues that must be considered when managing suspected or confirmed EVD in the paediatric population. There is limited information on the current outbreak and the impacts this has on children. However, because their circulating blood volumes are smaller, children are more likely to become fluid depleted as a result of vomiting or diarrhoea, so without rapid intervention, they have the potential to deteriorate more rapidly than adults. Thus, it may be desirable to transfer children to a specialist HLIF at an earlier stage (i.e. prior to laboratory diagnosis of EVD) than would be the case for an adult.

Children depend on their parents or caregivers for their physical needs and psychological support so the isolation and quarantine of children poses a challenge. With most infectious diseases, children are often isolated with a parent. However, in the case of EVD, because of the risk of parental exposure, parents may need to be separated from their child. This may impact on the child's compliance with treatment especially when confronted with clinical staff in full PPE.

The decision to allow parents to accompany a child or to administer sedation to aid with management must be made on a case-by-case basis. Hospital protocols, public health advice and the level of exposure between parent and child that may have occurred before seeking medical care must all be taken into consideration.[16]

ETHICAL ISSUES OF ESCALATION

The prioritisation and allocation of finite critical care resources occurs routinely throughout the health service. The provision of critical care is based on clinical decisions allowing for the most effective and ethically sound allocation of resources, free from external, political and public influences.

In EVD the most likely situation is that small numbers of patients will require simultaneous treatment. However, the treatment of a single EVD patient will require extraordinary resources. If exceptional demand is placed on critical care, such that resources cannot be provided to all patients who have the ability to benefit, the threshold for accessing critical care consequently rises.

Despite EVD's current prominence in the media and in public interest, the clinical and ethical principles underpinning such decision-making processes remain unchanged. This must be done on an individual case-by-case basis, with the patient with the higher clinical likelihood of benefit being given precedence.

In the case of EVD, there are two main conflicting ethical stances regarding the allocation of scarce critical care resources. The first approach attempts to weigh the potential benefits against harm and, in doing so, a balanced judgement can be made which results in the greatest net benefit. Taking into consideration the high mortality rate, the high risk of secondary contamination to health care staff and the subsequent denial of effective treatments for other patients due to redistribution of resources, the refusal of level 3 care for patients with confirmed EVD can be justified as the overall perceived harm outweighs the limited expected gains.

The opposing view considers our duties and obligations and how best they may be met. Here the argument is that, with strict adherence to infection control measures, the risk to staff and other patients is acceptably low, the reduction in mortality rates with relatively simple supportive care considerable, and the redistribution of work and resources possible with good organisation, planning and communication. This approach would support the provision of critical care interventions to patients with EVD.[12]

PRACTICAL ISSUES OF ESCALATION

Currently, there is limited evidence to support the provision of critical care in the management of EVD as, unlike optimum supportive care, the addition of renal and ventilatory support has yet to demonstrate a significant improvement in survival rates.

This attitude may be set to change, however, as clinical experience is continually increasing as a result of the treatment of EVD patients in the USA and Europe. In practice, the escalation of EVD patients to a critical care setting in a peripheral hospital presents many challenges.

In Texas, for example, a 25-bed critical care unit was closed for several weeks while an imported patient with EVD was treated. The closure of a critical care unit would have a significant impact on the ability of other patients to access a higher level of care. This may result in the restriction of surgeries, conversion of theatre recovery areas and of level 1 and 2 beds to level 3 and the rapid retraining and redeployment of medical and nursing staff. Devoting such resources to patients with EVD is likely to affect the hospital's ability to staff other services.

It is therefore recommended that no peripheral hospital should be required to provide level 3 care to a patient with confirmed EVD. Such patients should ideally be managed in an isolated ward-level bed prior to transfer to a specialist HLIF.[13]

At present, in the UK there is only one HLIF at the Royal Free Hospital in London, comprising two specialist beds available for the management of patients with highly infectious diseases. Three additional infectious disease units in the cities of Newcastle, Sheffield and Liverpool provide surge capacity where EVD patients could be transferred in the event of a larger outbreak, making a total of 26 beds available in the UK.

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Update in
Anaesthesia

Peripartum cardiomyopathy

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Summary

Peripartum cardiomyopathy is a rare condition that affects women in late pregnancy and in the postpartum period.

It is characterised by heart failure that presents in the absence of any other identifiable cause.

It is associated with significant morbidity and mortality.

Early recognition and aggressive management of the condition is crucial to improving outcome.

Example case

- A 37-year-old woman presents at 36 weeks' gestation in her fourth pregnancy with a 6-day history of worsening shortness of breath, paroxysmal nocturnal dyspnoea, orthopnoea and peripheral oedema. Her three previous pregnancies were uneventful and she delivered vaginally each time.
- Her past medical history includes hypothyroidism and morbid obesity (BMI 40). She has no known cardiac history. There is no familial history of note, and no background of drug or significant alcohol consumption.
- On examination the patient is tachypnoeic and tachycardic at rest, with normal blood pressure. Oxygen saturation is 92% in room air. Bibasal coarse crackles are audible on auscultation. Arterial blood gas analysis reveals a respiratory alkalosis with mild hypoxaemia. Electrocardiography (ECG) demonstrates sinus tachycardia with left bundle branch block and chest X-ray shows cardiomegaly with fluid in the horizontal fissure and prominent upper lobe vessels.
- Transthoracic echocardiography reveals severe left ventricular dysfunction, with an ejection fraction of 15–17%, dilated cardiomyopathy (left ventricular end-diastolic diameter 81 mm), severe mitral and moderate tricuspid regurgitation with moderately elevated pulmonary artery pressure.

INCIDENCE

The true incidence of peripartum cardiomyopathy (PPCM) is unknown. Reported incidence varies between 1 in 3000 and 1 in 10 000 pregnancies.

AETIOLOGY AND PATHOPHYSIOLOGY

The aetiology of PPCM is unknown. It is postulated that PPCM could be mediated through many mechanisms including immunological factors, an abnormal hormone response, abnormal inflammatory changes, myocarditis, or a genetic predisposition.

PPCM manifests predominantly as ventricular systolic dysfunction from a global reduction in myocardial contraction and thus left ventricular ejection fraction. Compensation through the enlargement of the left ventricle occurs, increasing end-diastolic volume and stroke volume. As compensation fails, cardiac output falls and cardiac failure ensues.

RISK FACTORS

Risk factors for PPCM include:

- maternal age > 30 years
- multiparity
- ethnic group, e.g. African descent
- obesity
- multiple pregnancy
- pregnancy-associated hypertensive disorders
- essential hypertension
- tocolytic therapy with β-agonists
- cocaine use.

CLINICAL FEATURES AND DIAGNOSIS

Symptoms of shortness of breath on exertion and orthopnoea are common in the third trimester. Diagnosis of PPCM can be delayed if these symptoms are erroneously attributed to the normal physiological changes of pregnancy. Symptoms of PPCM include dyspnoea, fatigue, orthopnoea, paroxysmal nocturnal dyspnoea, palpitations, haemoptysis and peripheral oedema. These may present as acute or subacute episodes of left ventricular failure.

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Tachyarrhythmias can occur in PPCM, including supraventricular tachycardia (SVT), atrial fibrillation (AF) and, rarely, ventricular tachycardia (VT). There is an increased risk of thromboembolism due to the potential development of mural thrombus.

PPCM is a diagnosis of exclusion. Parturients with recognised congenital or acquired heart disease can present with similar symptoms in late pregnancy or during labour. Similarly, pregnant women with undiagnosed ischaemic or structural heart disease have decreased functional reserve and are less able to tolerate the haemodynamic physiological changes of normal pregnancy.

Diagnosis of PPCM requires four criteria to be met:[1]

1. heart failure developing towards the end of pregnancy or up to 5 months post partum
2. absence of another identifiable cause of cardiac failure
3. absence of cardiac symptoms or disease prior to late pregnancy
4. left ventricular dysfunction – defined as an ejection fraction less than 45% or reduced fractional shortening of less than 30%.

Cardiomyopathy meeting criteria 2–4 but presenting earlier than the third trimester is referred to as pregnancy-associated cardiomyopathy (PACM). The underlying pathophysiology is probably similar to that of PPCM.[2]

DIFFERENTIAL DIAGNOSES

Differential diagnoses of PPCM include:

- pulmonary embolism
- severe sepsis
- amniotic fluid embolism
- pre-eclampsia/pregnancy-induced hypertensive disease
- arrhythmias
- severe anaemia
- myocardial infarction
- dilated cardiomyopathy of other aetiologies (see Table 1).

INVESTIGATIONS

Investigations include:

- ECG
- transthoracic echocardiography including Doppler studies
- cardiac magnetic resonance imaging
- coronary angiography
- viral studies
- B-type natriuretic peptide (BNP) is a screening marker but lacks specificity.

PROGNOSIS

Prognosis is poor and PPCM is one of the leading causes of maternal death.[3] A prognostic indicator is the degree of dysfunction at presentation, defined either by the New York Heart Association (NYHA) functional classification or by the findings on transthoracic echocardiography.

The mortality rate is between 15% and 50%, while 30–50% will improve and recover a left ventricular ejection fraction of 50% or more. Death results from intractable heart failure, arrhythmias and thromboembolism.

MANAGEMENT

Early identification of PPCM enables optimal management. Multidisciplinary management by senior staff is essential, and should include involvement from an obstetrician, a cardiologist with a special interest in obstetric disorders, and an anaesthetist. Should PPCM present during pregnancy, maternal optimisation is key, which may necessitation expedited delivery. A neonatologist should be involved in discussions regarding timing of delivery and to address the potential impact of maternal disease on neonatal outcome. If critical care admission is likely, early involvement of a critical care specialist is important.

Where women with PPCM should be cared for will depend on the timing and presentation of the condition. Referral to a specialist obstetric care centre with the expertise and resources to manage such patients should be considered in all cases.

Pharmacological therapies

Management of PPCM is similar to that of other causes of cardiac failure and includes maintenance of adequate oxygenation, fluid

Table 1. *Causes of dilated cardiomyopathy*

Aetiology	Examples
Infectious	Viral, e.g. coxsackievirus, HIV, Epstein–Barr virus
	Bacterial, e.g. *Streptococcus*, tuberculosis
Haematological	Iron deficiency anaemia, sickle cell disease, thalassaemia
Endocrine	Hypothyroidism, hyperthyroidism, phaeochromocytoma
Autoimmune	Systemic lupus erythematosus, rheumatoid arthritis
Metabolic	Haemochromatosis
Ischaemic	Coronary artery disease
Neuromuscular	Friedreich's ataxia, muscular dystrophies
Drugs	Alcohol, chemotherapeutic agents, e.g. cyclophosphamide
Others	Nutrition related, e.g. thiamine deficiency

and salt restriction and ventricular off-loading by vasodilation and diuresis.

Angiotensin-converting enzyme inhibitors (ACE inhibitors) have been shown to improve mortality in cardiac failure and are recommended as first-line therapy for the management of PPCM post partum. Angiotensin receptor blockers (ARBs) are an alternative for those intolerant to the side-effects of ACE inhibitors. ACE inhibitors and ARBs are contraindicated during pregnancy because of the risk of birth defects. Administration of ACE inhibitors, particularly in the second and third trimesters, is associated with increased fetal loss and fetal renal dysfunction, oligohydramnios and other congenital anomalies. ACE inhibitors and ARBs are not recommended for use in breastfeeding mothers initially because of the risk of neonatal hypotension.[4]

Post-partum ACE inhibitor therapy is indicated for as long as the left ventricle remains impaired. In the longer term, ACE inhibitor therapy may improve cardiac remodelling.

Hydralazine and nitrate therapy, such as isosorbide dinitrate, can be used safely during pregnancy. These drugs reduce afterload, preload and intracardiac filling pressures. Beta-blockers have been shown to improve survival and may be protective against tachyarrhythmias.

Digoxin is considered safe in pregnancy and may be used for its positive inotropic effect and for the treatment of atrial fibrillation should it occur. Digoxin plasma levels should be carefully monitored.

Loop diuretics, e.g. furosemide, may reduce pulmonary congestion and peripheral oedema and can be used safely in pregnancy and lactation.

