Clinical Cases for the FRCA

Key Topics Mapped to the RCoA Curriculum

Alisha Allana

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Key Topics Mapped to the RCoA Curriculum

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Khalil – this book is written for you, and because of you.
Always believe that you can do anything.

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FOREWORD

It has been nearly 30 years since I passed the FRCA, and since I passed, I have been running exam preparation courses for almost all of those 30 years. I know first-hand that exam preparation is hard work, and that much of that work is made more difficult by the number of resources that have to be consulted to try and find the exact piece of knowledge required to answer an exam question. Invariably, bits of information can be readily found, but these often provide subtly differing or conflicting statements, requiring further research to clarify in one's own mind the truth of the topic in question. This can lead to a curiosity-driven quest across innumerable resources, which, while interesting, can also be very time-consuming during a period when time is a very precious resource indeed.

What Dr Allana has managed to produce here is, in my opinion, remarkable. It is a concise summary of the current opinion and evidence to allow FRCA exam questions to be answered correctly and confidently. While it is aimed primarily at the Final FRCA, I can also see it being useful for primary FRCA, FFICM and EDIC, as well as for those running teaching courses and simulation programmes, and also as a clinical resource for departments of anaesthesia and critical care medicine. The management of each case scenario is laid out clearly with an intuitive structure and with relevant references to allow the interested reader to further research into the topics if they wish.

The decision to offer this material as a book, rather than an online resource, is, I believe, very sensible. A book is a resource that can be utilised without adding to "screen time", it can be annotated and marked and it can be shared and passed between candidates in the throes of exam preparation. Part of the key to exam success is developing a structure to hang your knowledge onto – having these structured summaries readily to hand and adding your own bits of "detail" will help all candidates to not only remember the answers in an exam but also to recall this knowledge better at a future time when it is needed clinically.

I commend this book to all anaesthetists and intensivists at any stage in their career, not just those sitting an exam. It is an excellent resource and "aide memoire" for teaching and for clinical work. I wish Dr Allana every success with its publication.

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PREFACE

The clinical cases in this book are mapped directly to the Royal College of Anaesthetists' curriculum, and can be used to revise for both the written and viva, Primary and Final sittings. With the addition of critical incidents throughout, the questions can also be used as the basis for simulation training and teaching for individual modules. The answers are based on the most up-to-date guidelines and protocols, and can be used as a guide to manage complex theatre cases by all anaesthetists, from the eager novice to the skilled consultant.

Revision for the FRCA examinations is a long, sometimes challenging, and hopefully rewarding journey. Nothing compares to the clinical experience and management of patients firsthand, but the aim of this book is to fill in any gaps, highlight important cases and support revision of difficult topics.

Alisha Allana

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Thanks to my husband, for always having faith in me and being there every step of the way; and to my parents and siblings, for their unwavering support and endless supply of food.

Thanks to everyone who facilitated viva preparation for me while I was revising for the exams, and to all the trainees who allowed me to practice the questions for this book on them. I hope it helped you as much as it did me!

Particular thanks and a huge amount of appreciation go to the following individuals who contributed in so many ways to ensure that the text of this book is as complete and up to date as possible. Your insight, knowledge and experience have been invaluable in the production of *Clinical Cases for the FRCA*.

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ABBREVIATIONS

2,3-DPG	2,3-diphosphoglyceric acid
AAGBI	Association of Anaesthetists of Great Britain and Ireland
ABG	arterial blood gas
ACE	angiotensin converting enzyme
ADH	anti-diuretic hormone.
ALS	advanced life support
ARDS	acute respiratory distress syndrome
BMI	body mass index
CF	cystic fibrosis
COPD	chronic obstructive pulmonary disease
CP	cerebral palsy
CPAP	continuous positive airway pressure
CPB	cardiopulmonary bypass
CPET	cardiopulmonary exercise testing
CPR	cardiopulmonary resuscitation
CSF	cerebrospinal fluid
CT	computed tomography
CTG	cardiotocography
CVP	central venous pressure
DIC	disseminated intravascular coagulation
DKA	diabetic ketoacidosis
ECG	electrocardiogram
ECT	electroconvulsive therapy
EEG	electroencephalogram
ENT	ear, nose and throat
FBC	full blood count
FEV_1	forced expiratory volume in 1 second
FFP	fresh frozen plasma

FVC	forced vital capacity
GCS	Glasgow Coma Score
GDD	global developmental delay
IASP	International Association for the Study of Pain
ICP	intra-cranial pressure
INR	international normalised ratio
ITU	intensive care unit
IV	intravenous
IVIg	intravenous immunoglobulin
LV	left ventricle
MAC	minimum alveolar concentration
MCV	mean cell volume
MRI	magnetic resonance imaging
NAP	National Audit Project
NICE	National Institute for Health and Care Excellence
NMDA	N-methyl-D-aspartate
NSAIDs	non-steroidal anti-inflammatory drugs
ODP	operating department practitioner
OSA	obstructive sleep apnoea
PCA	patient controlled analgesia
PEEP	positive end expiratory pressure
PO	oral
P-POSSUM	Portsmouth-Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity
PRES	posterior reversible leucoencephalopathy syndrome
ROSC	return of spontaneous circulation
RV	right ventricle
SIADH	syndrome of inappropriate ADH secretion
SIRS	systemic inflammatory response syndrome
SVR	systemic vascular resistance
TCI	target controlled infusion

TEG	thromboelastogram
TENS	transcutaneous electrical nerve stimulation
THRIVE	transnasal humidified rapid-insufflation ventilatory exchange
TIA	transient ischaemic attack
TIVA	total intravenous anaesthesia
TRAM	transversus rectus abdominis myocutaneous
U+E	urea and electrolytes
UKOSS	UK Obstetric Surveillance System
VF	ventricular fibrillation
VO_2	oxygen uptake
VTE	venous thromboembolism

AUTHOR

Alisha is an anaesthetic registrar in the Wessex deanery, with an interest in medical education, simulation and patient safety.

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NEUROSURGERY, NEURORADIOLOGY AND NEUROCRITICAL CARE

CASE: SUBARACHNOID HAEMORRHAGE

A 36-year-old female patient is listed for emergency embolisation of a cerebral aneurysm following a grade IV subarachnoid haemorrhage. She is intubated and ventilated following a drop in her GCS in the emergency department. She takes sertraline for depression but has no other known medical conditions.

What are the treatment options for this patient?

Conservative

- Supportive therapy on the neuro-intensive care unit to maintain a dequate cerebral perfusion pressure and optimal gas exchange.
- Avoidance of extremes of blood pressure to minimise the risk of re-bleeding and ischaemia.
- Excellent blood glucose and core temperature control (primarily treatment of pyrexia).
- Consideration of seizure prophylaxis.

Pharmacological

- 60 mg oral nimodipine (via a nasogastric tube) every 4 hours for 21 days to minimise the risk of vasospasm.

Interventional

- Surgical clipping.
- Endovascular coiling.

What are the benefits of coiling over clipping for this patient?

- The International Subarachnoid Aneurysm Trial (ISAT) evaluated the difference between clipping and coiling for subarachnoid haemorrhage secondary to aneurysm rupture.
- Coiling demonstrated a reduced risk of mortality at 1 year, but with a slightly higher incidence of re-bleeding.

What are the complications associated with a subarachnoid haemorrhage?

- Re-bleeding (minimal if the aneurysm is secured).

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- Hydrocephalus.
- Cerebral vasospasm (most common at days 3–21).
- Arrhythmias and ischaemic cardiac events. A troponin rise is commonly seen following a subarachnoid haemorrhage, likely due to endocardial ischaemia secondary to an increase in afterload and endogenous vasopressor release at the ictus. Patients with poorer-grade bleeds may also develop Takotsubo's cardiomyopathy.
- Aspiration, pneumonia and pulmonary oedema (particularly if co-existing heart disease is present).
- Endocrine pathology e.g. cerebral salt wasting syndrome, diabetes insipidus, SIADH.

What are the concerns associated with anaesthetising this patient?

Remote site anaesthesia

- Appropriate staffing required e.g. ODP, senior anaesthetist or emergency help.
- Lack of familiar or appropriate monitoring and equipment, and potentially out of hours.
- Lack of an appropriate recovery area.
- Poor lighting and limited access to the patient during the procedure.

Specific concerns associated with the pathology

- This is a critically unwell patient undergoing an emergency high-risk procedure that requires an experienced senior anaesthetist for optimal management.
- High risk of perioperative complications.
- There may be poor compliance from the patient if they are not sedated, but have an altered GCS.
- Risks associated with induction of anaesthesia in a potentially unstarved patient at a remote site.
- The patient may need an external ventricular drain before or after the procedure if hydrocephalus is evolving.

How would you manage this patient during her procedure?

- Take a thorough preoperative history and conduct the relevant examination and appropriate investigations. The patient is intubated so a history can be taken from a family member and from her GP/ hospital notes.
- Ensure a completed consent form and WHO checklist and discuss the patient with the multidisciplinary team and a consultant neuroanaesthetist.
- Consider the best location for the initial management of the patient prior to the procedure e.g. in neurocritical care if unstable.

- Apply AAGBI standard monitoring and insert an arterial cannula for invasive blood pressure monitoring with large bore intravenous access present.
- Prepare the appropriate emergency drugs and equipment including the resuscitation and difficult airway trolleys. Check the position of the endotracheal tube following the transfer.
- Insert a temperature probe, catheter and nasogastric tube (if required) prior to the procedure to facilitate adequate monitoring, drug administration and passage of high contrast volumes.
- Depending on the clinical situation before the procedure and any procedural concerns or complications, the patient may be extubated, but they may also require ongoing care in the high dependency or intensive care unit.

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CASE: ANEURYSM CLIPPING

A 59-year-old female patient is undergoing an elective craniotomy for clipping of an aneurysm. She has severe COPD and a permanent pacemaker in situ. Her current medication includes captopril, tiotropium, salbutamol and simvastatin.

What added information would you like prior to this case?

Patient factors

- A full and thorough anaesthetic history focusing on the patient's known cardiovascular and respiratory comorbidities, any previous anaesthetics and an airway assessment.
- A focused pacemaker history, to include the reason for and date of insertion, the date of the most recent check and any malfunction, the pacemaker mode and how dependent the patient is on the pacemaker.
- A baseline neurological examination checking for signs of raised intracranial pressure (fluctuating GCS, headache, vomiting and visual changes), gross focal neurological signs and any symptoms of hydrocephalus.

- Relevant investigations following the history and examination. This is likely to include an ECG to assess pacemaker function, bedside observations, blood tests including a full blood count and clotting, and CT/MRI brain imaging.

Surgical factors

- The patient's position during the procedure.
- The likelihood of diathermy use perioperatively, taking into account the permanent pacemaker.
- The urgency and likely duration of the procedure.
- Consideration of alternative procedures given the comorbid state of the patient. Radiological coiling is minimally invasive; hence, there would be a decreased requirement for opioid analgesia and its associated side effects.

Anaesthetic factors

- This is a patient with numerous comorbidities undergoing a major operation. The case should be supervised by a consultant neuroanaesthetist.
- Discuss the patient with the neurocritical care unit for the availability of postoperative level 2/3 care.

Which of her medication, if any, would you stop prior to surgery?

- Continue nimodipine, inhalers and simvastatin.
- Omit captopril on the morning of surgery; administration of ACE inhibitors can cause significant uncontrollable intraoperative hypotension.

What are the anaesthetic goals in this case?

- Maintenance of cerebral perfusion and gas exchange.
- Maintenance of haemodynamic stability, in particular avoiding the pressor response to laryngoscopy.
- Rapid postoperative emergence with good analgesia and prevention of coughing/vomiting.
- Reducing the risk of complications specific to neurosurgery e.g. air embolism.

Which anaesthetic agent(s) would you use to anaesthetise this patient?

There is no right answer to this question – discuss the agent(s) that you feel most comfortable with. The best anaesthetic for this patient is a safe anaesthetic that fulfils the above goals!

TIVA anaesthetic

- Use the Marsh or Schneider model with propofol and the Minto model with remifentanil.
- Ensure appropriate effect site concentrations of the drugs in use.

- The concentrations should be titrated to overcome the hypertensive response to stimuli e.g. during the application of Mayfield pins.

Volatile agents

- Induction with appropriate doses of propofol and fentanyl.
- Maintenance of anaesthesia with sevoflurane (note that sevoflurane uncouples the cerebral blood flow and cerebral metabolic rate of oxygen).
- Avoid nitrous oxide (can worsen pneumocephalus postoperatively).
- Control the hypertensive response to stimuli using an opioid (alfentanil bolus, remifentanil infusion) and/or a short-acting beta blocker (esmolol infusion).

If using a TIVA method, what features are important for safety?

- Ensure adequate training and competence of the anaesthetist.
- Use a TCI-specific infusion pump that has been checked and serviced.
- Ensure that the pump alarms are enabled to alert the anaesthetist to high pressures and an empty syringe.
- Consider two person checking of the drugs.
- Use Luer-lock connectors and anti-syphon valves.
- Ensure that there is a visible cannula during the procedure. A crystalloid solution can be used to maintain patency perioperatively (0.9% saline).

The surgeon states that the brain appears tight and swollen intraoperatively. What is your immediate management?

- Raise the patient to a head-up position if possible.
- Optimise the cerebral blood flow by adjusting the $PaCO_2$ to a low-normal range and ensuring normoxia.
- Judicious use of mannitol 0.5–1 g/kg (or hypertonic saline, as long as serum sodium adjustment occurs at a safe rate) after a discussion with the surgeon.
- Re-assess the patient using an ABCDE approach and facilitate further procedures or treatment as directed by the surgical team.

What analgesia regimen would you prescribe for this patient postoperatively?

- IV morphine and paracetamol intraoperatively and in recovery as necessary.
- Regular oral morphine and paracetamol postoperatively, which can be escalated to a morphine or fentanyl PCA if required.
- Avoid NSAIDs in the immediate postoperative period due to the bleeding risk.
- Prescribe adequate laxatives and consider regular anti-emetics.
- A scalp block can also be performed perioperatively by the surgeon or anaesthetist.

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CASE: TETANUS

A 36-year-old Turkish builder is admitted to the emergency department with difficulty breathing, spasms and neck stiffness. You are asked to review him urgently due to concerns regarding his airway.

What are the potential causes of this patient's symptoms?

Infective

- Meningitis/encephalitis.
- Oral or dental infection/abscess.
- Generalised sepsis.
- Tetanus.

Non-infective

- Electrolyte disturbances e.g. hypocalcaemia.
- Epileptic seizure.
- Drug reactions/withdrawal.
- Strychnine poisoning (pesticide).
- Psychological cause.

How is tetanus diagnosed?

Tetanus is caused by toxins released by Clostridium tetani, but it is primarily a clinical (rather than microbiological) diagnosis based on the patient's history and symptoms.

History

- Known or observed injury or trauma with an open wound.
- Sudden onset of symptoms.
- Lack of up-to-date tetanus vaccination.
- Work or home environment associated with metal, soil or manure.

Examination

- Muscle rigidity and spasms, including neck stiffness, masseter spasm and truncal rigidity.
- Autonomic dysfunction and severe haemodynamic instability.
- Respiratory failure.

What are the treatment options for patients with suspected tetanus?

- Treatment is largely supportive. Patients should be managed in the intensive care unit in a darkened, quiet room and observed closely.

- Ensure appropriate airway management with early intubation and lung protective ventilation if there are any concerns.
- Ensure close monitoring and treatment of haemodynamic instability with vasopressors and inotropes if required.
- Antimicrobial therapy should be commenced as soon as possible (intravenous metronidazole is the first line) and the patient should be discussed with a microbiology consultant.
- Tetanus human IVIg should be given to neutralise the unbound toxin.
- Consider wound debridement if there is an obvious source of infection. However, maintenance of cardiovascular and respiratory stability is the priority.
- Benzodiazepines and sedative agents can be used for spasm and rigidity control.

What is an autonomic storm?

- Tetanus is associated with rapid and significant changes in cardiovascular status.
- An autonomic storm arises due to the sudden release of adrenaline and noradrenaline into the bloodstream, causing severe hypertension and tachycardia.
- This may be followed by episodes of hypotension, bradyarrhythmias and cardiac arrest.
- The patient may also demonstrate other signs of sympathetic nervous system instability including sweating, ileus and increased secretions.

When you assess the patient, the oxygen saturations are 91% on 15 L oxygen, the GCS is 10 and there is a marked stridor. What is your management?

This is an anaesthetic and medical emergency that needs immediate management by the multidisciplinary team. Help should be sought immediately.

- Declare an airway emergency and call for urgent senior help given the likely risk of a difficult airway/intubation and the obvious need for the patient to go to intensive care. Whilst awaiting specialist help, maintain the patient's airway using a Mapleson C circuit with airway adjuncts if necessary.
- Ask the anaesthetic assistant to prepare emergency equipment and drugs for intubation and ventilation and formulate a plan, including the plan for airway management in the event of failed oxygenation or intubation.
- The equipment should include an intubation checklist, suction switched on and readily accessible, a videolaryngoscope, the difficult airway trolley, an appropriately sized endotracheal tube (with one size smaller immediately available) and the resuscitation trolley.
- Apply AAGBI standard monitoring and invasive blood pressure monitoring if possible, but insertion of an arterial cannula should not delay further management.

- Given the risk of haemodynamic instability on induction, draw up vasopressor and vagolytic agents prior to induction. Perform a rapid sequence induction, maintaining a stable cardiovascular state using appropriate doses of the induction agent, opioid and muscle relaxant.
- The airway should be secured with an appropriately sized endotracheal tube and lung protective ventilation initiated. The patient should be managed on the intensive care unit.
- Ongoing sedation with benzodiazepines may improve hypertonia. If not, muscle relaxant infusions may be required, with monitoring of creatine kinase levels and further treatment.

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CASE: PARKINSON'S DISEASE

A 68-year-old male patient is listed for an elective anterior resection. He was diagnosed with Parkinson's disease 2 years ago and is an ex-smoker. You are asked to review him in the preoperative assessment clinic.

What is Parkinsonism?

- Triad of symptoms: resting tremor, rigidity and bradykinesia.
- There are numerous causes of Parkinsonism that lead to an imbalance between dopamine and acetylcholine levels in the basal ganglia, including:
  - Parkinson's disease.
  - Infective causes.
  - Trauma.
  - Drugs.

What are the perioperative risks in patients with Parkinson's disease?

- Patients with Parkinson's disease have:
  - An overall increase in morbidity and mortality.
  - A higher likelihood of falls.
  - An increased incidence of a difficult airway and aspiration pneumonitis.
  - A higher risk of developing postoperative pulmonary complications.
  - An increased likelihood of venous thromboembolism due to perioperative immobility.

- An increased length of stay in intensive care and hospital, with its associated complications.
- More chance of developing postoperative delirium and cognitive decline.
- Potential for adverse effects of missed doses of anti-Parkinson's medications.

What are the key concerns when assessing this patient preoperatively?

General

- This is a high-risk patient undergoing major abdominal surgery. The patient should be discussed with the multidisciplinary team including the surgical team, a consultant anaesthetist and a neurologist, as well as the intensive care team for consideration of postoperative level 2/3 care.
- Given that the patient is being assessed in the preoperative clinic, there is adequate time available for optimisation of the patient prior to the procedure.
- Carry out a thorough anaesthetic assessment including the patient's comorbidities, regular medication, a social history and the airway.

Systemic symptoms of Parkinson's disease

- The patient may demonstrate signs of a difficult airway due to a fixed flexion neck deformity, rigidity and poor upper airway muscle function causing increased secretions and a higher risk of aspiration. In addition, the patient may have delayed gastric emptying secondary to the side effects of anti-Parkinsonian agents and dysphagia.
- A restrictive pulmonary deficit and obstructive sleep apnoea are common in patients with Parkinson's disease, making ventilation challenging. Lung function tests and a chest x-ray may be indicated.
- Postural hypotension and arrhythmias are common in patients with severe Parkinson's disease and may lead to intraoperative haemodynamic instability, particularly on induction of anaesthesia.

Medication

- The dosage and timing of Parkinson's medication should be noted and discussed with a disease specialist.
- The medication may interact with anaesthetic and analgesic agents with potential for worsening of symptoms.
- Ensure a return to oral intake as soon as possible through adequate hydration, analgesia and enhanced recovery where possible.
- Consider a nasogastric tube for medication postoperatively after discussing with the surgeon and neurologist.

What is your plan for analgesia and anti-emesis in this patient?

Analgesia

- Continue medication that the patient may be on for chronic pain, or convert to an intravenous dose if the patient is unable to take medication orally.
- Use regional nerve blockade or local anaesthetic infiltration where possible to minimise the use of opioid-based drugs.
- Assess the patient's dexterity (and therefore their ability to use a PCA) prior to prescribing analgesic regimens.
- Avoid pethidine and high-dose fentanyl, which may lead to increased rigidity during the perioperative period.

Anti-emesis

- Anti-emetic medications that act as dopamine receptor antagonists should be avoided as they may lead to extra-pyramidal side effects or intensify pre-existing Parkinsonian symptoms.
- Drugs that can be used safely include domperidone (a dopamine receptor antagonist that does not cross the blood brain barrier), ondansetron and cyclizine.
- However, other methods of minimising nausea and vomiting should be favoured including hydration, reassurance, avoidance of opiates where possible and effective analgesia.

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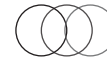
CASE: EPILEPSY

A 26-year-old male patient is listed for shoulder surgery following an injury while playing cricket last year. He has a history of epilepsy. You are asked to review him prior to his procedure.

What is epilepsy?

- A neurological condition caused by excessive or abnormal electrical activity in the brain.
- This leads to a spectrum of symptoms including a predisposition to behavioural changes and seizures.
- Epilepsy is diagnosed following two separate episodes of seizure activity.
- It is classified according to the cause and type of seizures:
  - Focal (simple or complex).



- Generalised (absence, tonic-clonic, myoclonic or atonic).
- Mixed.

How would you assess this patient?

History

- Take a full history including any cardiovascular and respiratory comorbidities, regular medication and allergies and a social history.
- Ask the patient about any previous anaesthetics.
- Take a focused history regarding the diagnosis of epilepsy, to include:
  - The date of diagnosis.
  - The cause of epilepsy, if known.
  - Any previous and current treatment (including the timing of doses).
  - Seizure frequency and type.
  - Known seizure triggers.
  - Comorbidities secondary to the diagnosis or treatment.

Examination

- Routine examinations including an airway assessment. Specific examinations would not usually be indicated unless there was an obvious reason noted from the history.

Investigations

- Baseline observations.
- Anti-epileptic medication levels only if poor compliance with treatment is suspected or a prolonged procedure/inpatient stay is expected.
- Further blood tests or investigations should be guided by the history and examination and would not usually be necessary for routine day-case surgery.

What are the key concerns when anaesthetising this patient?

Adequate anti-epileptic medication levels

- Continue regular anti-epileptic medication during the perioperative period, factoring in timings for each dose.
- Avoid prolonged fasting.
- Minimise perioperative nausea and vomiting.

Minimising risk of seizures

- Avoid drugs that decrease the seizure threshold.
- Ensure optimal oxygenation and avoid hypocapnia, which may provoke seizures.
- Plan perioperative analgesia, discussing with the surgical team.

Awareness of drug interactions

- Some anti-epileptic drugs act as enzyme inducers or inhibitors, which needs to be taken into account when choosing anaesthetic and analgesic agents.

Which commonly used agents should be avoided in patients with epilepsy?

- Enflurane has been associated with abnormal EEG activity, but is not commonly used in the UK.
- Methohexitone may provoke seizures, but is not used in the UK.
- Dopamine receptor antagonists e.g. metoclopramide can cause dystonia and may mimic seizures, thus introducing diagnostic challenges postoperatively and should be avoided.
- Alfentantil, tramadol and pethidine increase EEG brain activity and lower the seizure threshold.

During the procedure, the surgeon notes a sudden increase in muscle tone, which is associated with a heart rate of 145 and a blood pressure of 189/101. How do you proceed?

- This may be seizure activity under general anaesthetic. Alert the theatre team, call for urgent help and conduct a rapid ABCDE assessment to determine the cause of the patient's symptoms and rule out other potential causes.
- Apply 100% oxygen and manually ventilate the patient to assess compliance. Ensure that the patient has a normal-high end tidal carbon dioxide level.
- Check and correct electrolyte levels, acid–base balance, temperature and glucose (an arterial blood gas would be prudent when possible).
- Ensure adequate anaesthesia, muscle relaxation and analgesia.
- If the suspected seizure activity does not terminate, consider benzodiazepines, phenytoin or other anti-convulsants, noting what the patient has already taken preoperatively. Escalate to specialist care for further advice.
- Once the patient is stable, have a discussion with the surgeons regarding the expected duration of the procedure and the plan for postoperative care.

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CASE: POSTERIOR FOSSA SURGERY

A 48-year-old male patient is undergoing posterior fossa surgery for excision of a metastatic lesion secondary to lung cancer. He has a body mass index (BMI) of 41 and initially presented with seizures. You are asked to review him prior to his procedure.

What added information would you like before proceeding with this case?

Patient factors

- Take an anaesthetic history focusing on pre-existing comorbidities; particularly complications associated with obesity e.g. obstructive sleep apnoea, hypertension and ischaemic heart disease.
- Explore the diagnosis of lung cancer, including investigations and treatment so far.
- Discuss any interventions for the metastatic brain lesion and in particular, symptoms he has developed including the seizures mentioned in the history.
- Ask the patient about previous anaesthetics and conduct an airway assessment (the he may have a difficult airway due to his raised BMI).
- Take a medication and social history.

Surgical factors

- Preferred patient positioning. The options for posterior fossa surgery include sitting, prone, lateral and park-bench.
- Discuss any potential complications or challenges that may arise perioperatively with the suggested management in an emergency.

What specific signs and symptoms may the patient have due to the tumour?

- Signs suggestive of cerebellar involvement e.g. tremor, ataxic gait and dysarthria.
- Bulbar cranial nerve palsies. The patient may have had episodes of choking or aspiration due to a poor gag reflex. Coughing may also be impaired.
- The patient presented with seizures, which suggests raised intracranial pressure. Other symptoms include a headache, nausea, vomiting and fluctuating conscious levels. The patient should be assessed for these on the day of surgery as he may require preoperative medical or surgical management.
- Fluid and electrolyte imbalance and signs suggestive of hypovolaemia secondary to vomiting, diabetes insipidus, SIADH or poor oral intake.
- Side effects of high-dose steroids and other treatment that may have been initiated following the initial diagnosis.

The surgeons would like to proceed in the sitting position. What are the contraindications to surgery in this way?

Absolute

- Presence of a ventriculo-atrial shunt.
- Presence of a patent foramen ovale.

This is due to the potential risk of a venous air embolus entering the arterial circulation.

Relative

- Poorly controlled hypertension (due to the risk associated with hypotension when sitting).
- Very young/old patients.
- Chronic obstructive pulmonary disease.
- Autonomic neuropathy.

What specific complications are associated with surgery in the sitting position?

- Perioperative haemodynamic instability.
- Venous air embolism.
- Pneumocephalus.
- Tongue swelling.
- Permanent nerve damage (cervical spine flexion injury).

What forms of monitoring would you use when anaesthetising this patient?

- Full AAGBI standard monitoring including ECG, capnography, pulse oximetry and core temperature.
- "Train of four" monitoring if using neuromuscular blocking agents.
- Invasive blood pressure monitoring.
- Central venous pressure monitoring.
- Consider monitoring for venous air embolus:
  - Precordial Doppler.
  - Transoesophageal echocardiography.
- Somatosensory-evoked potentials if there is a surgical indication.

What are the anaesthetic goals for this patient?

- Maintenance of a stable blood pressure and cerebral perfusion pressure.
- Quick offset of anaesthetic to allow for rapid postoperative neurological monitoring.
- Careful patient positioning and padding to minimise the risk of complications secondary to the procedure and sitting position.

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CASE: CHRONIC SPINAL CORD INJURY

A 32 year-old female patient is listed for an elective Caesarean section. She has a history of mild asthma, for which she takes salbutamol, and had a spinal cord injury following a road traffic accident 5 years ago. You are asked to review her prior to her procedure.

How would you assess this patient?

History

- Take a detailed history of the symptoms, complications and treatment following the spinal cord injury. Knowledge of the level of the spinal cord injury will be essential to form an appropriate management plan. The history should include:
  - Any previous episodes of autonomic dysreflexia.
  - The presence of symptoms suggestive of central sleep apnoea.
  - Any prolonged ventilation or tracheostomy.
  - Current pressure sores.
  - Current treatment of chronic pain and/or spasticity.
- Take a medical history including the severity of asthma and any past hospital admissions.
- Ask the patient about previous anaesthetics, in particular those following the road traffic accident and review the anaesthetic charts if they are available.

Examination

- Conduct cardiovascular, respiratory and neurological examinations including palpation of the spinous processes to determine the ease of neuraxial blockade if necessary.
- Carry out an airway assessment. The patient may present with a potential difficult airway depending on the level of the spinal cord injury and/or spinal fixation that may have occurred.

Investigations

- Bedside observations including blood pressure and heart rate at rest.
- Baseline blood tests to include clotting and a cross-match if indicated.
- Further investigations should be guided by the patient's comorbidities and symptoms, but may include an ECG, echo and lung function tests.

What are the key concerns in patients presenting with a chronic spinal cord injury?

Airway and respiratory system

- The level of the spinal cord lesion will determine its effect on ventilation. Lesions above C5 will require ventilatory support.

- Decreased lung volumes and poor muscle function secondary to the neurological injury may predispose the patient to atypical respiratory tract infections and aspiration.
- Surgical fixation of the cervical spine may cause difficulty with intubation and ventilation.

Cardiovascular system

- Autonomic dysreflexia may occur during perioperative period, causing massive haemodynamic instability and end-organ damage e.g. myocardial infarction.
- There is an increased risk of undiagnosed ischaemic heart disease in this patient due to reduced movement and exercise levels.
- The patient presents with a high risk of venous thromboembolism secondary to immobility.
- The patient will have an overall reduction in plasma volume and haemoglobin concentration, which may be significant if there is significant blood loss perioperatively.

Neurological system

- Spasticity and contractures can make patient positioning and the surgical procedure challenging, and may require extra time.
- Previous spinal surgery can lead to unreliable neuraxial blockade.
- Patients with chronic spinal cord injuries have a high incidence of chronic pain.

Other

- Impaired haemostasis and temperature control.
- Delayed gastric emptying.
- Chronic urinary retention and a high incidence of urinary tract infections.

What are the options for anaesthesia in this patient?

The anaesthetic technique should be chosen based on the level of the lesion, the procedure (in this case, a Caesarean section) and the symptoms and preference of the patient. It should be decided following a multidisciplinary team discussion involving the patient, obstetrician, anaesthetist and neurosurgical team. The options for anaesthesia are detailed below.

- General anaesthetic.
- Neuraxial blockade (it would be prudent to discuss this with the neurosurgical team prior to the procedure).
- No anaesthetic (if the patient does not have autonomic dysreflexia and has no sensation in the neurological distribution of the surgical site).

The Caesarean section is carried out under a spinal anaesthetic. During the procedure, the patient suddenly complains of a headache and blurred vision, with difficulty in breathing. On examination her chest is flushed and her blood pressure is 178/93. How do you manage this?

- Call for help, alert the theatre team and conduct a rapid ABCDE assessment of patient.
- This is possible autonomic dysreflexia, which is a medical emergency and should be treated immediately.
- Pause the surgery as soon as possible.
- Position the patient in a reverse Trendelenburg position.
- Check the level of neuraxial blockade and consider a general anaesthetic if inadequate.
- Administer a short-acting antihypertensive agent e.g. sublingual nifedipine.
- Check the urinary catheter to ensure adequate drainage.
- Consider other causes in the differential diagnosis e.g. pain, pre-eclampsia.
- Consider level 2/3 care postoperatively if haemodynamic instability continues and discuss with a specialist.

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CASE: AWAKE CRANIOTOMY

A 25 year-old male patient is listed for an awake craniotomy for excision of a brain tumour. He has no other medical comorbidities.

What are the indications for an awake craniotomy?

- Excision of tumours or arterio-venous malformations from specific areas of the brain e.g. close to eloquent speech sensory and motor areas. Awake surgery allows for continuous monitoring of function to minimise postoperative neurological impairment.
- Functional neurosurgery including some surgery for epilepsy.
- Insertion of deep brain stimulators.

What added information would you like prior to proceeding with this case?

Patient factors

- Take an anaesthetic history focusing on any medical conditions, previous anaesthetics and the airway. The following factors may preclude an awake craniotomy:
  - Any condition that causes involuntary movements.
  - Poor compliance with healthcare professionals e.g. due to acute confusion and learning difficulties.

- Uncontrollable cough.
- Difficulty lying flat e.g. due to a raised BMI and obstructive sleep apnoea.
- High anxiety levels.
- Language barrier.

- Take a history of the brain tumour to include the diagnosis, any previous or current symptoms and treatment. The preoperative assessment should include a detailed neurological history and examination to determine the patient's preoperative status.

Surgical factors

- Discuss the expected duration of surgery including the likely period of being awake.
- Conduct a multidisciplinary discussion to include the patient suitability for awake neurosurgery and any challenges that may arise.

What are the key aspects to prepare for this procedure?

Patient preparation

- Psychological assessment for an awake procedure.
- Ensure adequate information describing the perioperative events and theatre complex.

Anaesthetic preparation

- Preoperative assessment by an experienced neuroanaesthetist.
- Conduct a multidisciplinary team meeting to discuss specific factors such as the anaesthetic plan, positioning, temperature and noise levels.

What are the options for anaesthesia in this patient?

Awake for the duration of the procedure

- Use conscious sedation, allowing the patient to maintain spontaneous ventilation and a response to stimuli.
- Agents of choice include propofol, remifentanil, clonidine, dexmedetomidine and benzodiazepines.

Asleep – awake – asleep

- Induction of general anaesthetic with a target-controlled infusion using propofol and remifentanil. Securing of airway with endotracheal tube or laryngeal mask airway.
- Reduction of anaesthetic agent concentrations during the "awake" period, followed by reintroduction of general anaesthesia for closure.

Asleep/sedated – awake

- As above, but the patient is kept awake for closure.
- In some centres, a general anaesthetic is not required initially.

How is a scalp block performed?

- Ensure consent, apply AAGBI monitoring, prepare emergency drugs and equipment and calculate the maximal dose of permitted local anaesthetic to avoid the risk of toxicity.
- A scalp block is performed under sedation or general anaesthetic.
- Use a sterile technique, and conduct a "stop before you block" moment.
- Infiltrate local anaesthetic to block specific nerves:
  - Supraorbital nerve (at the supraorbital notch).
  - Supratrochlear nerve (medial to the supraorbital notch).
  - Zygomaticotemporal nerve (at the temporalis muscle).
  - Auriculotemporal nerve (anterior to the auricle).
  - Lesser occipital nerve (posterior to the auricle).
  - Greater occipital nerve (medial to the occipital artery).
  - Greater auricular nerve (posterior to the auricle).

While the surgeon is carrying out cortical mapping, the patient has a seizure. How do you proceed?

- Alert the theatre team and call for urgent help.
- Ask the surgeons to irrigate the surgical site with ice-cold saline.
- Administer pre-prepared agents for seizure control following a discussion with the surgeon.
- Consider deepening sedation or general anaesthetic (with appropriate airway management) if seizure control is not achieved with the above measures.

What are the known complications associated with an awake craniotomy?

- Loss of the airway/airway obstruction.
- Respiratory depression.
- Aspiration.
- Air embolus.
- Haemodynamic instability.
- Anxiety/lack of compliance perioperatively.
- Local anaesthetic toxicity.

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2

CARDIOTHORACIC SURGERY

CASE: VENTRICULAR SEPTAL DEFECT

A 6-month-old male infant with a known ventricular septal defect (VSD) presents for elective repair of his cardiac lesion. You are asked to see the patient and his parents on the ward prior to his procedure.

What is a ventricular septal defect?

- A VSD is an abnormal communication between the left and right ventricles, due to a defect in the interventricular septal wall.
- It is the most commonly occurring congenital cardiac defect.

How can you classify congenital cardiac defects?

There are many different ways of classifying congenital defects. Here is one example.