Calcium channel blockers are usually avoided because of their negative inotropic properties. Aldosterone antagonists such as spironolactone are not recommended during pregnancy.

Endomyocardial biopsy can be performed to assess whether intravenous immunoglobulin may be of benefit. There is some evidence in small trials to suggest this targeted therapy and others, such as bromocriptine and pentoxifylline, may be of benefit if biopsy shows an inflammatory component.[5–7]

Not all PPCM is associated with a myocarditis inflammatory state and immunoglobulin therapy is not recommended empirically.

Owing to the risk of venous thromboembolism and mural thrombus associated with PPCM, prophylactic low-molecular-weight heparin (LMWH) therapy is indicated. If thromboembolic sequelae or mural thrombus have been identified, full anticoagulation is indicated.

Non-pharmacological therapies

Patients in the acute setting may need supportive therapy with non-invasive ventilation or intubation, ventilation and inotropic support. In severe cases an intra-aortic balloon pump, left ventricular assist device (LVAD) or extracorporeal membrane oxygenation (ECMO) may be required. Heart transplantation may be indicated for patients with severe disease who do not respond to pharmacological treatments.

Implantable defibrillators and cardiac resynchronisation are possible interventions in those women who survive the acute phase but experience on-going significant functional impairment.

Pre-conceptual counselling

Pre-conceptual counselling should be offered to all women with a history of PPCM. There is a significant risk of recurrence of PPCM in subsequent pregnancies. Women with on-going cardiac impairment following PPCM, i.e. NYHA class 3 or 4 cardiac failure, or those with a left ventricular ejection fraction of less than 30% are at highest risk from further pregnancies.

Women most at risk should be provided with information regarding the risks of future pregnancy and guidance on contraception, and potential need to consider termination should pregnancy occur.

ANAESTHETIC CONSIDERATIONS

PPCM poses many challenges for the anaesthetist. Anaesthetic technique will be influenced by the urgency of delivery and the physiological condition of the parturient. Women with suspected PPCM, or a past history of PPCM, should be reviewed by an anaesthetist in a timely manner and an agreed plan made for labour, delivery and postpartum care.

Considerations regarding mode of delivery should include the patient's obstetric history, current haemodynamic status and response to medical management. Vaginal delivery is an option for patients with compensated PPCM.

Techniques to limit the increase in plasma catecholamines, systemic vascular resistance and myocardial workload associated with labour are advised.

Aorto-caval compression should be prevented at all times by avoiding supine positioning without adequate uterine displacement. Regular monitoring with ECG and measurement of oxygen saturation and blood pressure should be initiated early with a low threshold for invasive arterial blood pressure monitoring. In order to limit cardiovascular stress, early labour epidural analgesia is recommended. This will not only reduce the sympathetic response caused by painful contractions, but also decrease afterload and provide a means of achieving surgical anaesthesia should operative intervention be required.

The second stage of labour can be managed with instrumental assistance, which may reduce myocardial workload and the

detrimental cardiovascular effects of prolonged Valsalva manoeuvres during pushing.

Both general and regional anaesthesia have been described for caesarean delivery.[8] Monitoring should include invasive arterial blood pressure. Cardiac output monitoring will provide additional information that may aid perioperative management.

The anaesthetic management aims are to:

- maintain myocardial perfusion by avoiding:
  - arrhythmias
  - episodes of hypotension or tachycardia
- optimise cardiac output
- maintain preload but prevent fluid overload
- maintain/increase myocardial contractility
- prevent increased afterload.

Titrated neuraxial anaesthesia, by incremental top-up of an epidural or a combined epidural and low-dose spinal anaesthetic technique, may achieve these aims. Neuraxial anaesthesia reduces afterload, promoting forward flow, and avoids the use of general anaesthetic agents that reduce myocardial contractility. Neuraxial opioids provide effective postoperative analgesia, thereby reducing sympathetically mediated postpartum increases in afterload. Significant falls in systemic vascular resistance should be avoided so that coronary perfusion is maintained. If using a neuraxial anaesthetic technique, attention should be given to the timing of anticoagulation administration.

If general anaesthesia is undertaken, induction should be as smooth as possible to minimise both hypotension and hypertension. The pressor response to laryngoscopy and intubation should be attenuated by administration of an appropriate dose of a rapid-acting opioid, e.g. alfentanil or remifentanil. Inotropes, such as dobutamine, calcium sensitisers (e.g. levosimendan) or phosphodiesterase inhibitors (e.g. milrinone) may be necessary to offset the myocardial depression of intravenous and volatile anaesthetic agents. Vasopressors may also be required to counteract vasodilation and maintain coronary perfusion. Preload should be maintained and minimally invasive or invasive cardiac output monitoring may provide useful information to guide these therapies.

Uterotonic drugs should be used cautiously because of their associated side-effects:

- Oxytocin can cause a marked decrease in systemic vascular resistance and in higher doses has an antidiuretic effect.
- Ergometrine may cause significant increases in afterload.

Following delivery the patient should be recovered in a critical care environment with on-going invasive haemodynamic monitoring, careful fluid management and adequate analgesia.

CONCLUSION

- Peripartum cardiomyopathy (PPCM) is a rare condition with significant mortality.
- PPCM has strict diagnostic criteria.
- Early identification of PPCM improves outcome.
- Management is multidisciplinary.
- Preconceptual counselling should be offered to women who have previously suffered from PPCM.

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Update in
Anaesthesia

Remote debriefing – a new paradigm for low resource and rural hospitals?

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This brief report describes the use of communication technology to allow distance learning between trainers in the UK and trainees in low- and middle-income countries. The advantages and disadvantages of this technique are discussed.

INTRODUCTION

In Kenyan rural hospitals, junior doctors and anaesthetic clinical officers often face medical emergencies alone; scenarios that are typically complex and chaotic to manage prove even more daunting with an absence of senior support and feedback on their performance. Proficiency in accurately assessing one's own performance and learning to reflect on tasks performed are important skills in improving clinical practice and identifying system constraints.[1] But how can medical staff learn from feedback on performance when the opportunity for senior supervision is limited?

Key terms

- **Freemium** is a pricing strategy by which a product or service (typically a digital application such as software, media, games or web services) is provided free of charge, but money (premium) is charged for proprietary features, functionality or virtual goods.
- **Skype**® is an application that specialises in providing internet video chat and voice calls. Users can also exchange text and video messages, files and images, as well as create conference calls. It is based on a freemium model between users.
- **Dropbox**® is a freemium file hosting service that offers cloud storage, file synchronisation, personal cloud, and client software. Dropbox allows users to create a special folder on their computer devices, which Dropbox then synchronises so that it appears to be the same folder (with the same contents) regardless of which computer is used to view it. Files placed in this folder are also accessible via the Dropbox website and mobile apps.

With assistance of the charity MEAK (Medical and Educational Aid to Kenya) I established a novel and innovative approach of review of a simulation in Nanyuki Hospital, Kenya, to provide feedback and guided reflection from senior clinicians (trained in giving feedback) in the UK using Skype®.

We have experienced a culture change in favour of reflective feedback and feel that remote debriefing of simulations will progress doctors' skills in managing complex situations.

METHOD

I organised a low-fidelity acute asthma simulation that was filmed using the hospital's laptop webcam. I have previously visited Nanyuki Hospital to help implement a trauma simulation course designed by emergency department doctors at Torbay Hospital, UK. I found the internet availability in Kenya to be good, even in rural areas.[2]

As the sample size of junior doctors available to participate was small, a qualitative method of data gathering through semi-structured interview transcript analysis was undertaken; traditional face-to-face ethnographic methodology was supplemented by digital ethnography. Advantages of digital ethnography include affordability, the ability to achieve global reach and the ability to map networks, which may aid future research.

Using the file hosting service Dropbox®, the video was uploaded in the hospital manager's office using a high-speed internet connection and was freely retrieved moments later on the other side of the world. The use of freemium voice-over IP service Skype® made expert advice from the UK available (Figures 1 and 2). A consultant anaesthetist specialising in medical education, a senior pharmacist, the Kenyan doctors and I watched the videos and the debrief began, focusing on non-technical skills. Formative feedback was used, focusing on encouraging reflection

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Figure 1. *Two consultants conduct feedback to trainees in Kenya using Skype®*

of human factors and discussing system restraints encountered. Formative assessment is that which modifies teaching and learning activities to improve student attainment, as opposed to summative assessment, which is an evaluative tool to look at learning outcomes, usually for the purpose of external accountability.

There are significant ethical issues surrounding the use of digital tools and data collection. Technological innovations and possibilities for new research outpace the creation of ethics guidelines. I utilised existing guidelines, updated by the Association of Internet Researchers.[3]

Comparative thematic analysis will be undertaken by the author; a method of constant comparison will be used, derived from grounded theory.[4] Cross-referencing of triangulated qualitative data forms such as images, transcript and videography are to be undertaken until data saturation occurs, to ensure depth and rigour of thematic analysis.

Scenario used for videoed simulation

- Welcome!
- The aim of this simulation is to rehearse a medical emergency that can occur in your hospital.
- This session is not designed to test your knowledge. It will be filmed so that you can watch it back and we will discuss what we see.
- Please treat SimMan as though he were a real person.
- Moses is an inpatient on the medical ward and he was admitted a few days ago with some tummy ache. He has a past medical history of a breathing problem.
- Suddenly today on the ward his breathing has become fast and noisy.
- Please treat this as if you were called to see this patient.
- There is a table of equipment available to you. If something you need is not there, we will pretend.
- If you wish to know observations, please assess Moses and your invigilator will tell you your findings.

RESULTS

Initial results demonstrate that the Kenyan junior doctors found facilitated self-review using video feedback to be motivating, worthwhile and not intimidating, particularly when partnered with benchmarking from consultant-experts proficient in giving formative feedback.

They appreciated positive comments on their quick diagnosis and management of the asthma patient. Both doctors acknowledged that in future they would delegate tasks and communicate their mental model with the team.

The most positive outcome occurred when they identified their own learning requirements and reflected on a solution, speculating on whether they ought to debrief their own teams after any particularly challenging incidents, in order to motivate each other and build tight teams with the nurses and clinical officers.

Figure 2. *Further images of remote debriefing in practice*

Word has spread to the next junior doctors due to start in Nanyuki and they are eager to do another simulation with feedback from the doctors in the UK. The experience was also well received by the UK members of the team, who are also keen to repeat the process.

CONCLUSION

Formative assessment using video review of clinical performance with appropriate expert feedback and benchmarking can be a useful tool to allow doctors to critically and accurately assess their skills, identify areas for improvement and cultivate proficiency in self-assessment.[5] With some simple aid from our team to encourage reflective feedback, the junior doctors managed to complete Kolb's experiential learning cycle without ever having heard of the concept; critically assessing their video, realising there was a performance gap and conceiving new ideas on how to improve their clinical practice (Figure 3).

Although it is difficult to remedy that Nanyuki Hospital is resource poor, building on teamworking and system factors can be a free way of improving patient care within the hospital.

Debriefing teams from a different cultural and clinical background is educational for the trainers as much as it is for the trainees. Doctors' actions and decisions are guided by frames and 'heuristics'. A cognitive 'frame' is an internal image or mental model of external reality. Clinicians actively filter and make sense of clinical situations through these frames. Mistakes can then be seen to made sense in the context of the person's mental model.[6] Recognising this allows the trainer to help find a helpful solution, rather than misdiagnose what the problem may be. Having to debrief a team in the context of their limited resources was a new challenge for us; it has changed my own approach to debriefing and I now have a healthy scepticism regarding my own conclusions about doctors' performance in the context of complex environments. It has taught me that debriefing with the team and discussing mental models is vital in correctly matching teaching points to student requirement.

There is a human resource crisis in Kenyan rural hospitals, as doctors wish to work in tertiary centres for easier access to medical resources, continued medical education (CME) and increased opportunity for observation and feedback of skills by senior clinicians.[7] Providing access to CME to build on teamworking and system factors may be a free way of retaining doctors rurally and improving patient care

Box 1. Critical events included in debrief and discussion

- Describe what happened in the scenario.
- Who was leading?
- How did it feel doing the scenario?
- How did you feel watching yourself back?
- What went well?
- Describe what the other person did well.
- Is there anything you would do differently next time?
- What have you taken away from this?
- Do you think this will help you deal with real-life scenarios?