- "Simple" left to right shunt, leading to increased pulmonary blood flow:
  - Atrial septal defect (ASD).
  - VSD.
  - Atrioventricular septal defect (AVSD).
  - Patent ductus arteriosus (PDA).
- "Simple" right to left shunt, leading to reduced pulmonary blood flow and cyanosis:
  - Pulmonary atresia.
  - Tetralogy of Fallot: right ventricular outflow tract obstruction, RV hypertrophy, VSD, and overriding aorta.
  - Tricuspid atresia.
  - Ebstein's anomaly.
- "Complex" lesions, with mixing of pulmonary and systemic blood and resulting cyanosis:
  - Hypoplastic left heart syndrome.
  - Transposition of the great arteries (TGA).
  - Truncus arteriosus.
  - Total anomalous pulmonary venous drainage (TAPVD).
- Obstructive defects:
  - Coarctation of the aorta.
  - Aortic stenosis.
  - Pulmonary stenosis.

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What symptoms and signs may be seen in this patient?

The symptoms and signs in a patient with a VSD vary depending on the size of the lesion and the degree of left to right shunting. Some VSDs may be diagnosed antenatally by foetal ultrasound, although some are diagnosed postnatally following presentation in the first 2–6 weeks of life.

Symptoms

- If the VSD is small, patients may be asymptomatic.
- With moderate or large VSDs, patients can manifest with symptoms related to the increased pulmonary blood flow, and development of congestive heart failure, including:
  - Reduced growth and development or failure to thrive.
  - Respiratory distress, which may be more apparent during, or can limit, feeding.
  - Recurrent respiratory tract infections.
  - Sweating.
  - Poor exercise tolerance.
- No cyanosis unless there has been the development of Eisenmenger syndrome and therefore shunt reversal.

Signs

- Pansystolic murmur at the left sternal border.
- Precordial thrill.
- Tachypnoea, dyspnoea, respiratory distress.
- Hepatomegaly.

What are the pathophysiological effects in a patient with a VSD?

- VSDs cause:
  - Intracardiac shunting.
  - Congestive cardiac failure.
  - The development of pulmonary hypertension over time.
- Small VSDs that exhibit resistance to blood flow across the lesion, and therefore that limit shunting, are deemed "restrictive". Large VSDs that exhibit no resistance to shunt flow across the lesion are deemed "non-restrictive".
- A VSD produces a left to right shunt. Some oxygenated blood from the left ventricle passes through the VSD to the right ventricle, mainly during systole, instead of ejection into the systemic circulation.
- In order to maintain an adequate systemic cardiac output in the presence of a left to right shunt, compensatory mechanisms are activated such as the sympathetic nervous system and the renin-angiotensin-aldosterone system. (However, these mechanisms can actually worsen the pathophysiology and symptomatology.)

- The left to right shunt causes increased pulmonary blood flow, and pulmonary overcirculation, leading to:
  - Increased left atrial and left ventricular blood volume, thereby leading to LV volume overload and dilatation, LV hypertrophy, and LA dilatation.
  - Pulmonary oedema, and over time, reactive pulmonary vascular changes and an increased PVR, leading to pulmonary hypertension and RV failure.
- The RV can also be directly affected by the volume overload and particularly the high pressure from the LV transmitted through large non-restrictive VSDs.
- If large, non-restrictive VSDs remain unrepaired, over time pulmonary hypertension gradually worsens and RV pressures increase. Ultimately, if pulmonary arterial or RV pressures exceed systemic arterial or LV pressures, the shunt reverses, and blood flows right to left across the VSD, resulting in cyanosis.
- The development of fixed severe pulmonary hypertension, shunt reversal and cyanosis signifies the existence of Eisenmenger syndrome.

What are the key considerations in the preoperative assessment of this patient?

History

- Ask the parents about any symptoms of respiratory tract infections such as fever, cough, coryza, wheeze or shortness of breath. A recent infection can predispose the patient to increased comorbidities following cardiopulmonary bypass.
- Explore symptoms related to cyanosis, dysrhythmias, congestive cardiac failure and pulmonary hypertension.
- A full anaesthetic history should be taken including a full medical and birth history; any previous anaesthetics or stays on neonatal intensive care; regular medication including timings and known allergies. VSDs can be associated with congenital abnormalities such as Trisomy 13, 18 and 21, which may increase the risk of other systemic conditions/defects, in particular airway abnormalities.
- A discussion about the anaesthetic procedure, risks, and consent should be included in the preoperative assessment, including the insertion of invasive lines, PICU postoperative stay, and potential need for blood or blood product transfusion.

Examination

- A full examination including an airway assessment should be done looking for the signs listed above.
- Venous access in these patients can be challenging. Look for potential sites during the preoperative examination.

Investigations

- Baseline blood tests to include a full blood count, clotting screen, blood group and screen for antibodies, electrolytes and renal and liver function. Ensure appropriate blood has been ordered and is available.
- An ECG (for LA or LV/RV hypertrophy).
- Echo (for VSD location and size, shunt direction, ventricular chamber size and function, estimates of pulmonary arterial pressure, and the presence of any other anomalies or defects).
- Chest X-ray (for cardiomegaly, pulmonary oedema and pulmonary vascular markings).

The patient is anaesthetised for VSD repair. What ventilatory strategy would you adopt during the operative period prior to cardiopulmonary bypass, and why?

- Avoid high inspired concentrations of oxygen.
- Avoid hypocarbia. Aim for high-normal end tidal carbon dioxide.
- This patient has a left to right shunt. High oxygen concentrations and hypocapnia will decrease the pulmonary vascular resistance, thereby increasing the degree of left to right shunt. This will lead to an increase in pulmonary blood flow at the expense of systemic blood flow, thereby resulting in systemic hypotension, reduced coronary perfusion pressure, and reduced end-organ perfusion – all of which should be avoided.

The patient undergoes uneventful surgical closure of the VSD. List some issues that could occur in the early postoperative period?

- SIRS response.
- Bleeding and coagulopathy.
- Cardiac tamponade.
- Low cardiac output state (other than due to tamponade).
- Tachy-dysrhythmias or heart block.
- Pulmonary hypertensive crisis.
- Presence of a residual defect.

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CASE: MITRAL VALVE REPLACEMENT

A 45-year-old female patient is listed for mitral valve replacement due to severe mitral valve stenosis.

What is the normal area of the mitral valve?

- The normal mitral valve area is more than 4 cm^2.
- Mitral stenosis is a valve area of <2 cm^2, with severe stenosis <1 cm^2.

What are the common causes of mitral stenosis?

- Rheumatic heart disease secondary to rheumatic fever (most common cause worldwide).
- Degenerative calcification.
- Infective endocarditis.
- Congenital (uncommon).
- Infiltrative diseases: sarcoidosis/amyloidosis (rare).

Worldwide, rheumatic heart disease is the most common cause. However, there is global variation in the prevalence of rheumatic heart disease. In high-income countries with a low prevalence, degenerative calcification or infective endocarditis are potentially more common causes.

What common symptoms might you expect in this patient?

- Fatigue.
- Dyspnoea.
- Reduced exercise tolerance.
- Cough.
- Palpitations (if presence of atrial fibrillation).
- Increased frequency of respiratory tract infections.

How is mitral stenosis classified?

- Mitral stenosis is classified based on the valve area and the mean pressures across the valve found on echo:
  - Mild: 1.6–2.0 cm^2, pressure <5 mmHg.
  - Moderate: 1.5–1.0 cm^2, pressure 6–10 mmHg.
  - Severe: less than 1.0 cm^2, pressure >10 mmHg.

Why is atrial fibrillation more common in patients with mitral stenosis?

- Patients with severe mitral valve stenosis develop increased left atrial pressure, due to the impedance to left ventricular filling from a progressively narrowed mitral valve.
- A high left atrial pressure causes increased stretching and dilation of the left atrium, increasing the likelihood of atrial dysrhythmias such as atrial fibrillation.

- These patients should be anticoagulated owing to the higher likelihood of thrombotic events.

What are the concerns when assessing this patient preoperatively?

A patient with severe mitral valve stenosis is a high-risk patient and her disease progression and symptoms should be explored thoroughly, together with any underlying conditions related to the disease.

- Implications of severe mitral valve stenosis: focus on signs, symptoms, and investigations that evaluate the severity of the pathophysiological process and degree of impairment of physiological reserve, including evidence of dysrhythmias, pulmonary venous congestion and pulmonary oedema, pulmonary hypertension, and right heart failure.
- She is a high-risk patient requiring preoperative assessment and anaesthesia managed by a cardiac anaesthetist, following preoperative optimisation with medical therapy.
- If the patient is on warfarin for atrial fibrillation, consider bridging therapy with an intravenous heparin infusion.
- Evaluate any comorbidities, including the cause of her cardiac disease and evidence of other end-organ dysfunction.
- Take a routine anaesthetic history and conduct an airway assessment, including her past medical and social history, and any allergies.

What are the anaesthetic goals for this patient?

Preserve left ventricular preload

- Low-normal heart rate – to preserve diastolic left ventricular filling and left ventricular end-diastolic volume, which serves to optimise left ventricular preload.
- Sinus rhythm – atrial fibrillation, with absence of atrial contraction, will detrimentally reduce left ventricular end-diastolic volume.
- Judicious use of fluids, in order to maintain preload while avoiding worsening pulmonary oedema.

Maintain contractility

- Avoid myocardial depressants. In the presence of right ventricular failure, inotropic support with right ventricular afterload reduction strategies may be required.

Optimise afterload

- Preservation of normal left ventricular afterload. As left ventricular cardiac output is relatively fixed, both a high or low afterload will be poorly tolerated.

Avoid worsening pulmonary hypertension or right ventricular afterload

- Avoid hypoxia, hypercarbia or acidosis, which would detrimentally increase pulmonary arterial resistance and right ventricular afterload. This includes adequate pain control in the perioperative period.

After surgical mitral valve implantation, the patient is to be weaned from cardiopulmonary bypass. How would you prepare for this?

- Re-warm the patient as guided by core and peripheral temperature monitoring. Avoid hypo and hyperthermia.
- De-airing: The heart needs to be de-aired, as directed by the surgical team. Transoesophageal echo is useful to search for any residual air.
- Adequate lung ventilation: If possible, visually check the surgical field for optimal lung re-expansion. Ventilate with 100% oxygen. Consider suctioning the endotracheal tube for secretions.
- Re-establish an appropriate heart rhythm and rate and ensure pacing equipment provides electro-mechanical capture. Aim for a heart rate of 80–100 and sinus rhythm. Epicardial pacing may be necessary to achieve this and to optimise sequential atrio-ventricular contraction.
- ST segment monitoring: Evidence of ischaemia should raise concern. Consider coronary air, graft or coronary occlusion, or an insufficient coronary perfusion pressure.
- Vasoactive medication: Consider the need for inotropes, vasopressors and arteriolar or veno-dilators as appropriate. In this case:
  - Consider inotropic support: Evaluate the patient's baseline ventricular function, the potentially deleterious effects of CPB, and the anticipated physiological effects of replacing the valve in the context of the pathology. Thus, consider the need to support left ventricular dysfunction, particularly if there is evidence of chronic deconditioning. Also consider the need to support the right ventricle if there is evidence of congestive heart failure.
  - Consider vasopressor support e.g. to maintain coronary perfusion pressure in the presence of vasodilation from a SIRS response to CPB.
- Acid–base balance: Correct metabolic acidosis if present.
- Electrolytes: Normalise electrolytes (Na^+, K^+ and Ca^{2+}) aiming for high-normal potassium.
- Blood sugar: Avoid hypo or hyperglycaemia.
- Haemoglobin: Optimise the haematocrit with blood products where necessary.

Following her mitral valve replacement, this patient is transferred to cardiac intensive care postoperatively. She remains intubated and ventilated. 6 hours later her blood pressure drops to 74/42 and her heart rate is 120. Her CVP rises from 12 to 18.

What is the definition of cardiac tamponade?

- Cardiac tamponade occurs when there is an accumulation of fluid in the pericardial sac to an extent that it creates an increased pressure within the pericardial space, thereby inhibiting effective filling of the heart chambers. This leads to a reduction in cardiac output and causes haemodynamic compromise and obstructive shock.

- A blood clot in the pericardial space causing external compression of the heart can also produce tamponade physiology.
- It can lead to life-threatening end-organ dysfunction, cardiovascular collapse and cardiac arrest.

A bedside echocardiogram demonstrates the presence of blood in the pericardium. What is your immediate management of this patient?

This is a medical and surgical emergency. The patient should be assessed and treated immediately.

- The findings suggest that the patient has developed cardiac tamponade postoperatively.
- This is an unstable patient that requires immediate evacuation of blood from the pericardial space.
- Call for urgent senior anaesthetic help and carry out a rapid assessment of the patient.
- Activate the cardiac unit's emergency team – this should include a cardiothoracic surgeon, the theatre team, and potentially a perfusionist.
- Aim to optimise haemodynamics:
  - Administer fluid boluses to increase ventricular filling pressure to counteract the diastolic filling restriction and improve ventricular preload.
  - Avoid high PEEP or high airway pressures, which would further compromise ventricular filling.
  - Consider vasoactive medication. While inotropes may increase cardiac output, they also may increase myocardial oxygen demand. Vasopressors may help to improve coronary and systemic perfusion but high afterload is poorly tolerated.
  - While the above may form temporary haemodynamic stability, the definitive treatment is to relieve the tamponade. For a postoperative cardiac patient: re-sternotomy, relief of the tamponade, and exploration for a possible bleeding source and surgical haemostasis should be emergently considered.
- Note that this patient may have a degree of coagulopathy post cardiac surgery, which should be considered and corrected if present.

As you approach the patient, she arrests. You note that the rhythm on the monitor is ventricular fibrillation. How do you proceed?

- Follow the Cardiac Advanced Life Support algorithm.
- This is a witnessed cardiac arrest with a recognisable rhythm in a patient who has just undergone cardiac surgery. Under these circumstances, external chest compressions may be delayed by 1 minute to facilitate the timely administration of three sequential shocks (for ventricular fibrillation or pulseless ventricular tachycardia). Therefore, administer three successive shocks (at 150 J) and then commence external chest compressions.

- Administer 300 mg IV amiodarone and prepare for an emergency resternotomy.
- Continue CPR with a single defibrillation attempt every 2 minutes.
- Resternotomy should occur within 5 minutes of cardiac arrest. This will facilitate internal cardiac massage, defibrillation (20 J) and release of tamponade.
- Continue ventilation with 100% oxygen and switch off PEEP. Confirm the position of the endotracheal tube and auscultate to ensure bilateral air entry.
- Avoid adrenaline unless specifically directed by a senior clinician, given the potential for profound hypertension after ROSC and thus the potentially catastrophic effect of damage to, and bleeding from, surgical anastomoses or suture lines.

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CASE: HEART TRANSPLANT

A 36-year-old male patient is listed for a laparoscopic appendicectomy. He has previously had a heart transplant. You are asked to assess him on the ward prior to his procedure.

Which conditions may lead to consideration of cardiac transplantation?

- Reasons for consideration of heart transplant include patients with chronic heart failure:
  - Who despite maximal medical therapy, exhibit limiting symptoms, or require frequent hospital admissions, or exhibit rising natriuretic peptide levels.
  - Who exhibit deteriorating renal function or intolerability to remove congestion without compromising renal function, or who require reduction or cessation of heart failure medication due to intolerable side effects e.g. hypotension and renal dysfunction.

  - With worsening right heart failure or pulmonary artery pressures.
  - Causing anaemia, weight loss, hyponatraemia or liver dysfunction.
  - Who exhibit frequent ventricular dysrhythmias despite optimal therapy.
- Urgent referral is indicated for patients dependent on intravenous inotropic therapy; those requiring mechanical support for cardiogenic shock; those requiring positive airway pressure ventilatory support for intractable pulmonary oedema; or those with refractory ventricular dysrhythmias.

(Bhagra et al 2019)

What are the contraindications to cardiac transplantation?

- Irreversible liver or renal failure.
- Diabetes: either poorly controlled or causing end-organ dysfunction.
- Obesity or other multi-system disease with poor long-term survival.
- Severe lung disease or pulmonary hypertension.
- Active or recent malignancy.
- Symptomatic cerebral or peripheral vascular disease.
- Active infection.
- Alcohol excess/drug abuse.
- Psychosocial factors such as non-compliance with medication, drug or alcohol misuse, current smoker and inadequate support.

(Bhagra et al 2019)

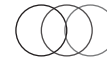
What are the long-term consequences of cardiac transplantation?

Effect on organ systems

- Immune-mediated coronary artery disease.
- The risk of organ rejection requires immunosuppression, long-term monitoring and surveillance cardiac biopsies.
- Persistence of any systemic disease processes that led to cardiac failure initially.
- Chronic graft dysfunction.
- Increased susceptibility to infection (including bacterial, viral, fungal and atypical) due to systemic immunosuppression.

Medication

- Patients require lifelong immunosuppressive agents. For maintenance immunosuppression, a triple therapy regime is commonly used including a calcineurin inhibitor (ciclosporin or tacrolimus), an anti-metabolite (azathioprine or mycophenolate) and a corticosteroid (prednisolone or methylprednisolone). Over time, a significant proportion of patients can be weaned off steroids.
- Therapeutic drug monitoring is required for some immunosuppressants, and careful avoidance of food or drug interactions that may potentiate or inhibit their effect. Some side effects include:



  - Azathioprine – liver toxicity, pancreatitis, leukopenia and risk of infection.
  - Mycophenolate – leukopenia, gastrointestinal symptoms, contraindicated in pregnancy due to the increased risk of miscarriage or congenital malformations.
  - Ciclosporin or tacrolimus – renal toxicity, diabetes, hypertension, neurotoxicity and gingival hyperplasia (ciclosporin).
  - Prednisolone – hypertension, hyperlipidaemia, diabetes, osteoporosis, Cushing's syndrome and fluid retention.
- As well as risk of infections, long-term consequences also include an increased risk of certain cancers.

What is the commonest cause of pacemaker insertion in patients with a heart transplant?

- During cardiac transplantation, the donor atria are sutured to the recipient atria. Recipient atrial activity does not cross the suture line, so the donor heart rate is dependent on the denervated donor sino-atrial node.
- Bradycardia due to ineffective blood supply to the donor sino-atrial node, or AV conduction defects, are common reasons for permanent pacing.

How would you assess this patient preoperatively?

History

- Ensure a thorough cardiac history including the reason for transplantation, any courses of treatment and disease progression. Explore symptoms suggestive of ischaemic heart disease or cardiac failure, bearing in mind that the patient is unlikely to experience angina due to the denervated heart.
- Take a full drug history including immunosuppressive agents and any side effects.
- Carry out a review of the patient's notes and discuss with the specialist transplant team regarding the patient's condition, including history of graft dysfunction, graft rejection, CMV status, and advice for perioperative management such as therapeutic drug monitoring and antibiotic prophylaxis.
- Systematic review and other comorbidities should be considered, as well as previous anaesthetics, airway assessment and social history.
- History of the patient's current illness.

Examination

- Cardiovascular examination and airway assessment.
- Examine for signs of sepsis. Discuss with a microbiologist early given the risk of atypical infections.

Investigations

- Baseline observations.
- Baseline blood tests to include a full blood count, renal function and electrolytes, and markers of infection.
- Baseline ECG, chest X-ray and recent echo.

What are the anaesthetic implications and goals for this patient?

Implications

- The heart is denervated at the time of donor retrieval. This significantly impacts its ability to alter heart rate following transplantation. The heart rate is usually maintained by donor sino-atrial activity between 90 and 100 bpm.
- In the denervated heart, there will be an absence of reflex autonomic heart rate changes to events such as laryngoscopy or traction to abdominal or pelvic viscera.
- Significant blood pressure fluctuations can occur due to the lack of heart rate compensatory responses to changes in systemic vascular resistance.
- Sympathetic stimulation to the denervated transplanted heart occurs through circulating catecholamines. This requires the use of direct-acting adrenergic sympathomimetic drugs including ephedrine, isoprenaline, noradrenaline or adrenaline.
- For brady-dysrhythmias, vagolytic drugs such as atropine and glycopyrrolate will be ineffective at the increasing heart rate. Use direct-acting beta-adrenergic drugs to increase heart rate, or electrical pacing if necessary.
- For tachy-dysrhythmias, digoxin will be ineffective at reducing heart rate through its vagally mediated mechanism of action. Consider the use of amiodarone or verapamil.
- Beware of denervation supersensitivity to drugs such as noradrenaline, adrenaline and adenosine.
- The Frank-Starling mechanism remains intact, facilitating preload-induced effects on stroke volume and thus cardiac output. The transplanted heart is particularly sensitive to preload changes and the subsequent effect on cardiac output, given the poor or absent autonomic heart rate response in denervated hearts.
- Due to denervation, patients may not experience angina despite the presence of myocardial ischaemia.
- There is evidence of a degree of sympathetic and/or parasympathetic re-innervation over time in some patients following cardiac transplantation, although this occurs to a variable extent. Regeneration of autonomic nerve fibres may, for example, improve the transplanted heart's ability to vary heart rate or contractility, or to re-establish the patient's ability to experience the sensation of angina.
- If the patient is CMV negative, they should receive CMV negative blood products.

Goals

- Take extra care during laryngoscopy or airway instrumentation as gingival hyperplasia may increase the risk of oral bleeding.
- Consider using cis-atracurium for neuromuscular blockade, given its favourable metabolism and elimination profile in the presence of hepatic or renal dysfunction. Neostigmine in combination with glycopyrrolate has been used safely in heart-transplanted patients, although cases of severe bradycardia or cardiac arrest following administration have been reported. Ensure immediate availability of direct-acting catecholaminergic drugs. Alternatively, rocuronium followed by sugammadex could be considered.
- Ensure a cardiostable anaesthetic. Be aware of the potential for exaggerated blood pressure variation, both with general anaesthetic or neuraxial blockade, due to the blunted heart rate response. Therefore, anticipate the effects of, and avoid, large swings in the systemic vascular resistance.
- Judicious use of fluids to maintain and optimise preload, given the preload dependence of the transplanted heart. Avoid hypovolaemia prior to induction.
- Maintain coronary perfusion pressures.
- Use direct-acting chronotropic and inotropic agents and have external pacing readily available.
- Consider cardiac output monitoring or intraoperative echo for monitoring and guiding management.
- Ensure optimal oxygenation, temperature and pain control.
- Use strict aseptic techniques for venous/arterial line or urinary catheter insertion, or regional/neuraxial anaesthetic procedures, due to the increased risk of infection.
- Ensure meticulous patient positioning and padding as steroids can cause thin and fragile skin and increase the risk of pressure sores.
- Seek advice regarding additional stress-dose cover if the patient is taking significant doses of corticosteroids for immunosuppression.
- Postoperatively, remove lines or catheters at the first appropriate opportunity, given the increased risk of infection.
- Ensure immunosuppressant therapy is maintained and therapeutic drug monitoring as advised by the transplant team.
- Avoid NSAIDs if there is a possibility of worsening renal dysfunction.

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CASE: CARDIAC IMPLANTABLE ELECTRICAL DEVICE

An 81-year-old male patient is listed for a transurethral resection of the prostate. He has a history of hypertension, COPD and has a permanent pacemaker in situ. You are asked to review him in the preoperative assessment clinic.

What are the indications for insertion of cardiac implantable electrical devices?

Permanent pacemaker (PPM)

- Atrioventricular blockade (unstable 2nd or 3rd degree).
- Sick sinus syndrome.

Biventricular pacemaker

- Moderate/severe cardiac failure (cardiac resynchronisation therapy).

Implantable cardioverter defibrillator (ICD)

- Previous ventricular dysrhythmias with significant haemodynamic compromise or cardiac arrest.
- Post-myocardial infarction at risk of ventricular dysrhythmias.
- Familial conditions with a high risk of sudden death, including long QT syndrome, Brugada syndrome, hypertrophic cardiomyopathy and arrhythmogenic right ventricular dysplasia.
- Congenital heart disease.

Implantable loop recorder

- For diagnostic or monitoring purposes.

What are the features of a permanent pacemaker?

- Source of energy (battery).
- Pulse generator.
- Pacing leads (unipolar or bipolar).

How would you assess this patient preoperatively?

History

- Take a thorough cardiovascular history including the extent of historical or existing cardiac disease or comorbidities. Elicit any current symptoms focusing on syncope, chest pain and palpitations, or symptoms of worsening cardiac function.
- Pacemaker review:
  - Date and indication for insertion, dependency on the pacemaker, and underlying rhythm.
  - Duration since last check.
  - Any concerns or issues.
  - Manufacturer and type of device, and lead and box location.
  - Pacing mode, including presence of rate modulation or anti-tachycardia function.
  - Patients may be able to produce their personal pacemaker ID card, which contains useful details regarding some of the above.
- Take a full respiratory history including any infections, hospital admissions and current symptoms.
- Non-cardiac comorbidities, social and medication history including medication compliance and anaesthetic history.

Examination

- Cardiovascular and respiratory examinations.
- Airway assessment.

Investigations

- Baseline observations.
- ECG (both pacing spikes and evidence of subsequent electrical complexes should be apparent).
- Echo if indicated.
- Chest X-ray to review the position of the pacemaker box, assessment of leads, and to assess for cardiac failure.
- Bloods to include full blood count, urea and electrolytes and clotting function, particularly if taking anticoagulants.

The patient's pacemaker ID card states the mode as VVIR. What does this mean?

- This is a five-letter code using the standard nomenclature from the Generic Pacemaker Code developed by the North American Society of Pacing and Electrophysiology and the British Pacing and Electrophysiology Group.
- The first letter denotes the chamber paced – in this case the right ventricle is paced.
- The second letter denotes the chamber sensed – in this case the right ventricle.

- The third letter denotes the response to sensing – in this case an inhibitory response to a sensed event.
- The fourth letter refers to ability for rate modulation; thereby altering pacing rate to meet changing physiological needs such as physical exercise.
- The fifth letter (not present) denotes the presence of an anti-tachycardia function.
- Therefore VVIR represents rate-responsive ventricular demand pacing.

What are the key considerations for perioperative care of this patient regarding his pacemaker?

- The patient should be reviewed by a cardiac physiologist on admission for a pacemaker check and to deactivate rate-response, anti-tachycardiac and defibrillator functions, if present. It is usually both inappropriate and potentially dangerous to change the mode to a fixed-rate (non-sensing) mode for surgery, but consider this in a patient who is highly dependent on their pacemaker and when electro-magnetic interference during the surgery is likely. A follow-up visit will be required after anaesthesia and surgery to check appropriate functioning of the device and reinstate previous functionality.
- Correct electrolytes prior to induction of anaesthesia.
- Ensure a cardiostable anaesthetic to minimise the risk of perioperative ischaemic events, dysrhythmias and disturbance of pacemaker function.
- Ensure immediate access to emergency resuscitation drugs, a defibrillator with pacing functionality, and isoprenaline, in case of pacemaker dysfunction. Place defibrillator/pacing pads before surgery at least 10 cm away from the pacemaker box to avoid damage.
- Routine AAGBI monitoring is appropriate and will not interfere with pacemaker function, although ensure the ECG display is set to detect pacing spikes. Invasive blood pressure monitoring should be considered for accurate measurement and evidence of reliable electro-mechanical coupling. Care should be taken with central venous catheter insertion to avoid lead displacement.
- Fasciculations associated with suxamethonium and shivering may cause pacemaker dysfunction. Consider using other neuromuscular blocking agents where possible.
- Discuss antibiotic prophylaxis, given the risk of developing pacing lead endocarditis.
- Theatre staff should be made aware of the pacemaker and bipolar diathermy should be used if essential.
- Ensure postoperative recovery in a high dependency environment with continuous monitoring and access to emergency resuscitation equipment.

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CASE: CARDIOMYOPATHY

A 53-year-old male patient is listed for an emergency laparotomy for small bowel obstruction. He has a history of hypertension and alcohol excess and is a smoker. He has a dilated cardiomyopathy but has not been reviewed for this since his diagnosis 2 years ago.

What is a cardiomyopathy?

- A contemporary definition (2007) from the European Society of Cardiology (ESC) Working Group on myocardial and pericardial diseases states that a cardiomyopathy is "a myocardial disorder in which the heart muscle is structurally and functionally abnormal, in the absence of coronary artery disease, hypertension, valvular disease and congenital heart disease sufficient to cause the observed myocardial abnormality".
- The ESC Working Group classifies cardiomyopathies into the following categories:
  - Hypertrophic cardiomyopathy.
  - Dilated cardiomyopathy.
  - Arrhythmogenic right ventricular cardiomyopathy.
  - Restrictive cardiomyopathy.
  - Unclassified (such as Takotsubo cardiomyopathy).

What are the risk factors for the development of a dilated cardiomyopathy?

- Family history.
- Male gender.
- Afro-Caribbean ethnicity.
- Sickle cell disease.
- Alcohol excess/substance misuse.
- Muscular dystrophy.
- Hypothyroidism.
- Exposure to cardiotoxic chemotherapy agents.

What signs and symptoms associated with dilated cardiomyopathies would you explore in this patient?

- Evidence of heart failure:
  - Dyspnoea.

  - Reduced exercise tolerance.
  - Orthopnoea.
  - Paroxysmal nocturnal dyspnoea.
  - Peripheral oedema.
  - Ascites.
- Dysrhythmias/palpitations.
- Evidence of thromboembolic events or complications.

How does a dilated cardiomyopathy lead to cardiac failure?

- Ventricular enlargement and dilatation cause systolic dysfunction and reduced stroke volume due to overstretching of the actin and myosin filaments.
- Given the increase in ventricular radius increases wall tension (through the Law of Laplace), the afterload (as defined by the ventricular wall tension in systole) increases, leading to the increased myocardial oxygen demand.
- Compensatory mechanisms occur. Sympathetic stimulation increases heart rate and contractility to initially help maintain cardiac output. Activation of the renin-angiotensin-aldosterone system and ADH secretion raises systemic vascular resistance (angiotensin II, ADH) to maintain mean arterial pressure, and increases intravascular volume (aldosterone, ADH) and therefore preload (if on the ascending part of the Frank-Starling curve).
- Although these compensatory mechanisms initially help to preserve cardiac output, they ultimately worsen the ventricular dilatation, wall tension, and oxygen demand, which further perpetuates systolic dysfunction and cardiac failure.

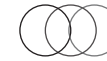
How would you assess this patient preoperatively?

This is a high-risk patient undergoing emergency major surgery with a high likelihood of perioperative morbidity and mortality due to their pre-existing health conditions and current pathology.

- The preoperative assessment should include a review by a consultant surgeon and anaesthetist, assessing the need for surgery and risk stratifying the patient using an appropriate tool e.g. P-POSSUM score. This should be discussed with the patient prior to surgery.
- The patient should be discussed with the intensive care team preoperatively, for consideration of optimisation prior to surgery and for management postoperatively. Ensure ongoing resuscitation if appropriate.

History

- Ensure a thorough cardiovascular history focusing on the patient's current symptoms, as described above to ascertain the degree of systolic dysfunction, cardiac failure if present and any evidence of



end-organ dysfunction or thromboembolic events. Conduct a review of the patient's previous notes and any discussions with the cardiology team regarding the patient's diagnosis and any initiated treatment.
- Take a history of the patient's other comorbidities including their smoking and alcohol history and current intake/medical conditions associated with either.
- Discuss previous anaesthetics, the airway and drug history.
- Explore the time course of the patient's current illness, oral intake and treatment so far including antimicrobial therapy.

Examination

- Bedside observations.
- Cardiovascular and respiratory examinations.
- Airway assessment.

Investigations

- Routine baseline bloods for evidence of coagulopathy, hepatic or renal dysfunction, evidence of anaemia, and biomarkers of heart failure. Measure an arterial blood gas to determine the patient's resting efficiency of gas exchange and lactate.
- Chest X-ray for assessment of pulmonary oedema, or co-existent infection.
- ECG in particular for atrial dysrhythmias, conduction defects, or ST segment/T wave abnormalities.
- Echo for left and right ventricular size and function, the presence of valvular dysfunction (such as mitral regurgitation caused by stretching of the mitral annulus from ventricular dilatation), atrial size, estimated pulmonary artery systemic pressure, and the presence of sluggish intracardiac blood flow or an intracardiac thrombus.

The degree of investigations or preoperative optimisation should be balanced against the urgency for surgery. For example, an echo would be particularly helpful to evaluate the degree of cardiac failure. This would provide insights into the degree to which the patient is likely to tolerate anaesthesia and surgery, whether prolonged or specialist postoperative critical care support is likely to be required, and assists in enhancing a risk assessment of perioperative morbidity and mortality.

What are the priorities for the anaesthetic management of this patient?

Think about how you can optimise preload, heart rate and rhythm, contractility and afterload for this patient. In addition, consider how positioning, ventilation, surgical procedures and complications (such as bleeding) will affect the physiology. Aim to optimise oxygen delivery and minimise oxygen consumption by the heart.

Preoperative

- Ensure a thorough work-up, as described above.
- Optimise cardiac medication if evidence of heart failure and control dysrhythmias.

Intraoperative

- Ensure a cardiostable anaesthetic led by an experienced team.
- Monitoring: ensure large bore intravenous access and intra-arterial, central venous pressure and cardiac output monitoring to guide treatment.
- Avoid tachycardia.
- Aim to maintain sinus rhythm. Dysrhythmias will be poorly tolerated. Ensure electrolytes are optimised (including Mg^{2+}) and treat dysrhythmias early with anti-arrhythmic drugs or cardioversion as appropriate.
- Maintain an appropriate preload; both hypovolaemia and fluid overload will be poorly tolerated. Use fluids or diuretics carefully.
- A high afterload (that increases myocardial work and reduces cardiac output) or an excessively low afterload (that compromises coronary perfusion or end-organ perfusion) will be poorly tolerated. Avoid both of these situations.
- Beware of anaesthetic agents that cause myocardial depression and drugs that cause either a significant increase in systemic vascular resistance or tachycardia (e.g. ketamine), or those that can precipitously drop SVR and compromise coronary perfusion (e.g. propofol). Depth of anaesthesia monitors should be considered to assist with agent titration and mitigate the cardiovascular effects of excessively deep anaesthesia.
- Inotropic support may be required, depending on the degree of ventricular impairment. A systemic inflammatory response from the surgery may also precipitate a degree of vasoplegia-induced hypotension, which may need vasopressor support. Note that pure vasopressor or high alpha-mediated vasoconstriction, leading to a high afterload, may be poorly tolerated if the afterload is increased without complementary inotropic support. This highlights the utility of considering cardiac output monitoring or intraoperative/bedside echo to optimise vasoactive support.
- Avoid excessive PEEP or high airway ventilatory pressures that would compromise ventricular filling.
- Beware of fluid shifts, insensible fluid loss, and blood loss during the laparotomy, as these will effect the above.
- Maintain normothermia.
- If blood products are administered, ensure Ca^{2+} is maintained/replaced (as Ca^{2+} is chelated by citrated blood products). A low Ca^{2+} level will be negatively inotropic, which will be poorly tolerated in this instance.

Postoperative

- Close monitoring and supportive treatment in cardiac intensive care.

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CASE: ONE-LUNG VENTILATION

A 72-year-old male patient is listed for a right upper lobectomy for lung malignancy. He is a smoker and is on ramipril for hypertension. He weighs 71 kg.

What are the indications for one-lung ventilation?

Absolute

- When a healthy lung needs to be isolated from the contralateral side affected by any pathological process (air, blood and pus) e.g. lung abscess and pulmonary haemorrhage.
- To facilitate ventilation e.g. bronchopleural fistula.
- To allow for washout of a single lung e.g. cystic fibrosis.

Relative

- Surgical access e.g. pneumonectomy/lobectomy, oesophageal surgery, and aortic surgery.

How can one-lung ventilation be achieved?

- Double-lumen tube.
- Bronchial blocker.
- Endobronchial intubation of a normal endotracheal tube.

How do right and left-sided double-lumen tubes differ?

- Both right- and left-sided double lumen tubes have separate tracheal and bronchial aspects.
- However, right-sided double-lumen tubes have a Murphy's eye in the bronchial lumen due to the anatomy of the right upper lobe.

What size double-lumen tube would you choose for this patient?

- The patient's height is the most accurate predictor for the size of the double-lumen tube used:
  - Less than 155 cm: 35 French.
  - 155–165 cm: 37 French.
  - 165–175 cm: 39 French.
  - More than 175 cm: 41 French.
- The size of the tube required can also be estimated based on direct measurements of the major bronchi on CT scans.

How would you intubate this patient with a double-lumen tube?