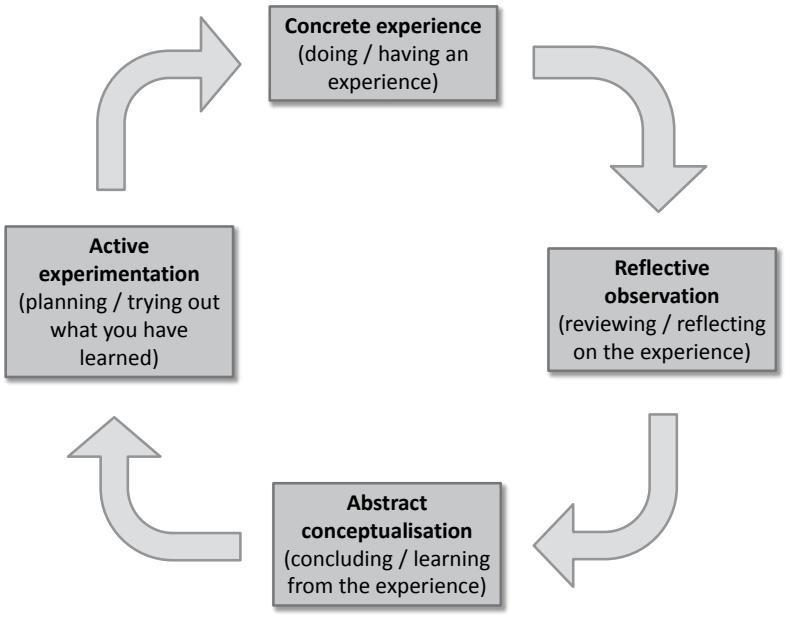

Figure 3. *Kolb's experiential learning cycle*

within the hospital. Remote debriefing could allow for internet-based distance learning with remote guidance from trained facilitators anywhere in the world, with participants performing a simulation with facilitated debriefing and reflection.

Increasingly there is consensus within the literature that high-frequency, low-intensity simulation sessions are more effective in long-term skill acquisition;[8] remote debriefing may therefore translate into improved performance away from the simulation setting.[9] With remote debriefing sessions continuing between our hospitals, I believe that in rural hospitals with limited resources in developing countries, low-cost simulation[10] with remote feedback is a feasible approach to improve human factors and motivate junior doctors to improve their skills, shaping their professional identity. I am looking to expand this further with the local health authorities by facilitating Skype® sessions between Nanyuki and senior clinicians in Kenya's first and newly built simulation centre in Kijabe.

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Update in
Anaesthesia

Affordable CPAP in low income countries

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Summary
Continuous positive airway pressure (CPAP) is a form of therapy used for the treatment of a wide variety of conditions causing respiratory distress in infants and young children. It entails the provision of a continuous supply of a mixture of compressed air and oxygen delivered in varying proportions, and at flow rates and pressures according to the patient's requirements. Whilst this is readily achievable in modern, well-equipped hospitals, this life-saving treatment is frequently unavailable in remote hospitals in poor countries because of the expense and logistical problems involved in the provision of medical oxygen and air. An alternative method of providing CPAP which overcomes these disadvantages is described.

THE DIAMEDICA BABY CPAP APPARATUS

The Diamedica Baby CPAP apparatus (Figure 1) has been designed to enable CPAP to be delivered safely and economically from a single unit in circumstances in which more conventional facilities are unavailable or unaffordable. It incorporates a standard oxygen concentrator that has been modified to produce an increased output with a variable concentration of oxygen. The concentrator has twin flowmeters for air and oxygen, each with a maximum flow rate of 8 L min^{-1}.

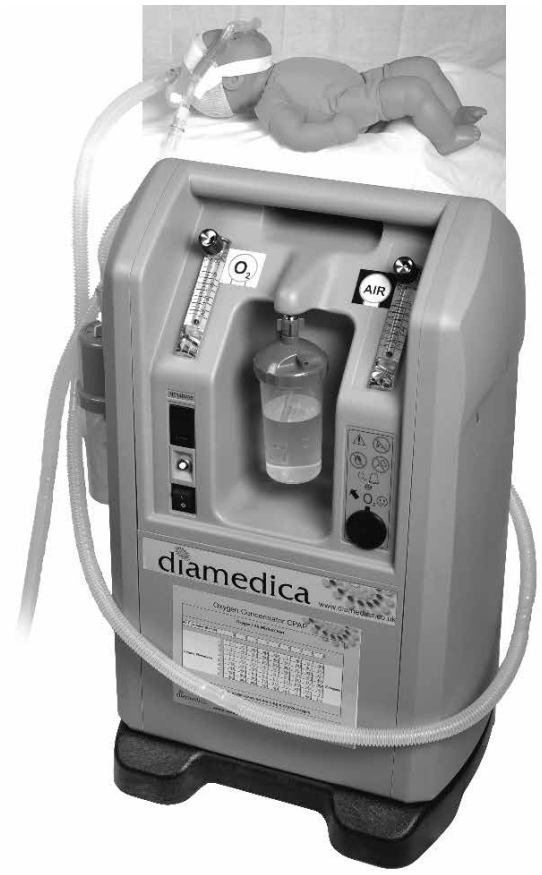

Figure 1. *The Diamedica Baby CPAP*

The oxygen–air mixture then passes over a water humidifier and via lightweight respiratory tubing to silicone nasal prongs or a face mask. In a new unique development, the concentrator has been further modified so that warm waste air from the concentrator's compressor is directed towards the humidifier bottle. This increases the temperature of the inspired gases, raising the dew point of the water and thus providing enhanced humidification to the device. Laboratory tests were carried out to determine these effects.

Pressure is maintained throughout the respiratory cycle by directing the gas flow to a container of water at the distal end of the circuit via a tube with an open end at an adjustable depth beneath the surface. The pressure is determined using a calibrated dial, which enables the depth of the tube to be adjusted *in situ*. As the pressure control is distal to the patient interface the system provides accurate control of the pressure with minimal pressure variation at the patient interface.

The concentration of oxygen delivered to the patient is determined by the relative flows of oxygen and

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air using twin flowmeters. The inspired oxygen concentration is displayed on an accompanying chart.

The modified concentrator measures 39 × 44 × 84 cm and weighs 26 kg. It is electrically powered, requiring 430 W. The cost of the Diamedica CPAP apparatus including a range of patient interfaces is £1700 and the running cost in UK at present is £0.10 per hour.

DISCUSSION

The administration of CPAP to infants and young children requires equipment capable of delivering the following:

1. A total gas flow exceeding the patient's maximum inspiratory flow rate. This is to ensure that the pressure in the airway remains above atmospheric pressure throughout the respiratory cycle. It also prevents dilution of the inspired mixture with atmospheric air, enabling the maximum possible FIO_2 to be administered when required.
2. A FIO_2 that can be adjusted according to the needs of the patient at different stages of treatment.
3. A means of adjusting the airway pressure.
4. An inspired mixture which can be warmed and humidified to approximately ambient temperature and above 90% relative humidity.

When administered in well-equipped hospitals having reliable monitoring equipment and centralised supplies of oxygen and compressed air, CPAP treatment is simple, effective and inexpensive.

However, in many hospitals in less affluent countries the situation is very different. Oxygen and compressed air are generally supplied in cylinders which may require transportation over long distances on roads which may, at times, be impassable. In these circumstances the supply may be interrupted. Even when cylinders are available, the flow requirements for CPAP are so great that the expense involved may make the treatment unaffordable.

Oxygen concentrators have been used for many years as an inexpensive source of oxygen in low-income countries both for oxygen therapy,[1,2] inpatient therapy and during anaesthesia and the postoperative period.[3,4] They have been particularly useful in maintaining the supply in remote locations where delivery of cylinders may be subject to frequent interruptions.

A recent study compared the performance of seven concentrators under the extreme conditions encountered in a range of developing countries.[5] The AirSep Elite oxygen concentrator was ranked the highest based on its overall performance and a concentrator from this manufacturer was selected for use in the Diamedica CPAP apparatus.

High concentrations of oxygen, when administered to infants over prolonged periods, can have a detrimental effect on the retina and may lead to blindness. For this reason the percentage of oxygen being delivered at any time is kept under constant review and is restricted to the minimum effective level. In the absence of an oxygen analyser, the inspired oxygen concentration is displayed on an accompanying chart located on the device (Figure 2).

Airway pressures between 3 and 6 cmH_2O are commonly used, but in severe cases pressures up to 10 cmH_2O may be required. High levels may impede venous return and diminish cardiac output so the minimal effective level is applied and adjustments made depending on the patient's response.

Even when cylinders of oxygen and compressed air are available, and can be supplied in sufficient quantities, the cost of providing high flow rates over prolonged periods may be unaffordable in low income countries.

Oxygen / Air Mixing Chart

Air Flowmeter (lt/min)	0	1	2	3	4	5	6	7	8	
1	95.0	57.5	45.0	38.8	35.0	32.5	30.7	29.4	28.3	
2	95.0	70.0	57.5	50.0	45.0	41.4	38.8	36.7	35.0	
3	95.0	76.3	65.0	57.5	52.1	48.1	45.0	42.5	40.5	
4	95.0	80.0	70.0	62.9	57.5	53.3	50.0	47.3	45.0	
Oxygen Flowmeter 5	95.0	82.5	73.6	66.9	61.7	57.5	54.1	51.3	48.8	% Oxygen
6	95.0	84.3	76.3	70.0	65.0	60.9	57.5	54.6	52.1	
7	95.0	85.6	78.3	72.5	67.7	63.8	60.4	57.5	55.0	
8	95.0	86.7	80.0	74.5	70.0	66.2	62.9	60.0	57.5	

Assuming an oxygen concentrator output of 95% Oxygen

Figure 2. *Chart to guide air/oxygen mixing to achieve certain FiO_2*

Figures 3. *Clinical use of the Diamedica Baby CPAP machine*

The cost of cylinders of compressed air and oxygen varies from country to country and even from place to place according to the geography. However, a standard E-size cylinder of oxygen (680 L) in most African hospitals costs in the region of £5 and the cost of compressed air is approximately the same.

The provision of CPAP in paediatric patients requires high flows of both compressed air and oxygen and a total flow of 10 L min^{-1} would therefore not be unusual. At this rate a single cylinder would last approximately 1 hour, giving a total cost exceeding £100 for 24 hours. In contrast the same flows can be supplied by the oxygen concentrator at a cost of £0.10 per hour or £2.40 for 24 hours.

The Diamedica Baby CPAP machine is already in use in over 18 countries in both hemispheres (Figure 3). Feedback from those using the equipment in the field has been very positive and has demonstrated that this life-saving treatment is affordable and can function in the poorest countries of the world helping to prevent avoidable deaths.

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Update in
Anaesthesia

Alternatives to traditional fibreoptic bronchoscopes for use in resource-poor settings

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Successful airway management is central to the practice of anaesthesia. In resource-rich environments, there are numerous tools of increasing complexity and cost available to deal with difficult airway management. Basic airway management is usually accomplished using laryngoscopes, endotracheal tubes and laryngeal mask airways; more difficult cases may utilise video laryngoscopes or other specialised devices. Fibreoptic bronchoscopes are reserved for particularly difficult intubations, awake intubations, or other special situations.

Traditional laryngoscopes, endotracheal tubes and laryngeal mask airways are relatively inexpensive and can be used in low-resource environments. Even slightly more sophisticated equipment such as video laryngoscopes have now become inexpensive enough and robust enough that they could be deployed to resource-poor environments. These tools, such as the GlideScope® by Verathon®, could be used as a substitute for fibreoptic bronchoscopes in some situations, for example awake intubations. However, they are unlikely to completely replace the need for fibreoptic bronchoscopes. Unfortunately, fibreoptic bronchoscopes remain relatively expensive to purchase and they require reliable electrical power, periodic maintenance and sterilisation. Because of their infrequent and specialised use, they have not benefited from the economies of scale that other airway technologies have and are unlikely to do so in the near future.