Induction

- Preparation for the anaesthetic includes patient consent; a team brief and completion of the WHO checklist; drawing up of routine and emergency drugs; insertion of intravenous access and placement of AAGBI monitoring.
- Given the patient's comorbidities and the major procedure, an arterial line should be inserted with vasopressor agents primed and attached to the patient for use during induction (anticipating cardiovascular instability secondary to anaesthetic agents).
- A senior thoracic anaesthetist and trained assistant should be present.
- Cardiostable induction of anaesthesia with doses of propofol and fentanyl slowly titrated to effect and rocuronium.

Intubation

- Ensure that a left-sided, appropriately sized double-lumen tube has been checked and lubricated appropriately, with the stylet inserted.
- Use a videolaryngoscope to view the vocal cords.
- Insert the tube through the glottis and remove the stylet to prevent injury. Rotate the tube 90 degrees anticlockwise. Advance the tube until 29–30 cm (28–29 cm in women) and resistance is felt.
- Connect to the anaesthetic circuit.

Verification of tube position

- Inflate the tracheal cuff and ventilate. Bilateral chest rise should be noted, with breath sounds bilaterally on auscultation.
- Clamp and disconnect the tracheal lumen, inflate the bronchial cuff and auscultate to ensure left-sided ventilation only.

Note that the cuff should only be inflated 1 mL at a time up to 3 mL, beyond which the risk of ischaemic injury to the bronchial mucosa increases exponentially. If a leak is still heard after 3 mL is inserted, the bronchial lumen is likely in the trachea.

- Unclamp and reconnect the tracheal lumen and recommence bilateral lung ventilation.

- The double-lumen tube position should always be confirmed using a fibreoptic bronchoscope following clinical checks.

What are the advantages of using a bronchial blocker over a double-lumen tube?

- Can be used in paediatric patients (bigger range of sizes).
- Can be used in patients with single-lumen endotracheal tube in situ e.g. patients on the intensive care unit, where exchange of tubes is not desirable due to potentially difficult or swollen airways, with a high risk of aspiration of gastric contents.
- Decreased risk of airway injury e.g. nerve damage and palsy.
- Less challenging insertion in certain patient groups e.g. patients with poor mouth opening, tracheostomy patients, and laryngectomy stoma patients.

What are the causes of hypoxia during one-lung ventilation?

- The main cause of hypoxia during one-lung ventilation is secondary to movement of the double-lumen tube. Other equipment-related causes include failure of oxygen delivery and anaesthetic circuit disconnection or blockage.
- Increased airway pressures can also cause hypoxia secondary to bronchospasm, pneumothorax, coughing or anaphylaxis.
- Shunt.

The patient desaturates to 82% during the procedure. How do you proceed?

- Ensure that the patient is on 100% oxygen.
- Inform the surgeons and theatre team, and call for help.
- Equipment check: oxygen supply, ventilator and circuit.
- Check the position of the double-lumen tube.
- Maintain adequate cardiac output with fluid, vasopressors and inotropes if required.
- Suction the dependent lung.
- Apply CPAP to the non-dependent lung (however, this minimises the surgical view, so may not be possible). Apnoeic oxygenation could also be used at this stage e.g. low-flow oxygen via a suction catheter.
- Recruitment manoeuvres and increase PEEP to the dependent lung, with lower tidal volumes. Given the patient's medical history, aim for sats of 88%–92% (PO_2 of 8 kPa).
- Surgeons to clamp pulmonary artery.
- Two-lung ventilation/consider abandoning procedure if severe hypoxia continues.

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CASE: LOBECTOMY FOR LUNG MALIGNANCY

A 69-year-old male patient is listed for a lung lobectomy for malignancy. He has a history of ischaemic heart disease, COPD and a hiatus hernia. He stopped smoking last year, having been a smoker for 38 years. You are asked to review him in the preoperative assessment clinic.

Which factors determine whether a patient is suitable for a lung lobectomy?

- Informed consent for the procedure (given the risks of the procedure and postoperative complications).
- The tumour should be a non-small cell malignancy (either adenocarcinoma or squamous cell).
- The tumour must be deemed resectable following surgical assessment.
- The patient must be assessed as suitable for general anaesthetic.
- The patient's postoperative predicted ventilatory capacity, gas exchange and CPET results should be within acceptable limits.
- Patients with severe right-sided cardiac failure should be excluded from surgery as a lobectomy causes a permanent increase in pulmonary vascular resistance and thus further severe right ventricular strain.

What are the important aspects in the history of this patient prior to surgery?

- This is high-risk surgery in a patient with an increased likelihood of perioperative morbidity and mortality. A thorough preoperative history, examination and investigations are key to determine whether the benefit of surgery outweighs the potential risks.
- Respiratory history: history of COPD and malignancy including recent symptoms, hospital admissions and infections. Pulmonary function tests and CPET are now routine in the majority of patients presenting for this surgery.
- Cardiovascular history: thorough history of symptoms suggestive of worsening cardiac disease or failure e.g. shortness of breath, chest

pain and ankle swelling. Patient should be risk stratified based on history and further assessed using relevant investigations.
- Nutritional status: recent decrease in body mass index and extreme weight loss can lead to increased perioperative complications and suggest disease spread. Notably, an albumin level of <30 g/L is associated with poor outcomes in this surgery.
- Other comorbidities, social history and anaesthetic history including airway assessment.

What are the indications for pulmonary function testing?

- Diagnosis of diseases in symptomatic patients.
- Assessing the progress of a condition or its response to treatment.
- In preoperative risk assessment for pulmonary or non-pulmonary surgery.
- For disease prognostication purposes.

How can pulmonary function be assessed in this patient?

- Oxygen saturations at rest and during exercise.
- Arterial blood gas for baseline oxygenation values.
- Peak expiratory flow rate using a flow meter – mainly used in diagnosis and monitoring of obstructive disease processes.
- Spirometry – giving values of FEV_1 and FVC.
- Transfer factor – assesses the gas diffusion capacity of the alveoli.
- Ventilation/perfusion scanning.
- Shuttle walk test/6 minute walk test.
- Cardiopulmonary exercise testing.

This patient requires a right upper and middle lobe lobectomy. How can his lung function postoperatively be predicted?

- The total number of lung segments is 19. The right upper lobe has three segments, and the right middle lobe has two segments. Therefore following his procedure, this patient will have 14/19 segments remaining.
- The patient's postoperative FEV_1 and FVC values can be estimated by multiplying the preoperative values by 14/19. This can also be done for transfer factor.

When would cardiopulmonary exercise testing be considered?

- The British Thoracic Society has produced an algorithm that aids in decision making for preoperative investigations.
- If the patient has an FEV_1 value of <1.5L (lobectomy) or <2L (pneumonectomy), they should be referred for spirometry and transfer factor testing.

- If the patient's predicted postoperative values for FEV_1 and transfer factor are <40%, they should be referred for cardiopulmonary exercise testing. Patients with a VO_2 max value of <15 mL/kg/minute are considered high risk for surgery.

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3

AIRWAY MANAGEMENT

CASE: OBSTRUCTIVE SLEEP APNOEA

A 43-year-old male patient presents to the preoperative assessment clinic prior to day case inguinal hernia surgery. He is a smoker and has a BMI of 47. You are asked to review this patient as his blood pressure is 174/96.

What are your anaesthetic concerns regarding this patient?

- This patient has a raised BMI. Concerns include: an increased incidence of a difficult airway; the need for additional anaesthetic and surgical equipment, staffing and time perioperatively; and the physiological consequences and comorbidities secondary to his obesity.
- Probable untreated hypertension in a high-risk patient.
- There is a high likelihood of undiagnosed (and hence untreated) obstructive sleep apnoea (OSA).
- The patient is a smoker. The physiological and pathological consequences of smoking cause an increased risk of a difficult airway and challenging ventilation; higher incidence of infection; and poor wound healing postoperatively.
- The need for postoperative high dependency or intensive care should be considered early. This patient may not be a good candidate for day case surgery.

What is OSA syndrome?

- OSA is a condition where complete or partial airway obstruction during periods of sleep leads to a decrease in airflow and subsequent desaturation.
- OSA *syndrome* is defined as a confirmed diagnosis of OSA together with increased daytime somnolence.
- OSA is thought to affect up to 1.5 million adults in the UK, with up to 85% of these being undiagnosed and therefore untreated.

What measures are involved in sleep studies?

- Sleep studies (polysomnography) can be used as an objective assessment of the presence and degree of OSA. Measurements include:
  - ECG.
  - EEG.
  - Oxygen saturations.
  - Airflow.
  - Eye movements.
  - Electromyography.

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What is a hypopnoea?

- A hypopnoea is defined as more than 30% reduction in airflow lasting for longer than 10 seconds, with at least a 4% decrease in oxygen saturations.

What are the risk factors for the development of OSA?

Anatomical

- Increased neck circumference (>40 cm).
- Enlarged tonsils/adenoids/tongue.
- Craniofacial abnormalities.

Comorbidities

- High BMI (>35).
  - Hypertension.
  - Diabetes mellitus.
  - Asthma.
  - Neuromuscular disorders.

Other

  - Male.
  - Age (40–70 years old).
  - Family history.
  - Smoker.
  - Alcohol excess.
  - Pregnancy.
  - Low physical activity levels.

What are the key considerations in your anaesthetic plan for this patient?

Preoperative

- This is a complex patient with numerous comorbidities presenting for non-urgent surgery, so the procedure should be delayed until the patient has been reviewed by the relevant teams:
  - GP review for a potential new diagnosis of and treatment for hypertension.
  - Assess for possible OSA (using the STOP-BANG screening tool) and refer for sleep studies. If a diagnosis of OSA is made, the patient should undergo at least 3 months of home CPAP prior to consideration for surgery.
  - Smoking cessation advice and encouragement.
  - Weight loss advice and encouragement.
  - Encourage an increase in physical activity through exercise regimes.
- When surgery is reconsidered for this patient, a complex and thorough preoperative anaesthetic history, examination and appropriate investigations are required once the above have been completed, with

a focus on the airway and cardiovascular system. This may include an ECG, echo and CPET.

Intraoperative

- Avoid sedative premedication.
- Prepare for a difficult airway/intubation with an airway plan, appropriate equipment and adequate senior support.
- Ensure that there is a plan for failed intubation and/or oxygenation.
- Prioritise non-opioid base analgesia during the perioperative period.
- Use regional anaesthesia where possible (for both analgesia and anaesthesia).

Postoperative

- If a general anaesthetic is used, consider extubating the patient onto his own CPAP machine with a prolonged stay in recovery, with continuous sats monitoring and supplemental oxygen.
- Consider high dependency care postoperatively.

What are the potential complications associated with OSA?

- Cardiovascular: hypertension, arrhythmias, myocardial infarction and right-sided cardiac failure.
- Poor cognitive function and mood disorders.
- Impaired glucose tolerance/type II diabetes mellitus.
- Sexual dysfunction.

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CASE: RHEUMATOID ARTHRITIS

A 45-year-old female is undergoing an extended hemi-colectomy for bowel cancer. She has a history of rheumatoid arthritis but is otherwise well.

What is rheumatoid arthritis?

- Rheumatoid arthritis is a chronic, inflammatory autoimmune polyarthropathy.
- It is both systemic and symmetrical, and causes tenosynovitis, loss of cartilage and bony erosions.

What are the airway concerns in a patient with rheumatoid arthritis?

- Atlanto-axial instability/subluxation (anterior ± posterior).
- Subaxial subluxation.

- Cervical spine ankylosis.
- Cricoarytenoid joint dysfunction.
- Temporomandibular joint dysfunction.

How would you assess this patient's airway?

The patient's airway should be assessed with a thorough history, examination and the appropriate investigations.

History

- Note any previous history or documentation of a difficult airway or intubation.
- Take a detailed medical history, focusing on the symptoms specific to rheumatoid arthritis:
  - Neck pain/upper limb paraesthesia, suggestive of atlanto-axial instability. Airway manipulation in these patients can lead to paralysis or death.
  - Neck stiffness (increasing the risk of a difficult airway).
  - Dyspnoea/hoarse voice, which may suggest laryngeal involvement.
- Ask the patient about any dental work and review their dental hygiene.

Examination

- A general examination may reveal risk factors for a difficult airway, including a raised BMI, obvious anatomical deformities and a receding jaw.
- Check the patient's mouth opening as it may be limited if she has temporomandibular joint dysfunction.
- Examine neck flexion/extension.
- Carry out specific airway tests:
  - Mandibular protrusion: the inability to protrude the lower incisors anterior to the upper incisors is associated with an increased risk of difficult laryngoscopy.
  - Mallampati: assesses the visibility of the uvula with maximal mouth opening.
  - Thyromental distance: <6 cm from the thyroid cartilage to the mandible with the neck in extension is suggestive of difficult laryngoscopy.
  - Sternomental distance: <12.5 cm from the sternal notch to the tip of the mandible with the neck in extension is suggestive of difficult laryngoscopy.
  - Wilson score: uses five elements (BMI, buck teeth, jaw movement, neck movement and receding mandible) to predict the likelihood of a difficult intubation.

A combination of the above should be used to assess the difficulty of the patient's airway, as the sensitivity and specificity of each test alone is not high enough to make an accurate prediction.

Investigations

- An X-ray of the cervical spine should be considered in patients with rheumatoid arthritis to assess for atlanto-axial involvement, particularly if the disease is longstanding or if the patient has symptoms such as pain or paraesthesia.
- MRI scan to follow if indicated.
- Nasendoscopy can be considered in patients with suspected laryngeal involvement.

What is the Wilson score?

- The Wilson score is used to assess the likelihood of a difficult intubation and constitutes five factors:
  - BMI.
  - Neck movement.
  - Jaw movement.
  - Protruding teeth.
  - Receding mandible.
- Each factor is given a score out of 2 (where 2 denotes an abnormality) and a total score of more than 1 suggests a difficult intubation may be likely.
- A score of >1 identifies 75% of difficult patients with a false positive rate of 12%.

What are the options for a patient who has been identified as high risk for extubation perioperatively?

The Difficult Airway Society extubation algorithm gives four options for patients that are high risk.

- Extubate the patient when they are fully awake.
- Postpone extubation and transfer the patient to the intensive care unit.
- Perform a tracheostomy for a definitive airway.
- Advanced airway techniques, including exchanging the endotracheal tube for a laryngeal mask airway; using a remifentanil infusion while extubating; or using an airway exchange catheter in case the patient needs re-intubation rapidly.

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CASE: ACUTE AIRWAY OBSTRUCTION

You are asked to review a 63-year-old male patient in recovery for sudden difficulty in breathing and neck swelling. He has a history of atrial fibrillation, ischaemic heart disease and type II diabetes mellitus. He has just undergone a prolonged laparotomy for small bowel obstruction, for which he had a central venous catheter placed.

What is your initial management of this patient?

- This is an anaesthetic emergency and needs to be dealt with immediately.
- The patient should be reviewed urgently in recovery. Senior anaesthetic help should be sought and the difficult airway trolley should be present at the bedside.
- Conduct a rapid airway assessment to determine the cause of the patient's dyspnoea. Apply 100% high-flow oxygen via a non-rebreathe mask and transfer the patient to a place of safety if possible (closest empty theatre).
- Escalate the case rapidly to the duty anaesthetic consultant or a senior registrar.
- Take a prompt medical and anaesthetic history from the anaesthetic chart:
  - Note the history of atrial fibrillation: this patient may be on an anticoagulant.

The neck swelling is rapidly expanding. What are the options for airway management in this patient?

The history and examination findings suggest that the cause of dyspnoea may be secondary to haematoma formation in the neck after placement of the central venous catheter. Both the ENT and vascular teams should be involved early.

Intubation

- The first line plan for this patient should be to secure the airway with an endotracheal tube as he is in danger of imminent airway obstruction. He may need a smaller tube size than expected due to the expanding neck swelling. Options for intubation are:
  - Intravenous induction with direct or videolaryngoscopy.
  - Gas induction with direct or videolaryngoscopy.
  - Asleep fibreoptic intubation.
  - Awake fibreoptic intubation.

Tracheostomy/front of neck access

- In a patient with a rapidly expanding neck haematoma, this would be extremely difficult and should only be done in an emergency as part of "plan D", or by a specialist (ENT surgeon).

Whichever of the above methods are chosen for intubation, the ENT surgeons should be scrubbed and ready to do a tracheostomy (if time allows).

What are the concerns with an awake fibreoptic intubation in this patient?

- Limited time/expertise: Given the urgent nature of the scenario, there may not be adequate time or expertise to ensure a safe and skilled approach, including the time required for satisfactory airway topicalisation.
- The airway anatomy may be distorted by the neck swelling, making the technique more challenging.
- The procedure is unlikely to be well tolerated by a patient in respiratory distress and may cause total airway obstruction.
- The use of sedation may increase the risk of complete loss of the airway.

What different types of videolaryngoscopes are available for use?

- Standard blade: This is a conventional blade with a camera, so it can also be used for direct laryngoscopy.
- Angulated blade: This requires the use of a stylet as the blade is more curved.
- Channelled: This uses mirrors and lenses, so the user has to look through the scope directly rather than at a screen.

What are the potential complications associated with endotracheal intubation?

Early

- Misplaced tube (oesophageal/endobronchial).
- Dental/oral damage.
- Laryngeal trauma.
- Haemorrhage.
- Vocal cord haematoma.
- Airway oedema.

Late

- Tracheal stenosis.
- Laryngeal nerve damage/palsy.

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CASE: LARYNGECTOMY

A 56-year-old male patient is undergoing an elective laryngectomy for malignancy.

What added information would you like prior to proceeding with this case?

Patient factors

- An anaesthetic history focusing on known cardiovascular and respiratory comorbidities, previous anaesthetics and the airway.
  - Patients with laryngeal cancer often have a history of smoking or alcohol excess, which will cause perioperative anaesthetic and surgical challenges.
  - The patient may be malnourished due to a decreased appetite or pain in the oropharyngeal area, necessitating dietician involvement.
  - Anaemia may be present due to blood loss, chronic disease or secondary to the patient's comorbidities and should be treated prior to surgery.
- Information should be sought about completed treatment (chemotherapy/radiotherapy), which may have implications for airway manipulation and management. Intubation of a patient who has undergone radiotherapy to the airway necessitates a precise airway plan, discussed with the surgical team.
- Specific information about the tumour: patient symptoms and progression, and investigations (CT/MRI/nasendoscopy) suggesting encroachment on local structures:
  - Changes in voice/hoarseness.
  - Stridor/dyspnoea.
  - Shortness of breath when lying flat.

Surgical factors

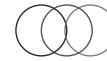
- Details about the extent of malignant spread and the expected procedure: whether it is a partial or total laryngectomy, including the possibility of neck dissection or free flap reconstruction.

What is a stridor?

- A stridor is a harsh inspiratory breath sound produced due to partial upper airway obstruction.

What is your plan for induction of anaesthesia in this patient?

- Ensure patient consent, a completed WHO checklist, AAGBI monitoring, the difficult airway trolley present, a consultant anaesthetist and trained anaesthetic assistant, and emergency drugs drawn up. Further monitoring may include an arterial line, a central line and a catheter to monitor urine output.



- This patient should be anaesthetised in theatre with the surgeons present and scrubbed, if the anaesthetic assessment deems that the patient may be difficult to intubate or ventilate.
- The airway plan should be discussed with the multidisciplinary team at the team brief, with preparation for what will be done in the event of a failed intubation.
- The plan for induction will depend on the specific patient history, examination and investigations. If very high risk for a difficult intubation, a preoperative awake tracheostomy should be done. However, the usual technique in this patient involves:
  - Preoperative assessment of the neck and landmark identification (ultrasound can be used to mark the cricothyroid membrane).
  - Preoxygenation with high flow nasal oxygen.
  - An intravenous induction with a sufficient dose of a muscle relaxant (rocuronium can be used with the correct dose of sugammadex drawn up if considered necessary).

What is THRIVE?

- "THRIVE" stands for transnasal humidified rapid insufflation ventilatory exchange.
- It is a technique that involves high flow humidified oxygen delivered via nasal specs (up to 70 L/minute).
- It uses apnoeic oxygenation. Maintenance of a patent airway allows gas exchange at a cellular level.
- The high flow of oxygen prevents entrainment of room air and generates a positive end expiratory pressure (PEEP) that prevents atelectasis and airway collapse.

The surgery is completed successfully and the patient is discharged home. Three months later, he presents to the emergency department with shortness of breath and difficulty breathing. What is your initial management?

- This is an anaesthetic emergency.
- Call for urgent senior anaesthetic and ENT help.
- Conduct a rapid assessment of the airway to assess the effort and efficacy of breathing via the stoma.
- Apply 100% oxygen using a Water's circuit and an appropriately sized mask for the patient's stoma.
- Assess the stoma to determine its patency by passing a suction catheter through.
- Ventilate the patient via his stoma while awaiting expert help.

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4

CRITICAL INCIDENTS

CASE: DRUG OVERDOSE

A 24-year-old female is admitted to the emergency department with a suspected drug overdose. You are asked to review her due to a drop in her conscious level.

What is your initial management for this patient?

- Review the patient immediately.
- Assess the patient for risk to clinical staff with a "hands-off" handover, to consider any concerns that may necessitate the use of personal protective equipment.
- Carry out an ABCDE assessment focusing on the patient's airway, which may need urgent intervention if impaired consciousness has led to the inability to maintain adequate ventilation.
- Ensure a thorough history is taken from the paramedics and/or a friend/relative to ascertain the potential ingested substances.
- Use specific and supportive treatment as indicated and refer to the relevant teams once she is stable e.g. medicine, intensive care, and psychiatry.

Based on the collateral history, it is estimated that she has ingested ~14 units of alcohol, an unknown quantity of diazepam and 16 g of paracetamol. How do you proceed?

Initial treatment

- Initial management of this patient depends on the findings from the ABCDE assessment but should include:
  - Stabilisation including considering a definitive airway if appropriate.
  - Examination to assess for alternative pathology (including trauma) causing an altered conscious level.
  - Treatment of specific symptoms e.g. vomiting.
  - Treatment of the paracetamol overdose according to local guidelines.

Investigations

- Continuous bedside monitoring of this patient in a safe location (e.g. the emergency department resuscitation bay) is essential, as well as initial baseline blood tests to include:
  - Full blood count.
  - Urea and electrolytes.
  - Liver function tests.

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- Clotting.
- Lactate and blood gas.
- Paracetamol and salicylate levels (4 hours post ingestion).
- Full screen to rule out overdose of other agents. Consider retention of toxicology samples for medico-legal purposes.

Further management

- Full medical and drug history.
- Escalation to intensive care if appropriate.

What is the role of activated charcoal in drug overdoses?

- Activated charcoal can be used in cases of drug overdose as it binds to agents and prevents them from being absorbed in the gastrointestinal tract.
- It should be given within an hour of drug ingestion but can be considered with drugs that are of slow or modified release formations, including the use of additional doses.
- Care should be taken in patients with reduced conscious levels as there is a risk of pulmonary aspiration.

How would you treat the paracetamol overdose?

- Supportive therapy is key.
- Specific treatment is with an intravenous infusion of N-acetylcysteine dosed according to weight. Local guidelines dictate timing and further investigations; however, it should be noted that this patient has ingested a significant amount of paracetamol and is at high risk for acute liver failure.

How would you manage the diazepam overdose?

- Treatment for benzodiazepine overdose is largely supportive.
- The specific antidote is flumazenil, a benzodiazepine receptor antagonist, but administration of this is not recommended initially due to the potential for harmful side effects including arrhythmias and seizures.

What are the criteria for consideration of a liver transplant due to acute liver failure secondary to a paracetamol overdose?

- The King's College Hospital criteria are:
  - pH<7.3.
  - Grade 3/4 encephalopathy.
  - Serum creatinine>300 µmol/L.
  - INR>6.5 (or prothrombin time>100 seconds).

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CASE: AWARENESS UNDER GENERAL ANAESTHESIA

You are the anaesthetist on-call for labour ward and are asked to anaesthetise a 34-year-old parturient for a category 1 Caesarean section for a fetal bradycardia, which is still present on arrival to theatre. The patient is otherwise well, has no allergies, is appropriately starved and has good mouth opening with a Mallampati score of 2. Her BMI is 24.

What is your plan for induction of anaesthesia?

- This is an emergency, and time is of the essence. The patient should be assessed quickly to facilitate a rapid transfer to theatre, focusing on comorbidities, previous anaesthetics and the airway. The discussion should include an explanation and consent for a general anaesthetic and the associated risks.
- Ensure availability of the difficult airway trolley, resus trolley and emergency drugs.
- Apply AAGBI monitoring, complete the WHO checklist and pre-medicate with sodium citrate.
- Use a specific obstetric general anaesthetic checklist.
- Ensure appropriate positioning of the patient and pre-oxygenate for 3 minutes, targeting ETO_2>85%. Continue to pre-oxygenate until the antiseptic skin preparation and surgical drapes have been applied and the obstetrician is scrubbed and ready to operate.
- Carry out a rapid sequence induction with cricoid pressure and suction on and readily available.
- The choice of drugs should reflect experience and local practice but follows the principle that the drugs should have a rapid onset and offset. Thiopentone and propofol are both commonly used, with suxamethonium as the muscle relaxant.
- Intubate and ventilate the patient with oxygen/air mix, nitrous oxide and sevoflurane.

The procedure is completed with no complications. Two hours later you are asked to review the patient due to her being "awake during the operation". How do you proceed?

An incident of accidental awareness is likely to be very traumatic for the patient. It should be taken very seriously, and in this case the patient should be reviewed immediately with a senior anaesthetist present.

- Review the anaesthetic chart prior to seeing the patient.
- Respond promptly and sympathetically in the presence of a senior midwife and the anaesthetic consultant on labour ward. The discussion should include a frank apology to the patient as well as an explanation.
- Take a detailed history from the patient about what she recalls including specific feelings, words or actions. Ask specifically about pain.
- Offer counselling and a further discussion with consultant anaesthetist at the earliest given opportunity.
- The conversation should be carefully documented and co-signed by those present.
- The patient should be followed up in an anaesthetic clinic.
- This should be reported as a serious untoward event and should be escalated according to local protocols.

What is the incidence of awareness in patients undergoing an obstetric procedure?

- 1:670 according to NAP 5.

How do you account for the increased incidence of accidental awareness under general anaesthesia (AAGA) in obstetric patients?

Obstetric patients are subject to a large number of risks for AAGA, which pertain to the patient group, the type of anaesthetic they need, the nature of the surgery and the human factors involved.

Patient factors

- Female.
- Younger age group.
- Raised BMI.
- Higher risk of a difficult airway.
- Anxious patient.

Anaesthetic factors

- Use of rapid sequence induction.
- Use of a muscle relaxant.

Surgical factors

- Emergency surgery.
- Excessive anaesthesia may be hazardous to the fetus, which may lead to the anaesthetist giving too low a dose of anaesthetic drugs.

- Some obstetric operations are performed in actively bleeding patients, therefore too low a dose of anaesthetic agent may be given with the intent of avoiding haemodynamic instability.

Human factors

- High stakes situation can be stressful and make drug errors more likely.
- Obstetric units are often staffed by junior anaesthetists out of hours, and relative inexperience may make drug errors more likely.
- Lack of familiarity of drugs used in obstetrics e.g. thiopentone.

What questions form the modified Brice questionnaire for assessing patients who may have experienced awareness under anaesthesia?

- What is the last thing you remember happening before you went to sleep?
- What is the first thing you remember on waking?
- Did you have any dreams while asleep?
- What was the worst thing about your operation?
- What was the next worst?

How can the depth of anaesthesia be monitored?

Clinical signs

- Dilated pupils.
- Sweating, lacrimation.
- Movement (unless muscle relaxants are used).
- Tachycardia and hypertension.

Specific monitoring

- Bispectral index (most commonly used).
- EEG monitoring.
- Auditory evoked potentials.
- Lower oesophageal contractility.

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5

DAY SURGERY

CASE: CHILD FOR DAY CASE SURGERY

A 6-year-old child is listed for day case adenoidectomy on your ENT list.

How is day case surgery defined in the UK?

- The patient is admitted and discharged on the same day, with day surgery as the intended management (AAGBI).

What are the age limits for paediatric patients undergoing day case surgery?

- All hospitals should have individualised guidelines based upon their available facilities, equipment and staff training and experience, as well as the child's comorbidities.
- Tertiary centres may adopt a lower limit of 44–46 weeks post-menstrual age (gestational plus chronological age).
- For ex-preterm infants, the limit is usually 60 weeks post-menstrual age if they are medically fit.

What are the benefits of day case surgery in paediatric patients?

- Decreased cost to the hospital and parents.
- Separation of day case patient pathways and duration of hospital stay, reducing the nosocomial infection risk (CP, CF, GDD) and transfer of infections from certain patient populations (classically multi-drug-resistant Pseudomonas in patients with cystic fibrosis).
- Reduced starvation time and less reliance on intravenous fluids.
- Reduced risk of cancellation (if an overnight bed is not required).
- Day surgery lends itself to protocols; protocolised day care pathways improve patient care and safety.
- Decreased child and parental anxiety.
- Less disruption for the child, particularly if they are of school age.

You review the child preoperatively. His mother says that he has had a runny nose for the last 2 days. How do you proceed?

Certain factors may preclude proceeding with surgery today, which can be determined by a thorough history, examination and basic investigations.

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History

- A full medical and anaesthetic history should be taken:
  - If the child has a history of asthma or obstructive sleep apnoea, this needs to be explored further to assess the risks and benefits of day case surgery.
  - Ask about the child's susceptibility to a runny nose: is this "normal" for the child?
- A history of the coryzal illness should be taken, focusing particularly on:
- The presence of a fever or productive cough.
- Loss of appetite, fatigue or feeling generally unwell.
- Parental concern (should not be underestimated).

Examination

- Chest auscultation: the presence of crackles or wheeze in a child is a worrying sign.
- Child looking generally unwell: listless, drowsy or dehydrated.

Investigations

- Basic observations should be done to assess for signs of infection or sepsis (fever, tachycardia, hypotension, tachypnoea).

The decision to either proceed with or cancel surgery would depend upon a combination of the above factors and surgical considerations (e.g. type of surgery – ENT). If there were any concerns the patient should be discussed with the anaesthetic and paediatric consultants.

Aside from the runny nose, the child has had no other symptoms and their observations are normal. You proceed with induction of anaesthesia and secure the airway with a laryngeal mask airway. As the surgeon begins operating you notice an inspiratory stridor. What is your immediate management?

- Alert the theatre team and surgeons and ask them to stop surgery immediately and remove any stimulus.
- Call for help early.
- Carry out an immediate assessment of the airway to include oxygen saturations, end tidal carbon dioxide, laryngeal mask airway position and adequacy of ventilation.
- Switch to the bag function if not self-ventilating and increase the inspired oxygen concentration to 100%.
- Gently attempt to manually ventilate the patient to assess airway patency and auscultate the chest.
- This patient may have developed laryngospasm. The following treatment should be carried out quickly and efficiently:
  - Apply CPAP.
  - Consider simple airway manoeuvres e.g. jaw thrust.

- Deepen anaesthesia by increasing the concentration of inhalational agent and/or administering a bolus of propofol appropriate to the patient's weight.
- Remove the laryngeal mask airway and apply CPAP using the facemask if the above measures do not show any improvement.
- Ask the anaesthetic assistant to prepare the airway trolley for intubation.
- If the patient further deteriorates despite the above interventions, administer a weight-appropriate dose of suxamethonium to induce muscle relaxation and facilitate intubation with a correctly sized endotracheal tube.
- Consider passing an orogastric or nasogastric tube to deflate the stomach following intubation.
- Reassess the chest, focusing on the risk of atelectasis and secretions, which may require re-inflation and passage of a suction catheter.
- If the symptoms have resolved and an adequate, safe airway is in situ, consider restarting surgery.

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CASE: LAPAROSCOPIC SURGERY

A 63-year-old female patient is undergoing a day case laparoscopic cholecystectomy.

What are the benefits of minimally invasive surgery?

- Reduced length of hospital stay:
  - Lower risk of hospital-acquired infections.
  - Reduced cost to the hospital.
  - Increased efficiency and patient throughput.
- Decreased risk of complications e.g. postoperative pulmonary complications and venous thromboembolism.
- Smaller wound size means less local tissue damage and reduced pain.
- Improved cosmesis.

Are there any contraindications to minimally invasive abdominal surgery?

There are no absolute contraindications, but caution is advised in the following situations.

- Severe right-sided or biventricular cardiac failure: The increased intra-abdominal pressure leads to an increase in systemic vascular resistance, which in turn could cause a decrease in the patient's cardiac output.
- Extreme hypovolaemic shock: The reduction in cardiac output may lead to severe cardiovascular instability and cardiac arrest.
- Poor surgical access.

What is your analgesic plan for this patient?

- Preoperative: 1 g paracetamol and 400 mg ibuprofen orally if not contraindicated.
- Intraoperative: fentanyl boluses titrated to effect and local anaesthetic infiltration.
- Postoperative: fentanyl/morphine boluses in recovery titrated to effect; regular oral paracetamol and ibuprofen; oral tramadol if required for rescue analgesia; and an appropriate oral dose of morphine sulphate prior to discharge.

The procedure is completed with no complications and the patient is transferred to recovery. Half an hour later you are asked to review her due to ongoing vomiting. What is your management?

- Carry out an assessment of the patient in recovery including observations and a review of the medication that the patient has received.
- Ensure adequate hydration (likely intravenous fluids if unable to tolerate oral).
- Reassure the patient and assess her nausea and pain.
- Consider further anti-emetic agents with multi-modal receptor targets and adequate management of their pain.

What are the complications of postoperative nausea and vomiting?

- Increased length of stay in recovery and/or hospital.
- Unplanned hospital admission in day case patients.
- Dehydration and electrolyte imbalance.
- Aspiration of gastric contents.
- Wound dehiscence.
- Boerhaave syndrome (very rare).

What are the criteria that should be met prior to discharge following day case surgery?

Medical factors

- Haemodynamically stable, awake, oriented and mobile.

- Able to eat and drink.
- Minimal or controlled nausea and pain.
- Wound site checked.

Social factors

- Accompanied by appropriate adult for next 24 hours.
- Access to a telephone.
- Adequate housing conditions and access to analgesia.
- Live within 30 minutes of a hospital with appropriate facilities.

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6

GENERAL, UROLOGICAL AND GYNAECOLOGICAL SURGERY

CASE: APPENDICITIS

A 42-year-old male patient is undergoing an emergency procedure for appendicitis. He is a smoker and a type 1 diabetic.

What added information would you like when approaching this case?

Patient factors

- A detailed anaesthetic history focusing on previous anaesthetics, known comorbidities and an airway assessment.
- Specific diabetic history: when it was diagnosed, the patient's compliance with treatment, and any micro and macro-vascular complications suggesting poor diabetic control. The patient's normal blood sugar level, and the levels at which they feel unwell, can also indicate their compliance.
- Smoking history: pack years; when the patient last smoked; any history of asthma/COPD; previous infections and hospital admissions; ICU admissions; and current chest symptoms e.g. sputum production, cough.
- The patient's starvation status, baseline observations, and relevant investigations should also be noted.

Surgical factors

- The urgency of surgery, the availability of the surgeon and theatre team, and the proposed surgery and approach.

The patient has a heart rate of 121 and a temperature of 39.2°C. He has a blood glucose level of 27 mmol/L with ketones present in his urine. The surgeons would like to operate as soon as possible. How do you proceed?

This is a sick, septic patient with signs of diabetic ketoacidosis, who needs urgent multidisciplinary management prior to anaesthesia and surgery. Immediate management should include the aspects listed below.

- Senior help with an ABCDE approach.
- Large bore IV access, 100% oxygen with a non-rebreathe mask and a fluid bolus.
- Early consideration of ICU team input.
- Investigations: FBC, U+E, blood culture, ABG and ketones.

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- Treatment for suspected diabetic ketoacidosis:
  - Fixed rate insulin infusion (0.1 U/kg/hour).
  - 0.9% sodium chloride fluid boluses with potassium replacement when appropriate.
  - Commence a 10% dextrose infusion when blood glucose levels fall below 14 mmol/L.
  - Monitor potassium and ketones carefully.
- Treat the underlying cause (likely appendicitis): proceed to theatre while continuing resuscitation.

In general, what are the risk factors for surgical-site infections?

Patient factors

- Comorbidities: diabetes mellitus, raised BMI, smoker, malnutrition, poor immune function.
- Smoker.
- Older age.

Surgical factors

- Length of the procedure (increased risk with a longer duration).
- Site and type of surgery.
- Soiling of the surgical wound.
- Surgical technique.
- Emergency surgery.

In this case, how can the risk of developing a postoperative surgical-site infection be reduced?