We therefore wish to discuss whether other technology could be repurposed or reused to provide fibreoptic capability in resource-poor environments.

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ALTERNATIVES TO FIBREOPTIC BRONCHOSCOPES

We identified two plausible approaches to providing a substitute for fibreoptic bronchoscopes. The first was acquiring single-use devices designed for the developed world, and sterilising and reusing these devices. The second was repurposing of commercially available scopes, commonly known as borescopes, for medical use.

Recent reductions in cost of electronic cameras have made single-use bronchoscopes feasible for resource-rich environments. For example, the Ambu® aScope™ is a single-use bronchoscope utilising a small electronic camera. At a cost in the range of hundreds of US dollars, it is much cheaper than a traditional fibreoptic bronchoscope, which costs in the range of tens of thousands of US dollars. However, to be economically viable in low-resource settings it would need to be reused, and it was not designed for this purpose.

This brings up several issues, the foremost being cleaning and sterilisation. Sterilising with heat or chemicals is likely to be problematic given that the scope was never designed with sterilisation in mind – the electronics or the plastic body are likely to be degraded. An alternative to sterilising the scope would be to mount a disposable cover over it. Although this would seem to be trivial, several problems arise. First, the ability to suction would be lost because the port would be occluded. Secondly, the light source and the camera of the Ambu® aScope™ are in close proximity. Even a transparent plastic cover would cause so much reflection back into the camera from the light source that the image would be washed out. To overcome this, there are several options – either the plastic window can be made at an angle such that the light is not reflected back into the camera, or a fluid can be introduced between the camera and the cover that matches the refractive index of the plastic and hence eliminates the reflection.

Because the aScope™ was not designed for reuse, even without sterilisation its long-term durability is unknown. Further, the aScope™ requires the purchase of a separate screen in order to visualise the output of the camera, significantly increasing cost and potentially putting it out of reach for resource-poor environments. Lastly, the aScope™ is not distributed in all countries.

Alternatively, commercially available scopes, known as borescopes, could be used. These are widely available and generally used for tasks such as pipe or wiring inspection. They have a form factor very similar to traditional bronchoscopes although they frequently use a pistol-style grip. They are also very inexpensive and widely available, priced from around US$100, and this amount includes the screen itself. They are also designed for long-term use. A photograph of a borescope with a pistol-style grip is shown in Figure 1.

Unfortunately, although they are cheaper and more widely available, borescopes suffer from many of the same drawbacks as the aScope™ as well as some new difficulties. They are not designed to be sterilised and so the above discussion applies regarding alternatives to heat or chemical sterilisation. Many borescopes may be too large in diameter to allow an endotracheal tube to be mounted on them and railroaded into the trachea (although they could still be used for external visualisation of the larynx). They also generally do not have suction ports built in. Some borescopes have steerable tips similar to those commonly found on endoscopes and bronchoscopes, but not all do. Generally, borescopes with steerable tips and thinner probes are more costly, and this may eliminate the cost advantage relative to the aScope™.

We constructed several covers for the scope shown in Figure 1 to assess their performance, including an approximate refraction-matching design using a lubricating jelly and an angled window design. We assessed the images produced by these scopes and practised intubating mannequins using the scopes. We found that a transparent cover with a sharply angled window to eliminate back-reflections was the simplest, most practical option. The primary drawback to using a cover in this shape is that, because the tubing extends beyond the camera on one side, the image in this area is obscured. Also, the relative stiffness of the cover reduces the practitioner's ability to steer the tip of the scope, and, as noted previously, any ability to suction is lost. We found, however, that the pistol-grip style scope seemed easier to use than the traditional bronchoscope form.

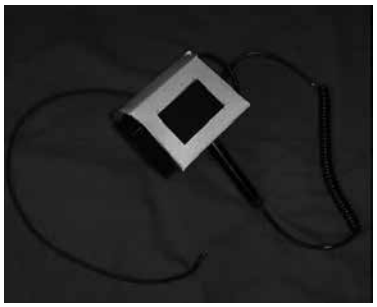

Figure 1. *Borescope with pistol-style grip. Borescopes of this style are widely available from a number of manufacturers*

CONCLUSIONS

Unfortunately, there is no obvious alternative to traditional fibreoptic bronchoscopes for resource-poor environments at this time, although we felt using commercial borescopes with an angled window held some promise. If the scope is intended for use only in life-threatening emergencies, and is thoroughly cleaned between uses (but not sterilised), then one might argue that the relative risk versus benefit is favourable to the patient. Of course, the on-going trend towards less expensive and more capable electronics may change this calculus and we certainly hope that a solution appropriate for developing countries will be available in the future.

FURTHER READING

1. Colt HG, Beamis JJ, Harrell JH, Mathur PM. Novel flexible fiberoptic bronchoscope and single use disposable sheath endoscopic system: a preliminary technology evaluation. *Chest* 2000; **118**: 183–7.

Update in
Anaesthesia

Cerebral challenge

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CASE 1

A 73-year-old man presents to the emergency department feeling generally unwell. He is short of breath and dizzy when he tries to stand. He denies chest pain, but does have a history of ischaemic heart disease and hypertension. On examination he is clammy and looks grey, and he has a raised jugular venous pressure with visible 'cannon' waves. On auscultation there are bibasal crackles. His initial observations are blood pressure 75/34 mmHg heart rate 38 per minute, respiratory rate 28 per minute and oxygen saturation 91% in room air. Figure 1 shows his ECG.

- What does this ECG show?
- What are the causes of the ECG findings?
- What is the treatment for this condition?

CASE 2

A 28-year-old woman is brought in to the emergency department having dived into the shallow end of a swimming pool whilst under the influence of alcohol. Friends immediately recovered her from the swimming pool, with no requirement for cardiopulmonary resuscitation at the scene. She has complained of neck pain since the injury, and paraesthesiae in her legs and fingers, but the paramedics were not able to immobilise her neck at the scene as she was agitated and non-compliant.

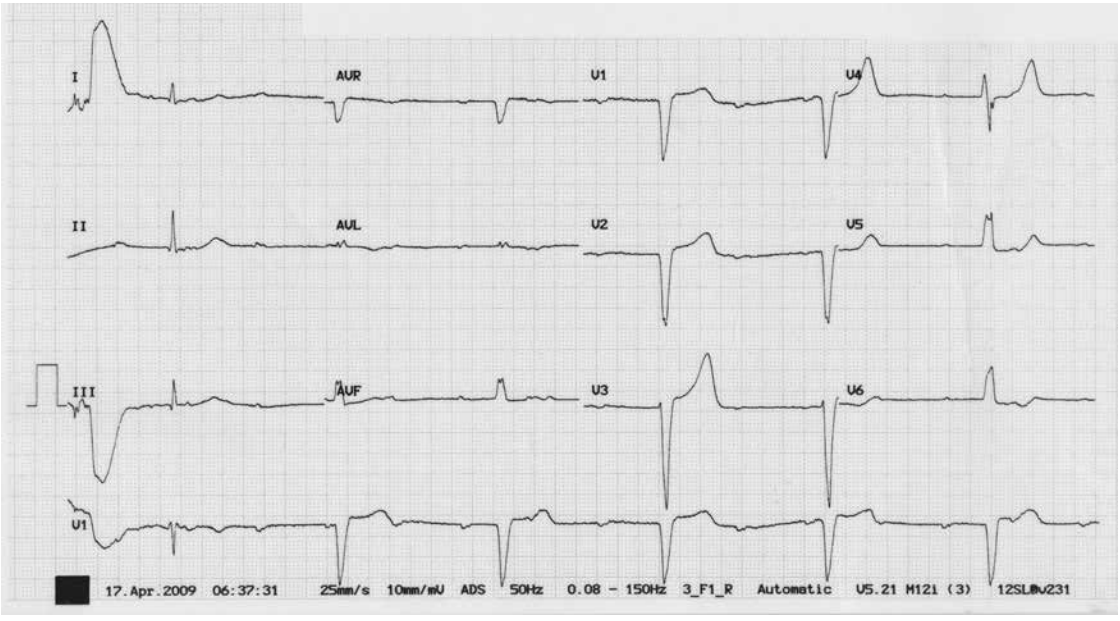

Figure 1. *ECG of patient 1*

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- What are the key priorities for management of this patient on arrival in the emergency department?
- What does this cervical spine X-ray (Figure 2) demonstrate?
- How should this patient be managed?

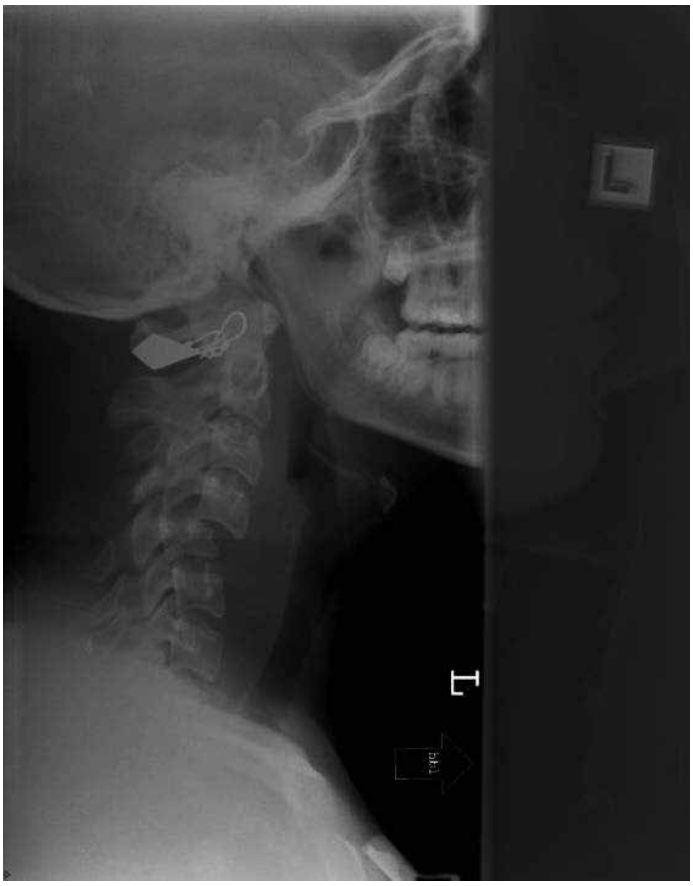

Figure 2. *Lateral cervical spine X-ray of patient 2*

CASE 3

You are asked to review a 33-year-old man in the high-dependency unit. He is a known asthmatic, admitted via the emergency department with an acute severe asthma attack and has been receiving appropriate medical therapy.

The nurse looking after him is concerned as he is complaining of increased chest pain and shortness of breath. You immediately attend to assess him. On examination you find him in respiratory distress, unable to speak a full sentence. He is swollen around the face and neck, tachypnoeic and tachycardic. There is a crackling under your fingertips on palpation of the swollen tissues in his neck, the trachea is central and there is decreased chest expansion on the left. His chest is hyper-resonant to percussion bilaterally and there is widespread expiratory wheeze on auscultation except for in the left upper zone, where you cannot hear any breath sounds. His oxygen saturations are 94% on supplemental oxygen. You order a chest X-ray (Figure 3).

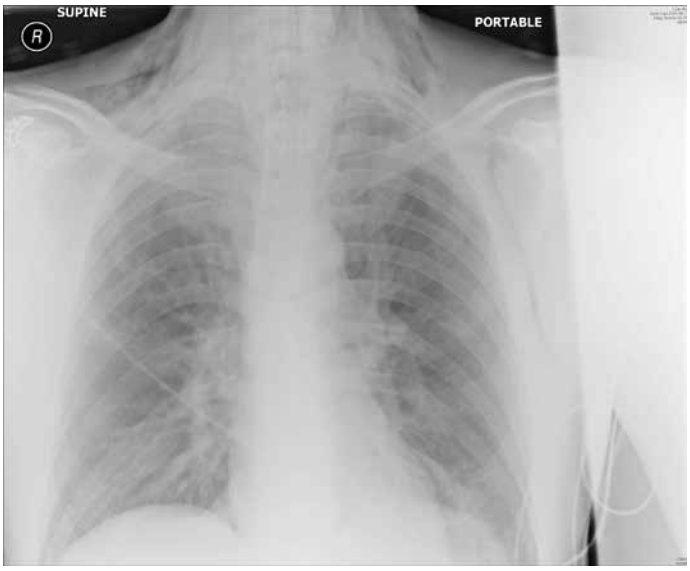

Figure 3. *Chest X-ray of patient 3*

- What does the chest X-ray show?
- What is the diagnosis?
- How would you manage this patient?