Preoperative

- Optimal blood glucose control.

Intraoperative

- Antibiotic prophylaxis within 30 minutes of induction, prior to wound incision.
- Appropriate antibiotics for the type of surgery – skin commensals and bowel contents.
- Perioperative haemostasis, optimal oxygenation, cardiovascular stability and normothermia.
- Asepsis of the theatre environment and surgical technique.

Postoperative

- Further antibiotics as indicated (often directed by the surgical team) e.g. if abdominal soiling is present.
- Good blood sugar control: consider a variable rate insulin infusion until the patient is eating and drinking when ketoacidosis is resolved.
- Keep the wound clean and dry.
- Ensure early mobilisation postoperatively.

The surgeon informs you that the appendix has ruptured and the patient has four-quadrant peritonitis. The procedure is converted into a laparotomy. What is your approach to pain management in this patient?

This patient requires a stepwise, multi-modal approach to analgesia.

- Regular paracetamol (IV until absorbing).
- NSAIDs unless contraindicated (note the patient's renal function).
- Opioids: intraoperative fentanyl boluses, postoperative oral morphine.
- Patient controlled analgesia if oral route is not suitable (fentanyl/morphine).
- Intraoperative adjuncts e.g. magnesium and ketamine bolus.
- Regional anaesthesia e.g. rectus sheath catheters.

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CASE: MINIMALLY INVASIVE OESOPHAGECTOMY

A 54-year-old male patient is undergoing a minimally invasive oesophagectomy (MIO) for malignancy. He is being reviewed in the preoperative assessment clinic.

What are the risk factors for the development of oesophageal adenocarcinoma?

- Smoking.
- Alcohol intake.
- Male.
- Poor diet.
- History of reflux or Barrett's oesophagus.
- Family history.

What aspects of this patient's preoperative assessment are key prior to his procedure?

- Assessment of comorbidities: Patients with oesophageal malignancy typically have a number of comorbidities, attributed to smoking or alcohol excess. A thorough assessment of both cardiovascular and respiratory systems is essential, as well as relevant investigations such as an echocardiogram, CPET, and lung function tests.

- Nutrition: Alcohol excess, cancer cachexia and anorexia due to treatment or dysphagia may all cause malnutrition in these patients, so assessment and nutrition supplementation are key in the perioperative period.
- Preoperative optimisation: Patients should be prepared psychologically and physically for a major procedure, the recovery period, and the risks associated with it. Local hospital programmes can facilitate a holistic and multidisciplinary approach using surgery schools and prehabilitation programmes. Smoking cessation in particular should be encouraged.

What are the challenges associated with anaesthetising this patient for his procedure?

This is a long procedure with a high risk of surgical complications in a premorbidly unfit patient.

- Abdominal and thoracic surgical insults.
- Potential requirement for one-lung ventilation depending upon the surgical approach.
- Pneumoperitoneum and thoracoscopic insufflation with the potential physiological implications.
- High risk for postoperative complications including venous thromboembolism, infection, anastomotic leak and arrhythmias.
- High analgesic requirements during the perioperative period with the associated side effects of medication.

What complications of pneumoperitoneum are more likely in patients during a MIO?

- As well as the known systemic physiological implications of pneumoperitoneum, due to creation of a passage between the peritoneum and the thoracic cavity, this patient is particularly at risk of:
  - Surgical emphysema.
  - Pneumothorax/tension pneumothorax.
  - Capnothorax.
  - Hypercapnia.
  - Hypotension due to reduced venous return and capno-pneumomediastinum.
  - Arrhythmias due to capno-pneumomediastinum and surgical irritation of the myocardium.
- A surgical chest drain is inserted electively in the perioperative period to mitigate the risks.

What is your plan for analgesia in this patient?

Preoperative

- Consideration of a thoracic epidural inserted into the patient awake.

- Paracetamol 1 g orally.
- Gabapentin 300–600 mg orally.

Intraoperative

- Intravenous paracetamol.
- Intravenous fentanyl.
- Non-opioid-based analgesic agents: consider magnesium and a ketamine bolus or infusion.
- Placement and loading of a paravertebral catheter on the operative side.

Postoperative

- Thoracic epidural infusion.
- Paravertebral catheter local anaesthetic infusion.
- Patient controlled analgesia with fentanyl/morphine.
- Regular paracetamol.

What are the benefits of an epidural catheter infusion in this patient?

- Good pain control during the perioperative period.
- Decreased stress response to surgery.
- Reduced opioid requirement with fewer respiratory and gastrointestinal side effects as a result.
- Decreased incidence of postoperative pulmonary complications.
- Lower risk of postoperative myocardial ischaemia and venous thromboembolism.
- Allows early mobilisation reducing chest complications and risk of VTE.

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CASE: LIVER TRANSPLANT

A 56-year-old male patient is undergoing a liver transplant. You are asked to review him on the ward prior to anaesthetising him.

What are the indications for a liver transplant?

- The decision for a liver transplant is made by a multidisciplinary team using the UKELD (UK Model for End Stage Liver Disease) score. This is calculated using the patient's serum bilirubin, creatinine, sodium and INR. The score is a predictor of morbidity and mortality and is used in the prioritisation of organs.

- Common indications for a liver transplant are:
  - Liver cirrhosis (viral, alcoholic and autoimmune).
  - Malignancy.
  - Acute liver failure (including due to overdose).
  - Metabolic conditions e.g. Wilson's disease.
  - Failed previous transplant.

What key features in this patient's history would you like to determine with regards to his chronic liver disease?

- The cause and duration of his liver disease.
- Conditions related to the cause of the liver disease e.g. alcohol-induced cardiomyopathy.
- The presence of any systemic complications of chronic liver disease, including:
  - Portal hypertension.
  - Splenomegaly.
  - Gastric/oesophageal varices.
  - Ischaemic heart disease/cardiomyopathy.
  - Hepatopulmonary syndrome.
  - Hepatorenal syndrome.
  - Anaemia.
  - Hepatic encephalopathy.

What is platypnea-orthodeoxia syndrome?

- This is a collection of symptoms that can occur secondary to hepatopulmonary syndrome, where the patient experiences shortness of breath and desaturation when moving from a lying to a sitting position.
- This is due to intrapulmonary arteriovenous shunting and ventilation/perfusion mismatch.

What investigations should be considered when working up a patient for a liver transplant?

- Blood tests including:
  - Full blood count (to check for anaemia and thrombocytopaenia).
  - Clotting assessment including both in vitro and laboratory (with thromboelastography).
  - Renal function (to assess for hepatorenal syndrome and electrolyte disturbances due to chronic water retention).
- Cardiac testing: ECG, echo.
- Pulmonary function tests.
- CPET for dynamic cardiorespiratory function.
- Imaging: ultrasound, abdominal MRI if there is a surgical indication.
- Psychological evaluation.

What dose adjustments for drugs during the anaesthetic should be considered for this patient?

- Propofol: The dose should be decreased due to the increased risk of severe hypotension on induction.
- Volatile anaesthetic agents: Titrate the dose carefully due to the depressant effect on the cardiovascular system. Depth of anaesthesia monitoring may be helpful. Minimal hepatic excretion with desflurane and faster wake-up may be beneficial.
- Neuromuscular blocking agents: This patient may need an increased initial dose due to the increased volume of distribution/decreased protein binding in patients with chronic liver disease but care with rocuronium (hepatic excretion), which may accumulate.
- Opioids: Doses should be titrated carefully due to the risk of accumulation. Shorter acting agents are recommended.

What are the perioperative anaesthetic concerns when anaesthetising a patient for a liver transplant?

- This is a high-risk comorbid patient for a prolonged major abdominal procedure.
- Risk of significant preoperative metabolic, clotting, renal and fluid imbalance.
- Risk of major haemorrhage due to pre-existing clotting abnormalities and a highly vascular organ.
- High incidence of metabolic acidosis and severe electrolyte disturbance during the anhepatic phase causing severe cardiovascular instability.

What are the potential postoperative complications in this patient?

Early

- Haemorrhage.
- Acute graft rejection.
- Hepatic vein/artery thrombosis.
- Sepsis.
- Renal failure.

Late

- Infection.
- Graft rejection.
- Side effects of immunosuppressant agents.
- Liver failure due to recurrence of the initial disease.

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7

HEAD, NECK, MAXILLO-FACIAL AND DENTAL SURGERY

CASE: LASER SURGERY

A 71-year-old male patient is undergoing laser surgery for excision of a laryngeal lesion. He is a smoker with severe COPD and has previously had a myocardial infarction that required stenting.

What are the principles behind laser surgery?

- "LASER" stands for light amplification by the stimulated emission of radiation. It uses a focused beam of light at a particular wavelength in order to heat and destroy specific tissues.
- Laser light is particularly effective as it is monochromatic, coherent and collimated, with high-density emission of particles over a small area.
- It consists of three basic elements: a laser medium, a high-energy source, and a mirror-containing tube or space.

Can you give some examples of medical laser types?

- Carbon dioxide (10,600 nm) – used for heating, cutting and coagulation of tissues. Commonly used in airway surgery.
- Argon (500 nm) – the energy generated causes disruption of molecular bonds. Commonly used in retinal surgery and for the treatment of birthmarks.
- Nd:YAG (1064 nm) – causes tissue ablation. Used for the treatment of gastrointestinal bleeds and tattoo removal.

What are the concerns associated with anaesthetising this patient?

Patient factors

- This is a high-risk patient with significant cardiovascular and respiratory comorbidities. He will require a thorough preoperative assessment with the relevant further investigations as directed by clinical examination e.g. ECG, echo, lung function tests and/or CPET. He may also need to stop his anti-platelet medication perioperatively, which increases the risk of stent occlusion.
- The laryngeal lesion suggests a potential for malignancy in this patient, and its associated complications e.g. malnutrition and the side effects of adjuvant treatment.
- The lesion may present with an increased risk of a difficult airway.

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Surgical factors

- Laryngeal surgery: surgical preference may necessitate a microlaryngeal tube or tubeless field, with the challenges associated with adequate oxygenation and ventilation.
- Laser surgery: poses risks to the patient and staff involved, hence adequate preparation and discussions are required preoperatively.

The surgeon would prefer a tubeless field for this procedure. What are the options for oxygenation and ventilation intraoperatively?

- Manual jet ventilation (Manujet or Sanders injector).
- High-frequency jet ventilation.
- High flow oxygen delivery via nasal cannulae (THRIVE).

The above techniques are commonly used in conjunction with a TIVA-based anaesthetic. Ideally, an oxygen concentration of <30% should be used in laser surgery to minimise the risk of an airway fire developing.

What are the complications of high-frequency jet ventilation?

- Barotrauma.
- Pneumothorax.
- Subcutaneous emphysema.
- Airway injury due to dry gas e.g. damage to epithelial cells, inflammation and oedema.
- Hypercarbia.
- Poor ventilation and hypoxaemia.
- Aspiration.

What safety aspects need to be considered with regard to laser surgery?

Patient factors

- Use a specific laser-resistant endotracheal tube (if required) with saline-filled cuffs.
- Ensure eye protection for the patient specific to the laser wavelength in use.
- Avoid nitrous oxide and aim for inspired oxygen concentration <30%.
- Avoid flammable skin prep.

Staffing factors

- Ensure the presence of a designated laser safety officer.
- Keep the theatre locked and marked clearly when laser is in use.
- Ensure eye protection for the staff specific to the laser wavelength in use.
- Ensure matt surfaces to prevent reflection of laser light.
- Ensure the minimum amount of staff required is in theatre.
- Regular staff training and servicing of equipment.

How would you manage an airway fire during laser surgery?

- This is a surgical and anaesthetic emergency.
- Alert the theatre team immediately, call for help and turn off the laser light.
- Stop oxygenating/ventilating the patient and remove the endotracheal tube if present.
- Flood the surgical field with water.
- Commence ventilation with 100% oxygen via a bag valve mask or re-intubate at this point.
- Reassess the airway (rigid bronchoscopy) and formulate a plan for further management, which may require intensive care and/or an emergency tracheostomy.

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CASE: DENTAL ABSCESS

You are reviewing a 32-year-old male patient, who has been listed for emergency incision and drainage of a dental abscess. He is a smoker and has learning difficulties.

What are your key concerns in the anaesthetic management of this patient?

- Concerns with regard to the dental abscess:
  - Possible difficult airway.
  - Local or systemic sepsis may affect the patient's haemodynamic stability under a general anaesthetic.
  - Potential for poor dentition secondary to smoking increases the risk of a difficult airway.
- Smoker: The patient is likely to have a reactive airway when anaesthetised, as well as the physiological effects of nicotine, carbon monoxide and other toxins contained within cigarettes.
- Learning difficulties: He may present as a challenging patient with limited compliance for treatment and possible consent issues.

What are the increased risks associated with smokers in the perioperative period?

- Increased incidence of adverse respiratory events including laryngospasm, bronchospasm, aspiration of gastric contents, type I respiratory failure and pulmonary oedema.

- Increased risk of postoperative pulmonary complications e.g. atelectasis, pneumonia.
- Increased risk of postoperative cardiac events.
- Higher incidence of sepsis and poor wound healing postoperatively.
- Overall increase in duration of hospital stay, morbidity and mortality.

What are the complications of an untreated dental abscess?

- Dental cyst.
- Ludwig's angina.
- Mediastinitis.
- Maxillary sinusitis.
- Complete airway obstruction.
- Orbital cellulitis.
- Cavernous sinus thrombosis.
- Osteomyelitis.
- Systemic sepsis/shock.

How would you assess this patient's airway?

In this case, patient assessment may be challenging due to the history of learning difficulties, and should ideally be done with a specialist nurse/carer or family member present to facilitate patient reassurance, and also for a collateral history if required.

History

- Duration of symptoms and speed of progression.
- Changes in speech.
- Difficulty swallowing, eating and breathing.

Examination

- Observations and general appearance for signs of respiratory distress e.g. stridor, hypoxia, drooling.
- Specific airway assessment:
  - Mouth opening.
  - Mallampati score.
  - Jaw protrusion.
  - Neck extension.
  - Ability to protrude tongue.

The patient is calm but becomes distressed on examination due to pain. He is able to open his mouth to 1 finger width, and neck extension is also limited due to severe discomfort.

What is your plan for induction of anaesthesia in this patient?

There is no right answer to this question – be able to justify and explain your answer, ensuring that it is a safe approach for induction. There are a number of choices listed below for revision; however, the examiners often want you to

pick one and describe how you would carry it out, rather than give the various options.

- A multidisciplinary team discussion regarding the concerns about the patient is essential. He is at high risk of a difficult airway. A focused discussion with the senior surgeon and anaesthetic consultant should be undertaken to establish the plan for securing the airway, and the plan in the event of a failed intubation.
- Options for anaesthesia include:
  - Intravenous induction with muscle relaxation.
  - Gas induction.
  - Rapid sequence induction.
  - Awake/asleep fibreoptic intubation.
  - Awake tracheostomy.
- The main concern in this patient is trismus, which may not relax on induction of anaesthesia. The patient appeared calm and compliant during pre-assessment, so an awake fibreoptic intubation would be a sensible choice of induction, with sedation.
- However, if the severity of learning difficulties is greater (and therefore an awake intubation would be more challenging), it is important to question whether mask ventilation is likely to be easy or difficult. In this case, the plan for intubation could be an attempt with videolaryngoscopy, followed by an asleep fibreoptic intubation as plan B.

Technique

- Ensure AAGBI monitoring is attached, the difficult airway trolley is present, and the resus trolley and emergency drugs are readily available.
- Have two senior anaesthetists present, a trained assistant and surgeons present and scrubbed in theatre.
- Ensure early oxygenation with high flow nasal oxygen delivery and appropriate positioning of the patient (head-up).
- Give sedation with remifentanil (target-controlled infusion titrated to effect) controlled by a third anaesthetist.
- Topicalise the airway being mindful of the maximum doses of local anaesthetic for the patient's weight.
- Perform the fibreoptic intubation and confirm endotracheal tube placement prior to induction of anaesthesia.

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8

MANAGEMENT OF RESPIRATORY AND CARDIAC ARREST

CASE: COLLAPSE IN A PREGNANT PATIENT

A 35-year-old female patient has collapsed on labour ward. She is 39 weeks pregnant and has been induced for reduced foetal movements. She has an epidural catheter in situ.

What are the causes of collapse in a pregnant patient?

Medical causes

- Intracranial haemorrhage.
- Aortic dissection.
- Cardiac causes: arrhythmias, cardiomyopathy and myocardial ischaemia/infarct.
- Respiratory causes: acute asthma attack and pulmonary embolus.
- Hypoglycaemia.
- Sepsis.
- Drug toxicity.

Obstetric causes

- Eclampsia.
- Amniotic fluid embolus.
- Haemorrhage.

Anaesthetic causes (commonest causes of arrest in pregnancy)

- Anaphylaxis.
- Local anaesthetic toxicity.
- High or total epidural blockade.

How would you manage this patient?

This is an anaesthetic and obstetric emergency that requires urgent and immediate management.

- Request immediate senior help with an anaesthetic and obstetric emergency or cardiac arrest call to include senior registrars/consultants, the labour ward ODP, the midwife in charge and the neonatal team.
- Rapid assessment of the patient: If there are no signs of life, commence the ALS protocol. If the patient is breathing and has a pulse, carry

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out an urgent ABCDE assessment to establish the likely cause of the collapse.
- Stop the epidural infusion if running and check the last known rate and concentration of the infusion.
- Key treatment early on includes:
  - Manual uterine displacement (or left lateral tilt if this is not possible).
  - 100% oxygen via a non-rebreathe mask.
  - Large bore IV access and a crystalloid fluid bolus.
  - Immediate specific treatment if the likely cause is identified.
- Consideration of fetal condition if the mother has not arrested.
- Consideration of the partner if present.

How does the ALS protocol differ in pregnant patients?

The key differences are listed below and focus on restoring the mother's circulation.

- Manual displacement of the uterus in pregnant patients while ensuring adequate chest compressions.
- A peri-mortem caesarean section within 5 minutes of the cardiac arrest.
- Consideration of specific obstetric causes of arrest ("BEAUCHOPS"):
  - Bleeding.
  - Embolism.
  - Anaesthetic causes.
  - Uterine atony.
  - Cardiac.
  - Hypertension.
  - Other – 4Hs and 4Ts.
  - Placental abruption.
  - Sepsis.
- Human factors: heightened emotions and anxiety/stress levels.