DISCUSSION

Case 1

The ECG shows P-waves (atrial contraction) and QRS complexes (ventricular contraction) that have no relationship to each other – in normal cardiac conduction, each P-wave should be followed by a QRS complex. This is complete atrioventricular (AV) dissociation, also called third-degree heart block (or complete heart block). The QRS complexes are widened (142 ms, normal < 120 ms) and the rate is slow – this is termed a 'ventricular escape rhythm', here with a rate of 38 beats per minute.

Complete heart block occurs when there is no conduction of electrical activity from the atria to the ventricles. This block in electrical conductance can occur at the AV node, the bundle of His or the Purkinje system. Both the rate of the escape rhythm and the width of the QRS complexes are determined by the site of origin of the escape beats. If the pacemaker cells of the heart causing the escape rhythm are above the bundle of His, a narrow QRS complex will be produced; pacemaker cells in the bundle of His or Purkinje system will lead to a broad QRS complex.

Table 1. *Causes of third-degree heart block*

Congenital	Autoimmune (maternal SLE), structural heart disease (transposition of the great vessels)
Idiopathic fibrosis of the His Purkinje system	Lev's disease, Lenegre's disease
Ischaemic heart disease	Acute myocardial infarction (particularly of the right coronary circulation), ischaemic cardiomyopathy
Non-ischaemic heart disease	Calcific aortic stenosis, idiopathic dilated cardiomyopathy
Cardiac surgery	Valve replacement, coronary artery bypass graft, ventricular septal defect repair
Iatrogenic	Radiofrequency AV node ablation, pacemaker implantation
Drug induced	Beta blockers, amiodarone, digoxin, calcium channel antagonists (diltiazem and verapamil); tricyclic antidepressants, clonidine
Infective	Endocarditis, Lyme's disease, rheumatic fever, Chagas' disease, diphtheria
Connective tissue	SLE, rheumatoid arthritis
Neuromuscular	Duchenne muscular dystrophy

AV dissociation is not only seen in complete heart block; it can occur when the atrial rate is slower than the ventricular rate, such as in ventricular tachycardia.

The most likely cause in this man is ischaemic heart disease (IHD). Both IHD and hypertension can lead to left ventricular hypertrophy and myocardial damage, eventually causing third-degree heart block. Other causes include infectious diseases, for example diphtheria and rheumatic fever (group A *Streptococcus*) and congenital and autoimmune diseases, such as systemic lupus erythematosus (see Table 1).

Heart block can occur after cardiac surgery. Cardiac medications aimed at treating tachyarrhythmias, such as amiodarone, beta-blockers, digoxin and calcium channel antagonists, can also predispose to complete heart block, as can clonidine and tricyclic antidepressants.

Complete heart block can present with a broad range of symptoms. These can range from fatigue, confusion, dizziness and blackouts, known as Stokes–Adams attacks, to chest pain, severe dyspnoea, cardiogenic shock and cardiac arrest.

Treatment of third-degree heart block

Initial management follows an ABCDE approach; with application of high-flow oxygen, intravenous (IV) access and initial attempts to increase heart rate by administration of atropine 500 µg, up to 3 mg in total. However, this may only work temporarily, and will only work if the block is at the AV node. It can also be dangerous to administer to a patient with an on-going myocardial infarction.

Some patients suffer sudden asystolic cardiac arrest and so this patient should receive continuous cardiac monitoring and, if available, the application of transcutaneous pacing pads. This man requires cardiac pacing, and a cardiologist should be sought as a matter of urgency to insert a temporary pacing wire. Transcutaneous pacing is uncomfortable for the patient, and so, if it is instigated due to haemodynamic compromise, a transvenous pacing wire should then be inserted as soon as possible. Ultimately, a permanent pacemaker may be required, if no reversible cause is identified.

Medications should be reviewed, and any potential causative agents stopped immediately. If overdose of medication is suspected, these should be treated accordingly. It is important to identify if the patient is suffering from an acute myocardial infarction at the time of presentation, as a patient with an evolving infarct is at greater risk of cardiac arrest. Reversal of acute ischaemia may reverse the heart block.

Case 2

What are the key priorities for management of this patient on arrival?

As with all trauma cases, the management of this patient begins with a 'C-ABCDE' assessment.

The C prior to the usual ABCDE encourages immediate assessment and management of:

- **C**atastrophic haemorrhage
- **A**irway with inline **C**-spine immobilisation
- **B**reathing
- **C**irculation
- **D**isability (neurological assessment)
- **E**xposure/environment.

C

In this case, there is no obvious catastrophic haemorrhage, his only complaints being pain in his neck and paraesthesiae.

A with cervical spine immobilisation

This woman is likely to have sustained a cervical spine injury – the mechanism of injury, diving into a shallow pool has caused an axial load to her head. This is a factor associated with high risk of cervical spine injury according to the Canadian C-spine risk factors. Other risk factors are listed in Table 2.

She has been drinking and, although she is able to communicate and her airway is patent at the moment, her agitation *may* be due to an

intracranial injury. She tolerates manual in-line stabilisation of her neck, but not a hard collar. In these situations, it is best to accept what the patient will allow, as opposed to trying to enforce a hard collar, potentially leading to further patient agitation and movement creating further injuries. If definitive airway control is indicated, a rapid sequence induction is recommended, as these patients are likely to have gastric paresis and a full stomach.

B

The location of a spinal cord injury will determine its impact on breathing. As well as excluding life-threatening complications, such as pneumothorax or haemothorax, attention needs to be paid to the ability to deep breathe and cough. Repeat assessments need to be made, as the neurological level of a spinal cord injury can ascend in the hours following injury. Thoracic spinal injuries will affect the innervation to the intercostal muscles, whereas spinal injuries to C3–C5 will affect the phrenic nerve and diaphragmatic innervation. Respiratory rate and saturations need to be recorded; any oxygen requirement should raise concerns. You notice that this woman has 'see-saw' breathing – when she breathes in her abdomen bulges and her chest is drawn in. This is also called 'paradoxical' breathing; the movements of the chest and abdomen are opposite to what we would usually see in spontaneous breathing. This occurs when a high thoracic or cervical cord injury has paralysed the intercostal muscles and the patient is reliant solely on diaphragmatic breathing.

Table 2. *Canadian C-spine risk factors*

High risk factors
Age > 65 years
Paraesthesiae in upper/lower limbs
Dangerous mechanism of injury
Fall from height > 1 m or five steps
Axial load to head (diving)
High speed motor vehicle collision
Ejection from/rollover vehicle accident
Bicycle collision
Horse-riding accident
Low risk factors
Involved in minor rear-end collision
Not comfortable in sitting position
Not ambulatory since time of accident
Midline cervical spine tenderness
Delayed onset neck pain
and
Unable to actively rotate neck to 45° to left and right

C

Secure IV access, and record heart rate and blood pressure regularly. In any trauma patient, hypotension needs to be investigated thoroughly, but patients with a spinal cord injury may present with bradycardia and hypotension but be warm and vasodilated due to interruption of the sympathetic nervous system pathways. This is neurogenic shock. The hypotension can be resistant to fluid resuscitation, and vasopressor support may be required, in order to prevent secondary spinal cord ischaemic injury.

D

Thorough and systematic repeated full neurological assessments need to be accurately documented. The American Spinal Injuries Association (ASIA) has produced sheets (ASIA charts) to accurately and repeatedly document neurological findings in patients with spinal cord injuries. This allows identification of deterioration and improvement in neurological findings. Any symptoms of spinal pain, weakness in the arms or legs, altered sensation or priapism requires that spinal protective measures be taken. If there are any distracting injuries, reduced consciousness or the patient is under the influence of alcohol or drugs, then spinal protective measures should be initiated. A high index of suspicion needs to be maintained for associated head injury, and usual guidelines for urgent computerised tomography (CT) of the head should be followed.

E

The patient should be fully exposed, whilst maintaining dignity and warmth as much as possible to look for further injuries. This often occurs as part of the log roll, and the spine is palpated for tenderness, and a digital rectal examination should be performed to assess anal tone. Monitor temperature and keep the patient warm, providing warm fluids, forced air blankets and warm mattresses if possible.

What does this cervical spine X-ray demonstrate?

This cervical spine X-ray (Figure 4) shows subluxation of C4 on C5, probably representing a fracture dislocation at this level. This is likely to have caused a major cord lesion at this level.

Cervical spine X-ray imaging is usually performed using three views.

Lateral view

- Ensure that the top of T1 vertebral body is included. To fully assess the images, three lines should be traced to assess vertebral alignment (Figure 5). These should be smooth unbroken lines:
  - along the anterior margins of the vertebral bodies
  - along the posterior margins of the vertebral bodies
  - joining the bases of the spinous processes.
- The vertebral body anterior and posterior heights should be equal, and the intervertebral discs should be the same height.
- Prevertebral soft tissues should be a maximum of 7 mm C1–C4 and 22 mm C5–C7. Any increase or swelling should highlight the potential presence of injury.

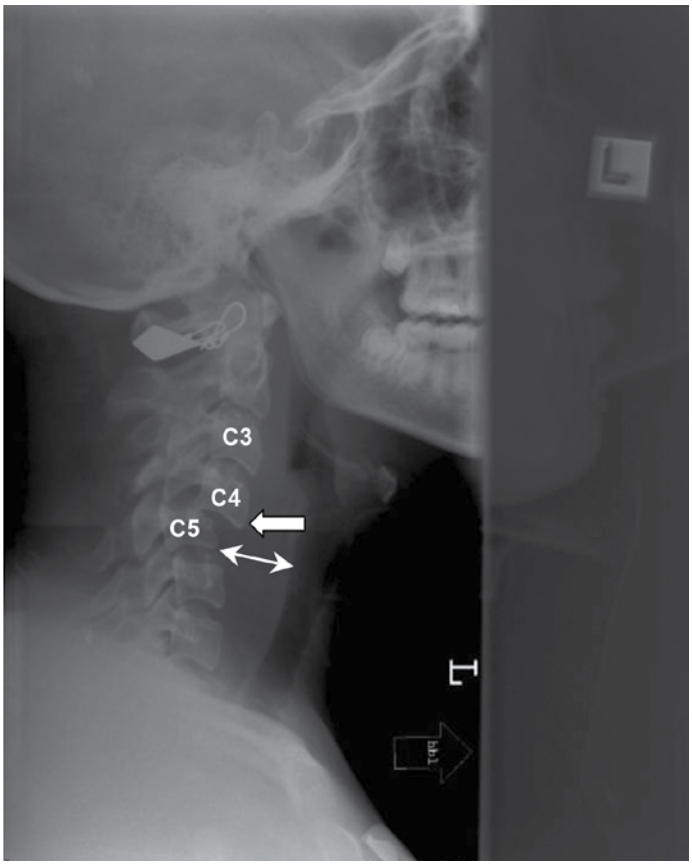

Figure 4. *Lateral cervical spine X-ray of patient 2, showing anterior subluxation (shift) of C4 on C5 (arrow). There is considerable soft tissue swelling anterior to the fracture-dislocation (double arrow). The metallic object at the top of the cervical spine is an overlying ear ring.*

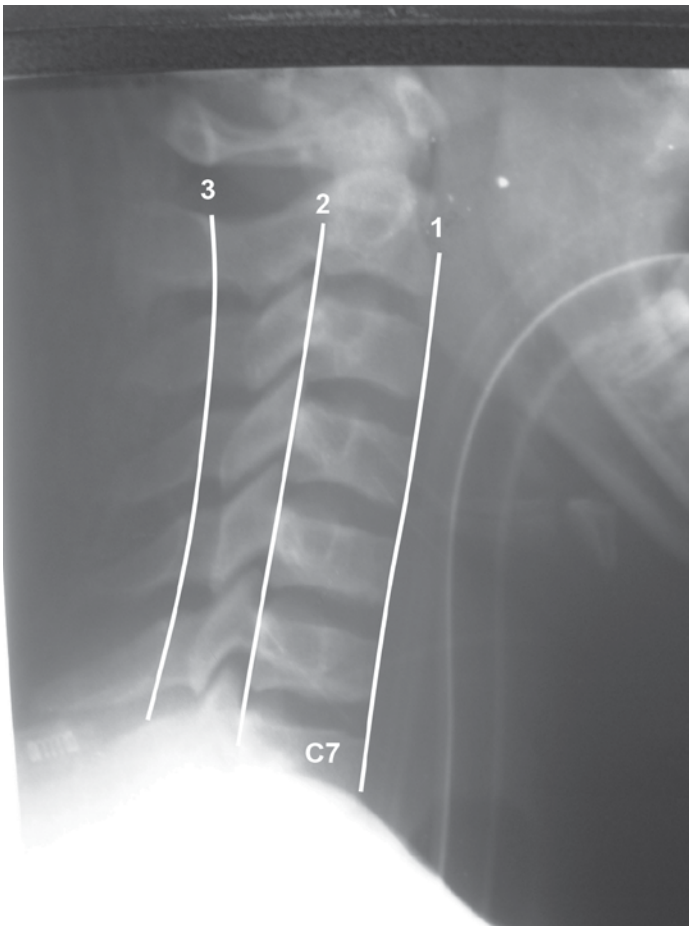

Figure 5. *Normal lateral cervical spine X-ray showing the smooth lines (1) along the anterior margins of the vertebral bodies; (2) along the posterior margins of the vertebral bodies and (3) joining the bases of the spinous processes.* ***Note that the body of C7 is not wholly seen and no part of T1 is seen and so this would not constitute an adequate lateral C-spine view***

Long anteroposterior (AP) view

- In this orientation the spinous processes should lie in a straight line and should be equidistant; an increase in distance of 50% more than the space above or below suggests the possibility of injury.

Open mouth AP view ('peg view')

- Shows C1/C2 articulation.
- The lateral margins of C1 should be in alignment with the lateral margins of C2, with equal distances between the sides of the odontoid peg and lateral mass of C2. These images can be difficult to interpret if there is any neck rotation, which can mimic subluxation.

How should this patient be managed?

Once the primary survey has been carried out and the patient has been stabilised, preparations should be made to transport the patient for CT imaging, in this case of the cervical spine and head. Any Canadian C-spine high risk factor should warrant a CT scan of the cervical spine, as should clinical suspicion but inadequate plain films. Imaging should be reviewed by a consultant radiologist, and abnormal images reviewed by a neurosurgical team for consideration or stabilisation, closed or open reduction or decompression.

Close monitoring of the patient should occur in a high-dependency unit, as there may be ascending cord oedema leading to diaphragmatic paralysis requiring intubation and ventilation. A low threshold for airway support should be maintained, as patients with cervical cord injury will be unable to cough and clear secretions; this inability to clear secretions may warrant intubation. Succinylcholine may be used within the first 72 hour, but not thereafter for 6–9 months. Vasopressors may be required to maintain a high mean arterial pressure to prevent secondary cord ischaemia. Therapies aimed at the prevention of pressure sores, venous thromboembolic disease and peptic ulcers need to be implemented.

Further reading

1. Theron A, Ford P. management of acute cervical spine injuries. *Update Anaesth* 2008; **24,1**: 30–4.

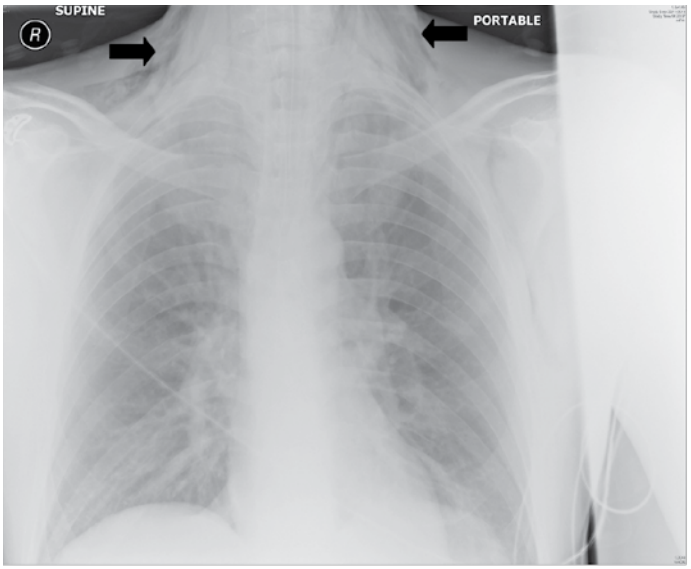

Figure 6. *Chest X-ray of patient 3 shows surgical emphysema at the root of the neck bilaterally (black arrows)*

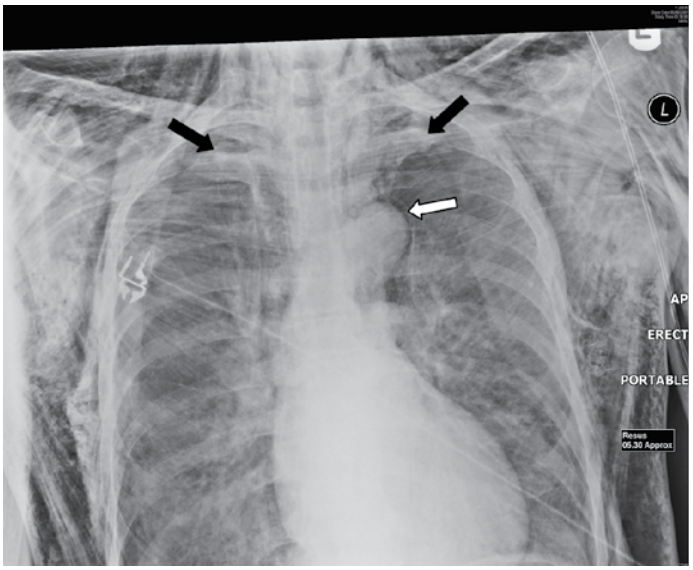

Figure 7. *Chest X-ray of a different patient, with severe surgical emphysema, throughout the X-ray. Bilateral pneumothoraces are seen (black arrows), with air in the mediastinum and around the aortic knuckle (white arrow). Radiolucent striations are seen outlining the pectoralis major when there is surgical emphysema in the anterior chest wall (Ginkgo leaf sign)*

Case 3

What does the chest X-ray show?

What is the diagnosis?

The presence of surgical emphysema suggests that this man's asthma has been complicated by pneumomediastinum and possibly pneumothorax. A pneumothorax is not seen on the chest X-ray and may not be present although that not all pneumothoraces can be seen on chest X-ray, particularly those that are small and anterior. Although rare, pneumothorax should be considered and sought in any severe acute attack of asthma, particularly when an acute deterioration occurs despite full treatment.

Pneumothorax and pneumomediastinum are rare but recognised complications of asthma. In acute severe asthma, there is overexpansion of the distal air ways due to obstruction in the bronchi and bronchioles. Excessive alveolar pressure can cause their rupture and air tracks in to the lung interstitium. The air within the interstitium follows a pressure gradient and migrates in a centripetal direction from the lung parenchyma towards the mediastinum, resulting in a pneumomediastinum. Sometimes a small double border to the left heart or aortic knuckle can be seen, representing mediastinal air (Figure 7). Air can continue to track between tissue planes and appear on the radiograph as subcutaneous emphysema in the face, neck, limbs, chest wall and abdomen. This may be very dramatic (Figure 7).

A further and more serious complication of pneumomediastinum is tension pneumothorax, which can be unilateral or bilateral. This occurs when there is a continuous leak between the airways, interstitium and tissue planes. Clinical diagnosis of a tension pneumothorax in a patient with acute asthma can be challenging but is indicated by following key signs:

- haemodynamic instability
- unequal chest movement
- tracheal deviation away from the affected side and absent breath sounds.

In acute severe asthma, tracheal deviation is the sign that best differentiates tension pneumothorax from other signs that may reasonably be attributed to asthma. Treatment is with immediate needle decompression. As the tension pneumothorax develops, cardiac output is impaired because venous return to the heart is reduced from a combination of increased intrathoracic pressure causing venous compression and kinking of major thoracic veins as the mediastinum shifts. There have been case reports describing bilateral tension pneumothoraces, and clinical detection of this is extremely difficult because tracheal deviation may be minimal or absent.

The prevalence of pneumomediastinum in asthma is thought to be 1 in 33 000, with the majority of cases reported in healthy, young asthmatic adults. There is about a 10% chance of a pneumothorax complicating a pneumomediastinum, and pneumothorax may occur in the absence of clinically detectable pneumomediastinum. Any patient with structurally abnormal lung tissue, such as chronic obstructive pulmonary disease with emphysematous bullae, bronchiectasis and asthma is at increased risk of developing pneumothoraces, and this should be considered in the differential diagnosis of a dyspnoeic patient with underlying lung disease. Positive-pressure ventilation, for anaesthesia or resuscitation, increases the chance of simple and tension pneumothorax in all patients with these lung conditions.

Pneumomediastinum is more commonly occurs as result of trauma. This can be blunt chest trauma or iatrogenic, for example after central venous cannula insertion, endotracheal tube insertion, chest drain placement or percutaneous tracheostomy. Furthermore, any mechanism that raises intramediastinal pressure can cause pneumomediastinum. Of note, oesophageal perforation following repeated vomiting should be suspected if a respiratory cause is not found and there is evidence of a pleural collection.

How would you manage this patient?

Most cases of surgical emphysema are an incidental finding on examination and resolve over time through reabsorption. Pneumomediastinum can usually be managed conservatively. The key in this patient is to maintain a high level of suspicion of pneumothorax, with frequent reassessment, particularly if the patient fails to improve or worsens with standard treatment for his asthma.

Your focus should be to optimise management of his asthma. An ABCDE assessment is sensible in any acutely unwell patient and this should be undertaken as you institute standard therapy for acute severe asthma (this is described in detail in the British Thoracic Society guidance.[1]

Rare cases of mediastinal air tracking to the hypopharynx have been reported, which means that there is potential for acute airway obstruction. This may be clear clinically with stridor or it may become apparent at laryngoscopy, when there can be gross oedema and it can be difficult to insert an appropriately sized endotracheal tube. If there is concern about airway patency, the airway should be secured. If gas exchange is severely impaired and/or the patient is tiring, P_aCO_2 will rise (Figure 8) and contribute to loss of consciousness, necessitating airway support.

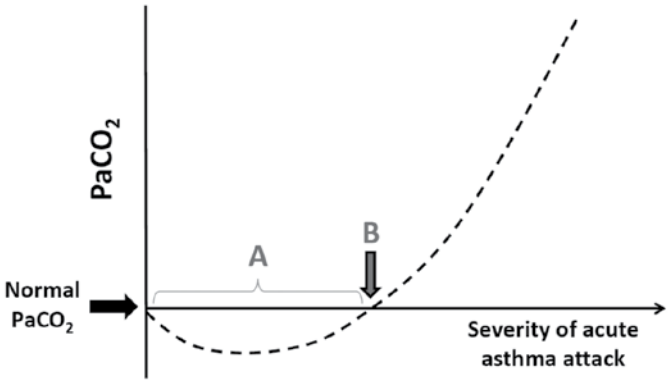

Figure 8. *Schematic graph to show change in P_aCO_2 with increasing severity of an acute asthma attack. Initially the patient will hyperventilate and tend to have a lower than normal P_aCO_2 (A). As they tire, or bronchospasm worsens, the P_aCO_2 rises. An arterial blood gas sample taken at point B may show a normal P_aCO_2, but this is not a reassuring sign (unless the patient is completely well) – the patient may be on the cusp of further deterioration to type 2 respiratory failure, CO_2 retention, loss of consciousness and collapse. Beware the normal P_aCO_2 in an acute severe asthmatic!*

REFERENCE

1. British Thoracic Society/Scottish Intercollegiate Guidelines Network. Quick reference guide. British guideline on the management of asthma 2014. Available at: https://www.brit-thoracic.org.uk/document-library/clinical-information/asthma/btssign-asthma-guideline-quick-reference-guide-2014/

From the journals

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Postural modification to the standard Valsalva manoeuvre for emergency treatment of supraventricular tachycardias (REVERT): a randomised control trial.

Appelboam A, Reuben A, Mann C, Gagg J et al. *Lancet* 2015; **386**: 1747–53.

The Valsalva manoeuvre is an internationally recognised treatment for supraventricular tachycardia. However, cardioversion is rare (5–20%), necessitating the use of other treatments, including intravenous adenosine, which may have unpleasant side effects.

This multicentre randomised controlled trial investigated whether postural modifications to a standard Valsalva technique could improve its effectiveness. Patients with suspected supraventricular tachycardia on presentation were screened for enrolment, with those that were unstable requiring immediate cardioversion, and those in suspected atrial fibrillation or flutter excluded.

The control group received a standard Valsalva manoeuvre in the semirecumbent position, whereas the treatment group received the modified Valsalva manoeuvre performed in the semirecumbent position followed by repositioning to the supine position with legs elevated immediately after the Valsalva strain.

A total of 428 participants were enrolled into the study from 10 emergency departments in the south-west of England (two teaching hospitals and eight district general hospitals), with 214 patients allocated to each group. In the control group 37 patients were converted to sinus rhythm (17%), compared with 93 (43%) in the treatment group (adjusted odds ratio 3.7; 95% confidence interval 2.3–5.8; $P < 0.0001$).

The authors suggest that, in patients with supraventricular tachycardia, a modified Valsalva manoeuvre with patient repositioning to the supine position and legs elevated immediately after the Valsalva strain should be considered as routine first-line treatment.

5th National Audit Project (NAP 5): Accidental Awareness during General Anaesthesia (AAGA) in the United Kingdom. Available at: http://www.nationalauditprojects.org.uk/NAP5report

The 5th National Audit Project concentrated on the incidence of AAGA in the UK. The project relied on patient reports of AAGA and calculated incidence from an activity survey that estimated that 2.8 million general anaesthetics are performed annually in the UK. Reports were then categorised into how likely it is that they represented a true case of AAGA. The incidence of AAGA ranged from a 'pessimistic estimate' 1:6500, which included all reports of AAGA regardless of calibre, and an incidence of 1:20 000 if only reports from 'certain/probable/possible' categories were used.

Almost two-thirds of all experiences reported involved either induction or emergence from anaesthesia whilst only one-third of reported experiences occurred during the maintenance phase of anaesthesia.

There were considerable variations in incidence when various subspecialties and anaesthetic techniques were taken into account. The cases of AAGA reported to NAP5 were overwhelmingly cases of unintended awareness when neuromuscular blockade was employed. When neuromuscular blockade was used, the incidence was 1:8000; when no blockade used the incidence fell to 1:136 000. Within the cohort in which neuromuscular blockade was used, reports of AAGA were overrepresented in those patients in whom no nerve stimulator or no reversal of blockade was used.

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Subspecialties with increased incidence included cardiothoracic surgery (1:8600), which may reflect the largely opioid-based anaesthetic techniques, and anaesthesia for Caesarean section, which had a significantly greater incidence of 1:670, possibly owing to the avoidance of volatile agent prior to and sometimes even after delivery.

Other factors that were more common in cases of AAGA included;

- the use of thiopental
- 'rapid sequence induction'
- total intravenous anaesthesia
- female patients
- out-of-hours operating
- a junior anaesthetist and
- previous incidence of AAGA.

AAGA was less prevalent in:

- children
- trauma, orthopaedic and plastic surgery patients.

The First Patient Report of the National Emergency Laparotomy Audit (NELA). Available at: http://www.nela.org.uk/

The National Emergency Laparotomy Audit was established in order to describe and compare inpatient care and outcomes of patients undergoing non-elective laparotomy in England and Wales.

More than 30 000 patients undergo emergency laparotomy each year in the UK. These procedures are associated with high rates of postoperative complications and mortality. Recent studies suggest that 1-month mortality in this group is as high as 15%.

The NELA report compares hospital performance against a number of previously set standards and guidelines, designed to improve the outcome of patients undergoing emergency laparotomy.

These standards and recommendations included aspects concerned with patient care before, during and after surgery, and auditing factors such as consultant-led care throughout, early diagnostic investigations, prompt access to theatre and planned admission to intensive care as decided by calculating a risk of mortality.

Data were collected for over 20 000 patients from 192 hospitals in England and Wales in the first year of the project. Thirty-day inpatient mortality was 11%, which may reflect a real reduction in mortality but the authors advise caution in the interpretation of these results pending validation with independent mortality data from the Office for National Statistics.

KEY FINDINGS

Timeliness of care

- Only half (48%) of patients who were admitted as an emergency and underwent bowel surgery were reviewed by a consultant surgeon within 12 hours of admission.
- Further analysis showed that two-thirds (68%) received a review within 12 hours of admission by a consultant surgeon, if admitted between the hours of midnight and 8 am, compared with only one-third (34%) if admitted between midday and 6 pm.
- There was a large variation between individual hospitals.
- For those patients admitted with peritonitis requiring emergency laparotomy, almost half waited for more than 4 hours for their first dose of antibiotics. A quarter waited more than 7 hours.

Assessment and appreciation of risk

- Risk of surgery (for example with P-POSSUM score) was documented before surgery in just over half (56%) of all patients.
- Where risk was documented prior to surgery, more high-risk patients received the required standards of care such as early consultant review and planned admission to intensive care.
- Again there was large variation between hospitals.

Resources

- Overall, two-thirds of operations had direct input from both a consultant surgeon and consultant anaesthetist.
- This varied greatly between hospitals but also the time of day; both consultants were present for just 41% of operations carried out at night, after midnight, compared with 75% during daylight hours.
- Among those requiring a CT scan prior to surgery, in two-thirds (68%) CT was carried out by a consultant radiologist.
- Overall, 60% of patients were admitted directly to intensive care following surgery, with a large variation between hospitals.

While the authors suggest that emergency laparotomy care overall is improving, they suggest that the large variation between hospitals seen in all areas remains a problem. They suggest that individual hospitals use the findings of this NELA report to implement their own care pathways to improve patient care.

Bubble continuous positive airway pressure for children with severe pneumonia and hypoxaemia in Bangladesh: an open, randomised controlled trial.

Christi MJ, Salam MA, Smith JH, et al. *Lancet* 2015; **386**: 1057–65.

Mortality from severe pneumonia in children in low-income countries is high. In 2011, an estimated 1.3 million children died from pneumonia even with standard oxygen therapy, appropriate antibiotics and other supportive care. The authors of this paper

investigated whether oxygen delivery by bubble continuous positive airway pressure (CPAP) improved outcome.

Bubble CPAP is a low-cost method of delivering positive end-expiratory pressure to patients, in order to improve oxygenation. The method consists of connecting the expiratory limb of a breathing circuit to a tube, which is submerged in water. The distance at which the open end of the tube is submerged under water is equivalent to the pressure (in cmH_2O). The system can be made cheaply from locally available materials including standard oxygen nasal prongs, tubing used for the administration of intravenous fluids and a shampoo bottle.

The randomised controlled trial was undertaken in a large hospital in Bangladesh, recruiting children less than 5 years old with severe pneumonia and hypoxaemia. A total of 225 patients were recruited over a 2-year period and were randomised to receive treatment with one of three oxygen therapies:

- bubble CPAP ($5\,L\,min^{-1}$ starting at CPAP level of $5\,cmH_2O$)
- low flow nasal cannula ($2\,L\,min^{-1}$) or
- high-flow nasal cannula ($2\,L\,kg^{-1}\,min^{-1}$ up to maximum of $12\,L\,min^{-1}$).

In addition, all patients received WHO standard management of very severe pneumonia. The primary outcome was treatment failure, i.e. clinical failure, intubation and mechanical ventilation, death, or termination of hospital stay against medical advice.

Of the patients who received bubble CPAP, five (6%) failed treatment, compared with 16 (24%) in the low-flow group, and 10 (13%) in the high-flow group. Treatment failure was experienced by significantly fewer children in the bubble CPAP group than in the low-flow group (relative risk 0.27, 99.7% confidence interval (CI) 0.07–0.99, $P = 0.0026$). No significant difference was noted between the bubble CPAP and high flow oxygen groups (RR 0.50, 99.7% CI 0.11–2.29; $P = 0.175$). Mortality was also significantly lower in the group of children who received bubble CPAP than in the group that received standard low-flow oxygen therapy. The trial was stopped early owing to the higher mortality rate in the low-flow group.

The authors suggest that bubble CPAP is a low-cost technique that could improve care in those hospitals where the only respiratory support for severe pneumonia is low-flow oxygen therapy.

The effect of patient warming during Caesarean delivery on maternal and neonatal outcomes: a meta-analysis.

Sultan P, Habib AS, Cho Y, Carvalho B. *Br J Anaesth* 2015; **115**: 500–10.

The benefits of patient warming in the perioperative period are well recognised. Such benefits include reductions in wound infections, myocardial ischaemia, the risk of perioperative coagulopathy, blood loss and transfusion requirement. However, the benefits of patient warming in Caesarean delivery remain unclear. There are currently no European or US guidelines regarding the use of warming during Caesarean delivery, and thus routine patient warming during Caesarean delivery is rarely used despite widespread availability of the facility to do this. The authors of this meta-analysis aimed to determine the efficacy of active warming on outcomes after elective Caesarean delivery.

The primary outcome in this meta-analysis was maximum maternal temperature change in the perioperative period, as this was deemed the most important clinical outcome linked to the harmful effects of hypothermia. Secondary outcomes included thermal comfort, shivering, vasopressor use, hypothermia, neonatal temperature, umbilical cord pH, maternal nausea and vomiting, and Apgar scores at 1 and 5 minutes.

Forty randomised controlled trials were considered for this meta-analysis, of which 12 were analysed for the primary outcome. There were 394 patients were in the warmed groups and 366 patients in the control group, receiving no warming. Overall, warming significantly reduced maximum temperature change compared with control (standard mean difference –1.27°C; confidence interval –1.86°C to –0.69°C; $P = 0.00002$). The subgroup analysis revealed no significant difference between the types of warming method used (forced air warming or fluid warming). Of the secondary outcomes, patient warming resulted in a significant reduction in shivering, a reduction in the incidence of hypothermia, improvement in thermal comfort and increase in umbilical artery pH.

The main finding of this meta-analysis is that the magnitude of perioperative temperature change was smaller when active warming was used. The authors believe that this is clinically significant as the mean temperature change of 1.27°C is more than twice the normal physiological variation (±0.5°C), which would therefore result in a greater number of patients becoming hypothermic. However, the authors acknowledge the significant heterogeneity between the studies included. There were marked variations in patient warming techniques, temperature measurement, the volume of warmed fluid administered and local anaesthetic and opioid combinations used in regional anaesthesia. Publication bias (the higher likelihood that studies with positive findings get published) may also be a factor.

The authors conclude by recommending that active warming should be used for elective Caesarean delivery in order to minimise decreases in maternal temperature, to reduce the incidence of hypothermia and shivering and to improve thermal comfort. They also suggest that more studies need to be conducted to determine optimum warming technique (fluid or air), and whether a combination of techniques offers an advantage over a single modality.

Implementation of the WHO Surgical Safety Checklist and surgical swab and instrument counts at a regional referral hospital in Uganda – a quality improvement project.

M Lilaonitkul, Kwikiriza A, Ttendo S, Kiwanuka J. *Anaesthesia* 2015; **70**: 1345–55.

The World Health Organization (WHO) checklist and surgical instrument and swab counts have been shown to be cost-effective tools that improve patient outcome. The authors of this study investigated their applicability to low income settings by conducting a prospective study in large hospital in Uganda.

Mbarara Regional Referral Hospital is located in a large urban area in Uganda, and performs approximately 4000 operations per year. The checklist was first introduced to this hospital's busy obstetric department over a period of 5 months several years previously by a volunteer anaesthetist. However, the use of the checklist was not sustained after the volunteer left the hospital. Barriers to checklist implementation were identified as lack of clarity about responsibilities; lack of leadership and support from higher-level staff; and not enough time to complete the checklist. With these issues in mind, the authors attempted to re-implement the checklist with a formal year-long quality improvement project with multiple 'plan–do–study–act' (PDSA) cycles, hoping this would lead to a sustained change in practice.

An 'implementation team' was formed from senior representatives from surgery, obstetrics and gynaecology, anaesthetics and theatre nursing. During the pre-implementation phase, educational meetings were held for staff, emphasising the importance of the checklist in improving patient care. Following testing in two theatres the checklist was reviewed for its relevance and practicality, and finally a locally adapted version was produced. As there were no standardised instrument packs for most surgical procedures and no formal instruments lists, each surgical department was asked to submit a list of instruments most commonly used for each procedure. These were then tabulated and printed on the reverse of the checklist in order to make counts easier to conduct.

Monthly feedback meetings were held for each department and a summary of findings were formally presented by one of the authors. Feedback information included rate of checklist compliance, patient consent, swab and instrument counts, and run charts were also kept and shared between departments to keep staff up to date with the progress of implementation and individual performance.

A total of 3341 operations were conducted in the study period. During the study, checklist and surgical count compliance rates increased from a baseline median of 29.5% to 85% and from 25.5% to 83% respectively.

The authors suggest that the success of the project was attributed to quality improvement methodology, prospective data collection, PDSA cycles and regular structured feedback to users to improve their performance. They believe that the introduction of basic paperwork, together with adaptation of the checklist to suit local practice, were key interventions to support implementation.

Book reviews

Advanced Training in Anaesthesia

Edited by Jeremy Prout, Tanya Jones and Daniel Martin
Oxford University Press 2014
Price: £79.99
ISBN: 9780199609956

The comments on the back of *Advanced training in Anaesthesia* state that it 'contains everything candidates need in preparation for taking the Final FRCA exam'. This is a bold claim, but its 550 pages come closer than many to achieving this goal.

Edited by three London-based consultant anaesthetists, and with contributions from predominantly London-based trainees and consultants, the book begins with a section devoted to basic sciences, covering the various physiological systems with separate chapters on statistics, nutrition and physics and clinical measurement. Whilst under a 'basic science' banner, the chapters are clinically based (in line with the final FRCA exam) and include useful exam topics such as tables comparing the various types of cardiac output monitoring and an entire chapter devoted to critical illness scoring systems. This approach will undoubtedly save candidates from wasting valuable revision time trying to assimilate large amounts of information from multiple sources. Condensing large topics into a small number of pages requires an assumption of a reasonable level of basic knowledge in the reader, but in a book aimed at final FRCA candidates this does not seem unreasonable.

The second section of the book concentrates on clinical anaesthesia divided by surgical specialty. The chapters are clearly written with vivas in mind, with well-structured approaches to important clinical topics and frequent boxes in the text with recent recommendations and guidelines. Not all of the guidelines and definitions are current (for instance, the text includes definitions for ARDS and acute lung injury rather than the more recent Berlin definitions), and readers should bear this in mind when using the book for exam preparation.

Throughout the book there is a good mix of text, tables and illustrations, making it easy to read and identify key learning points. Most subjects are dealt with two A4 sides, making them digestible and easy to dip in and out of. It is ordered in a logical way with a comprehensive index, meaning little time is wasted trying to access specific contents.

In addition to its role in revision for postgraduate exams, the book is also a useful resource for clinical anaesthesia, and many post-fellowship trainees and consultants will find pearls of wisdom within its pages.

Does this contain 'everything candidates need for the final FRCA'? Probably not, but it about as close as I have seen a single book achieve.

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Regional Anaesthesia – A Pocket Guide

Alwin Chuan and David Scott
Oxford University Press 2014
Price: £29.99
ISBN: 9780199684236

As an anaesthetic registrar, this book has been highly beneficial to me during solo lists, and also as a teaching aid in supervised lists.

Created by internationally known reputable authors, this book is well written and logically laid out. It provides a good basic introduction for novices to regional anaesthesia and ultrasound use. A comprehensive range of blocks is covered; during my regional anaesthesia module I have not yet discovered a block that is not featured. The landmark and ultrasound-guided approach is described for most blocks making the book applicable to high-, middle- and low-resource settings. The method for each block is described clearly, with a range of good-quality anatomical, landmark and ultrasound images to support the explanation. However, certain basic blocks (e.g. ilioinguinal iliohypogastric block) feature only the ultrasound guided approach; I

am not sure whether this is because the authors do not recommend using the landmark approach.

The book is conveniently sized to fit in a pocket, making it accessible for every day 'on the job' use.

Overall this book will be perfect for budding regional anaesthetists who are interested in developing their array of ultrasound guided blocks.

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Guide for Contributors

Update in Anaesthesia is primarily an educational journal that aims to provide ongoing learning and support for anaesthetists working in situations with limited resources.

Update is sent to over 3000 English-speaking anaesthetists, and read by many others, including surgeons, nurses and medical students. *Update* is also translated into different languages, including Spanish, Russian, French and Mandarin. After being produced in paper format, *Update* is published on the internet (www.worldanaesthesia.org) and read by 90 people a day from more than 130 countries. *Update* is also distributed in the form of a CD-ROM, produced by the Association of Anaesthetists of Great Britain and Ireland.

Articles for consideration by the Editorial Board should be submitted as Word documents (rich text format (RTF) is preferred) to the Editor-in-chief, Bruce McCormick, by email at **Bruce.McCormick@rdeft.nhs.uk** or by post on CD-ROM or as a paper copy to Dr Bruce McCormick, Department of Anaesthesia, Royal Devon and Exeter Hospital, Barrack Road, Exeter EX2 5DW, UK.

CLINICAL OVERVIEW ARTICLES

General considerations

- Papers must not have been published in whole or any part in another journal.
- Papers are subject to editorial revision.
- On acceptance for publication copyright becomes vested in the journal.
- Original textual matter quoted from other authors must have formal citation and be appropriately referenced.
- Some readers' first language may not be English. Please keep your text straightforward and avoid long sentences and complex terminology. Explain words and abbreviations that may not be universally standardised. Aim to include the full range of therapies available worldwide, but provide most detailed descriptions of those therapies available in resource-poor settings (see 'Management of sepsis with limited resources' in *Update 23* – www.worldanaesthesia org/component/option,com_docmantask,cat_viewgid,67 Itemid,49/). Discuss older drugs as well as newer ones; halothane, thiopentone, ketamine and ether are widely used around the world.
- The article should be long enough to cover the topic in reasonable detail. Many readers will not have access to texts or journals to supplement their reading. Include text boxes and teaching points to make the layout interesting. Avoid long numbered lists with complex subdivisions. Check that your text is correct, particularly drug doses, as many readers will not be able to verify them.

Authors' details

Please supply the full forename and surname of all authors, stating their title (Anaesthetic Clinical Officer, Dr, Professor, etc.) and the name and address of their institution. One author should be identified for correspondence, with an email address provided.

Drug doses

Please use the international units, e.g. mg kg^{-1} rather than mg/kg. Use SI notation for g, mg, μg, etc. Please use internationally accepted non-proprietary drug names, e.g. furosemide, epinephrine and avoid trade names.

Headings

Three levels of heading may be used: CAPITALS, **bold** and *italic*. Please do not employ different fonts within the text. Bullet points can be helpful.

Illustrations/figures

These may be sent to us as drawings (black on white), which we will scan into the text, or as picture files in JPEG format. If you send JPEGs, please send the highest resolution available (300 dpi is ideal).

Black and white photos are also suitable. If you do not have facilities to produce drawings, contact the editor for help. If you copy illustrations from another publication please obtain copyright permission from the publishers or author. If patients appear in a photo please ensure that they have consented to this. Text accompanying illustrations should be supplied on a separate piece of paper.

Tables or figures reproduced from other published texts should be accompanied by a statement that permission for reproduction has been obtained from the author or publisher. An acknowledgement should be included in the caption and the full reference included in the reference list.

All figures should be cited in the text, in chronological order.

Tables

These should be prepared using the Microsoft Word table facility whenever possible. Each item of data should be in a separate table cell.

All tables should be cited in the text, in chronological order.

Graphs

Graphs should be supplied using the Microsoft graph-compiling feature within Microsoft Word, or as a figure on paper.

References

A minority of *Update* readers have access to journals and therefore references should in general be limited to those that would be considered as 'further reading'. Please format your references as shown. Number the references in the order they appear in the text, adding the reference number as a superscript at the relevant point in the text.

References should include: names and initials of all authors (unless

more than eight, in which case only the first six are given, followed by 'et al.'); title of the paper; the Medline abbreviation of the journal title (in italic); year of publication; volume number; first and last page numbers.

Papers accepted but not yet published should be included in the references, with the abbreviated journal name, followed by '(in press)'.

Those in preparation (including any submitted for publication), personal communications and unpublished observations should be referred to as such in the text.

1. Reynolds F, O'Sullivan G. Lumbar puncture and headache. 'Atraumatic needle' is a better term than 'blunt needle'. *Br Med J* 1998; **316**: 1018.
2. Costigan SN, Sprigge JS. Dural puncture: the patients' perspective. A patient survey of cases at a DGH maternity unit 1983–1993. *Acta Anaesthesiol Scand* 1996; **40**: 710–14.
3. Spriggs DA, Burn DJ, French J, Cartlidge NE, Bates D. Is bedrest useful after diagnostic lumbar puncture? *Postgrad Med J* 1992; **68**: 581–3.

References to books should give book title, place of publication, publisher and year; those of multiple authorship should also include chapter title, first and last page numbers, and names and initials of editors. For example:

1. Roberts F. Chapter 22: Ear, nose and throat surgery. In: Allman KG, Wilson IH, eds. *Oxford handbook of Anaesthesia*. Oxford: Oxford University Press, 2001: 506–39.

UPDATE SHORT REPORTS

The scope for publication of articles describing original research and audit conducted in, and specifically relevant to, poorly resourced settings is limited. Successful publication in major journals is rare and the distribution and accessibility of the national and regional journals that currently publish these articles is often poor. As the official journal of the World Federation of Societies of Anaesthesiologists, *Update in Anaesthesia* is the appropriate forum for publication of these manuscripts and offers a wide distribution.

The guidance above for clinical overview articles applies, with the following additional considerations.

Legal considerations

- Papers based on clinical investigation on humans should include the consent of patients and a statement of approval from an appropriate Ethics Committee. In those institutions where Institutional Review Board consent is required for the performance of audits, this should be obtained and referred to in the text.
- Avoid use of identifiable names, initials and hospital numbers of patients.
- l Human subjects of case reports, research or audits should not be identifiable. Manuscripts should not disclose patients' names, initials, hospital numbers (or other data that might identify the patient(s)).
- Guides for use of tables, figures and illustrations are as described above for Clinical Overview articles.

Brief Communications

- Original investigative articles or audits of patient outcome or clinical techniques.
- Up to 1500 words (approximately two pages of *Update in Anaesthesia).*
- Subdivided into:
  - Summary (maximum five sentences) and key words
  - Introduction
  - Patients and methods
  - Results
  - Discussion
  - Acknowledgements
  - References (maximum 15)
  - Tables and/or figures - limited to two per article.

Case Reports

- Suitable for presenting descriptive studies (a series of cases), personal experience or individual case reports of particular interest.
- Up to 800 words. Three tables or figures is allowed in addition to text.
- A summary may be included (up to five sentences). Division into sections is optional.
- Up to seven references may be given.

Correspondence

- Welcomed on any subject, including editorials or articles that have appeared in *Update in Anaesthesia*.
- Letters may also be a suitable vehicle for presenting items of experience or observation that are too brief for Brief Communications.
- Papers describing procedures, techniques or equipment adapted by readers to their own conditions of work are welcomed.

Proofs

- Proofs are sent to the author designated to receive them. Corrections should be kept to a minimum and the proofs returned within 7 days of receipt.

The editorial team will be delighted to help with the preparation of articles. The best way of doing this is via email: Bruce.McCormick@rdeft.nhs.uk

Dr Bruce McCormick
Editor-in-chief
Update in Anaesthesia, May 2016

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