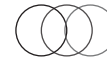
What is the incidence of amniotic fluid embolism?

- Approximately five in every 100,000 pregnancies.
- However, this varies due to the difficulty in accurate diagnosis.

What are the risk factors for development of an amniotic fluid embolus?

- It is thought that there may be an increased risk with the following:
  - Induction of labour.
  - Use of oxytocin.
  - Assisted/operative delivery.
  - Maternal age >35 years old.
  - Multiple pregnancy.
  - Eclampsia.
  - Placental abnormalities (praevia or abruption).

However, no risk factors have been clinically proven.



What is the pathophysiology of an amniotic fluid embolism developing?

- The presence of amniotic fluid or fetal cells (squames, hair and vernix) in the maternal circulation leads to either or both of the theories mentioned below.
  - "Mechanical" theory: blockage of the pulmonary vessels by the fetal cells.
  - "Immune-mediated" response: an abnormal activation of the maternal immune system in response to the presence of foreign cells, causing an anaphylactoid response.

How is a diagnosis of amniotic fluid embolism made?

- Amniotic fluid embolus is a diagnosis of exclusion, where maternal collapse occurs together with:
  - Fetal compromise.
  - Cardiac arrest, instability or arrhythmias.
  - Coagulopathy or DIC.
  - Major obstetric haemorrhage.
  - Seizures.
  - Dyspnoea.

The patient undergoes two cycles of chest compressions and a peri-mortem caesarean section is carried out. An initial diagnosis of amniotic fluid embolus is made. ROSC is obtained, and the patient is taken to theatre where closure of the abdomen takes place. What are the next steps in the management of this patient?

Patient management

- Bleeding is likely. Consider early use of uterotonics, uterine packing and a hysterectomy if necessary. Regular monitoring of clotting (including fibrinogen levels and thromboelastography) can be used to direct the administration of blood products.
- Multidisciplinary management and transfer of the patient to intensive care once stable.
- Initiate supportive care based on the patient's physiological abnormalities including lung protective ventilation and inotropes or vasopressors to maintain cardiovascular stability.
- Counselling and discussion with the patient and their family about events.

Staff management

- "Hot" and "cold" debriefing of staff and counselling or further training where appropriate.
- Escalation to supervisors within the appropriate teams.
- Document and report the case to UKOSS.

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9

NON-THEATRE

CASE: ELECTROCONVULSIVE THERAPY

A 48-year-old female patient is undergoing a course of electroconvulsive therapy (ECT) under general anaesthesia. She has a history of hypertension, for which she takes amlodipine, and asthma, for which she takes salbutamol as required. The procedure is taking place in the mental health building, which is located on a different site to the main hospital.

What are the indications for ECT?

- Drug resistant or life-threatening depression and mania.
- Acute catatonic state.
- Schizophrenia.
- Rarely: Parkinson's disease, neuroleptic malignant syndrome and delirium.

How is ECT carried out?

- Induction of an electrical current across the brain via two electrodes (either unilateral or bilateral).
- This gives rise to a tonic-clonic seizure lasting for up to 2 minutes.
- It uses a current of 0.5A, with energy of 30–45 J lasting ~1 second.
- It is administered twice a week for up to 4 weeks.

What are your main concerns when anaesthetising this patient?

Patient factors

- There may be a lack of capacity to consent for the procedure.
- The patient may be a poor historian due to her psychiatric illness.
- There is potential for decreased compliance with treatment for her comorbidities.
- The patient may be on medication for her psychiatric condition that interacts with the anaesthetic agents used.

Anaesthetic factors

- A bite block is commonly used when anaesthetising a patient for ECT, which may be challenging if the patient has a difficult airway, poor dental hygiene or active reflux.
- There are concerns associated with remote site anaesthesia including the risks to the patient and staff.

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Procedural factors

- The patient's comorbidities may affect her suitability for ECT due to the physiological changes that take place during the procedure.
- The physiological systemic changes caused by ECT may lead to further complications in the post-procedural period.

What are the contraindications for ECT?

Absolute

- Patient refusal if he/she has capacity (this is complex and should be discussed closely with their parent team).

Relative

- Myocardial infarction or cerebrovascular accident during the last 3 months.
- Cardiac failure.
- Glaucoma.
- Untreated deep vein thrombosis.
- Severe osteoporosis or an unstable fracture.
- Raised intracranial pressure.
- Presence of electrical implantable devices (modern devices may be safe).

What are the specific issues with managing a patient in a remote site?

- The potential lack of appropriate staffing e.g. ODP, senior or emergency help.
- A lack of familiar or appropriate monitoring and equipment.
- The remote site may not have an adequate recovery area.

What are the anaesthetic goals when anaesthetising a patient for ECT?

- Induction of anaesthesia with muscle relaxation and a rapid onset and offset.
- Minimise the effects of anaesthesia on the seizure threshold (in particular raising the threshold).
- Decrease the risk of potential complications associated with both ECT and general anaesthesia.

What are the main risks and complications associated with ECT?

The risks associated with ECT can be classified according to the systems that are affected.

- Airway: laryngospasm, aspiration, dental damage (minimised with the use of a bite block).
- Cardiovascular: bradycardias/asystole and myocardial infarction due to the sympathetic surge that takes place after the initial parasympathetic response.

- Neurological: memory deficits, confusion, prolonged seizure activity, intracranial haemorrhage.
- Muscular: myalgia, weakness.

The patient has been brought into the anaesthetic room and the WHO checklist is being done. However, she is now refusing to go ahead with the treatment. How do you proceed?

- Do not proceed with the general anaesthetic.
- Discuss the case with the attending psychiatrist and consultant anaesthetist on duty.
- Assessment of capacity is essential; if the patient is found to have capacity, this treatment cannot be given against her will.
- A second opinion needs to be sought. The treatment needs to be deemed life-saving or necessary to be given if the patient refuses treatment.
- However, emergency treatment can be given without consent or a second opinion.

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10

ORTHOPAEDIC SURGERY

CASE: TOURNIQUET USE DURING ORTHOPAEDIC SURGERY

A 29-year-old male patient is undergoing urgent orthopaedic surgery to his distal upper limb for tendon damage due to trauma. He has a history of sickle cell disease, but no other medical conditions. The surgeons require the use of a tourniquet.

What are the indications for tourniquet use?

- To provide a bloodless, clear surgical field for distal limb procedures and decrease the risk of perioperative bleeding.
- For intravenous regional anaesthesia (Bier's block).
- In pre-hospital medicine for patients with a catastrophic major haemorrhage.
- Intravenous regional sympathectomy in the management of complex regional pain syndromes.
- Isolated limb perfusion in the management of localised malignancy.

What are the systemic effects of tourniquet use in limb surgery?

Cardiovascular

- Overall increase in systemic vascular resistance after tourniquet application.
- Increased effective blood volume in the central circulation with a rise in the central venous and systemic arterial pressures seen as a result.
- An increase in heart rate and blood pressure is seen after 30–60 minutes which persists until deflation of the tourniquet. This phenomenon is referred to as "tourniquet pain".

Respiratory

- No effect on tourniquet inflation.
- Tourniquet deflation causes a sudden increase in end tidal carbon dioxide due to the release of end products of metabolism in the blood distal to the tourniquet.

Neurological

- No systemic effects with inflation, but on deflation the increased $PaCO_2$ leads to an increase in cerebral blood flow through vasodilation.
- A conduction block is seen in both motor and sensory nerves local to the tourniquet, which is reversed on tourniquet deflation.

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Haematological

- Tourniquet inflation leads to a hypercoagulable state secondary to platelet aggregation, although the relationship between coagulation and tourniquet use is complicated and there may be a short period of increased thrombolytic activity on tourniquet deflation.

Other

- An increase in temperature is seen after inflation as heat is conserved in a smaller space, which is reversed on tourniquet deflation due to mixing of blood in the two compartments.
- After 1–2 hours of limb ischaemia, there is a modest increase in arterial plasma potassium and lactate concentrations after tourniquet release.
- Local ischaemic changes and anaerobic metabolism in muscular cells also take place following a period of tourniquet inflation.

What is post-tourniquet syndrome?

- Post-tourniquet syndrome occurs in patients who have had a prolonged tourniquet time. It is the most common morbidity associated with tourniquet use.
- It is caused by a combined effect of muscle ischaemia, oedema and microvascular congestion.
- Symptoms include limb stiffness, generalised weakness and numbness, which is subjective. Paralysis is not a feature. The limb may be swollen and pale.
- It can last from days to weeks, and is thought to occur due to the effects of localised oedema and ischaemic changes that take place due to prolonged tourniquet inflation.

What are the concerns with tourniquet use in this patient? How do you proceed?

- Sickle cell disease is a genetic haemoglobinopathy that causes deformation and sickling of red blood cells under conditions such as hypoxia and stress. This is likely to occur in the residual blood distal to the inflated tourniquet.
- There is no absolute contraindication to the use of tourniquets in patients with sickle cell disease. A senior-led multidisciplinary discussion should be undertaken where the risk of complications relating to tourniquet use should be weighed against the benefits of reduced blood loss and improved operating conditions.

The surgeons proceed with surgery using a tourniquet. How can this patient be optimised during the perioperative period?

Patients with sickle cell disease are complex to manage perioperatively. They may have pathology in multiple body systems including congestive cardiac

failure, pulmonary hypertension, strokes and chronic kidney disease. They may suffer from chronic pain and intolerance to opioid analgesia. They may be severely anaemic. As a result, optimisation will be dependent on the course of the disease. As this operation is urgent, optimisation will be time-limited. The focus should be on preventing their haemoglobin sickling and causing a vaso-occlusive crisis.

Preoperative

- Maintain adequate hydration through intravenous and oral fluids with minimal fasting.
- Preoperative chest physiotherapy and pulmonary function testing may be indicated in patients with associated lung disease.
- Investigations should include haemoglobin and a group and save (with a cross match if severely anaemic).
- Discussions with haematology regarding transfusion may be required as management is complicated. A guiding principle is to reduce the concentration of HbS and achieve adequate haemoglobin for oxygen delivery, while avoiding the sequelae of over-transfusion.

Intraoperative

- Maintenance of optimal conditions including oxygenation and normocapnia. An arterial line may be necessary.
- Strict temperature monitoring and control.
- Optimisation of analgesia with multimodal techniques.
- Minimise tourniquet time and use the lowest acceptable inflation pressure.
- Consider regional anaesthesia. The vasodilation may reduce the risk of a vaso-occlusive crisis postoperatively and also reduce reliance on opioid analgesia in a patient that may be tolerant.

Postoperative

- Close monitoring on a high dependency unit.
- Continue adequate oxygenation, warming, analgesia and hydration.
- Appropriate venous thromboembolism prophylaxis.

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CASE: REVISION HIP SURGERY

A 76-year-old gentleman is undergoing revision of a total hip replacement due to loosening of his primary replacement and pain. He has a history of hypertension, for which he takes captopril, mild aortic stenosis, a hiatus hernia and is a smoker.

What are the key concerns in the management of this patient?

Surgical

- Compared to primary hip surgery, revision surgery increases the risks of the following:
  - Intraoperative complication rate, which includes perforation of the femur and intraoperative fracture.
  - Increased operative time, blood loss and surgical complexity.
  - Postoperative infection.
  - Poor wound healing.
  - Venous thromboembolism.

Anaesthetic

- Prolonged surgical time leads to an increased risk to the patient due to:
  - Prolonged mechanical ventilation if a general anaesthetic is used and increased incidence of postoperative pulmonary complications.
  - Higher risk for perioperative hypothermia.

Patient

- Advanced age, smoking status and comorbidities may compound some of the risks mentioned above.

What are the risk factors for the development of a postoperative joint infection?

Patient factors

- Diabetes mellitus.
- High BMI.
- Smoker.
- Malnutrition.
- Immune suppression.
- Pre-existing infection relating to:
  - The overlying skin (e.g. cellulitis).
  - The joint prosthesis.
  - An unrelated cause contributing to a bacteraemia (e.g. UTI/pneumonia).

Surgical factors

- Prolonged procedure.
- Lack of laminar flow ventilation.

- Postoperative haemorrhage.
- Catheter insertion.

How can this patient be optimised prior to surgery?

This optimisation process should start with a thorough preoperative history, examination and review of recent investigations to explore the relevant comorbidities. This will guide further investigation and identify correctable pathology to treat. The interventions most pertinent to this patient include the following.

- Encourage the patient to stop smoking and engage in local services.
- Refer for lung function tests if the patient is a long-term smoker to determine the presence and extent of lung disease.
- Review a 12-lead ECG and recent echocardiogram to determine the severity of aortic stenosis and associated cardiac pathology.
- Ensure that the patient's blood pressure is appropriately treated with targets that take into account the aortic valve pressure gradient.
- Investigate and correct common treatable pathology including:
  - Anaemia.
  - Electrolyte imbalance.
  - Blood sugar control in diabetes.
  - Coagulopathy.
- Sign-post to weight loss services if applicable to the patient.
- MRSA/MSSA decolonisation.
- Provide preoperative nutritional supplements.
- Educate the patient through local services to encourage adequate nutrition, exercise and reduced alcohol intake (prehabilitation).

How would you anaesthetise this patient?

There is no right answer to this question – just be able to justify your answer as each technique has risks and benefits that should be taken into account when making your decision.

Preoperative

- Preoperative management should focus on identifying risk factors as identified above.
- The patient should have a valid group and save or have blood cross-matched if the risk of bleeding is sufficiently high. They should be consented for blood transfusion.
- The supervising consultant anaesthetist should be informed of the case due to the potential complications that may arise.
- Premedication, for example, with paracetamol, ranitidine and metoclopramide. The patient's normal dose of captopril should be omitted for 48 hours.
- Ensure availability of a higher care bed, according to the local protocols.

- Ensure AAGBI monitoring, resus equipment, difficult airway trolley and emergency drugs are readily available.

Intraoperative

General anaesthesia is indicated if this operation is likely to be prolonged or have a high potential for haemorrhage. If the operation is likely to be shorter with a lower bleeding risk (e.g. a straightforward acetabular cup revision compared to an operation where both components are loosened and uncemented in osteolytic bone), then a spinal anaesthetic or combined spinal-epidural could be considered. However, this is very dependent on local experience/expertise, so communication with the surgeon is vital.

Without the benefit of an echocardiogram to quantify the aortic stenosis, and without specific reassurance from the surgical team about the nature of the operation, the most appropriate choice of anaesthetic for this case would be to perform a general anaesthetic. The hiatus hernia demands a rapid sequence induction. As the procedure has the potential to be long, choose maintenance drugs with a quicker offset such as propofol or sevoflurane. A particular challenge for this anaesthetic will be to reduce blood loss and maintain stable haemodynamics.

- Insert at least one large bore intravenous cannula.
- Site invasive blood pressure monitoring if blood loss is likely to be excessive, or if there is evidence of moderate/severe aortic stenosis.
- Proactive management of blood pressure using crystalloid fluids, a vasopressor such as metaraminol and targeted blood products.
- Administer tranexamic acid.
- Actively warm the patient.
- Discuss intraoperative cell salvage with the surgical team.
- Discuss the timing of antibiotics with the surgeon as swabs may need to be taken to send to microbiology prior to administration.
- Analgesia should be multi-modal. A nerve block, such as a fascia iliaca block, should be considered to help with postoperative pain.

Postoperative

- Close monitoring on a suitable ward, with a low threshold for critical care admission if there is significant blood loss.
- Continue adequate oxygenation, warming, analgesia and hydration.
- Appropriate venous thromboembolism (mechanical and chemical).

What are the options for analgesia in this patient?

- Simple analgesia: paracetamol. NSAIDs are contraindicated in this case due to the patient's age, hypertension, ACE inhibitor and bleeding risk, which together would increase the risk of an acute kidney injury.
- Opioid-based analgesia: intravenous morphine/fentanyl perioperatively; oxycodone, oramorph and tramadol postoperatively. Patient-controlled analgesia (PCA) may be necessary postoperatively.

- Opioid sparing agents such as ketamine, lidocaine infusion, magnesium and gabapentin.
- Regional anaesthesia: The choice will depend on the surgical approach and anaesthetic expertise. Options include a fascia iliaca block, a pericapsular nerve group (PENG) block, local anaesthetic field block or a wound catheter.
- Neuraxial anaesthesia: single shot spinal (with intrathecal opioids) and lumbar epidural infusion/patient-controlled epidural analgesia.

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CASE: SCOLIOSIS SURGERY

A 13-year-old male patient is undergoing spinal surgery for correction of his scoliosis.

What is scoliosis?

- Scoliosis is a condition defined by lateral curvature of the spine with varying degrees of rotation. There may be associated deformity of the rib cage.
- Scoliosis involves other body systems, principally the respiratory and cardiovascular systems.

What are the potential causes of scoliosis in this patient?

- Idiopathic (about 70% of patients).
- Congenital.
- Secondary to neuromuscular disorders e.g. cerebral palsy, muscular dystrophy.

What are the complications and implications for anaesthesia in patients with an uncorrected scoliosis?

Airway

- Airway difficulties may occur where the scoliosis involves the upper thoracic or cervical spine.
- Devices such as halo traction may make intubation more challenging.

Respiratory

- Restrictive lung disease and poor pulmonary function due to limited lung and diaphragmatic movement. This may result in alveolar

hypoventilation, ventilation-perfusion mismatch, increased dead-space and a reduced total lung capacity.
- In patients with neuromuscular disorders, patients may also have further respiratory muscle dysfunction.
- The respiratory complications outlined above necessitate a thorough history, examination and appropriate investigations preoperatively (including pulmonary function tests) to assess the disease severity and the ability of the patient to tolerate a general anaesthetic. Patients may require preoperative chest physiotherapy.
- Patients with increased curvature and more significant pulmonary sequelae are likely to need a longer period of ventilation postoperatively.
- Long-term restrictive lung dysfunction may lead to a chronic type II respiratory failure and right-sided cardiac disease.

Cardiac

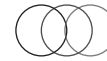
- The primary cause of cardiac dysfunction in scoliosis patients occurs secondary to severe lung disease, but patients with congenital or neuromuscular disorders may also present with structural cardiac defects or cardiomyopathies.
- Severe curvature may distort the mediastinum causing a restrictive pericarditis, impaired ventricular filling and a fixed cardiac output state.
- The preoperative anaesthetic assessment should include a detailed cardiac history and examination, and further investigations as directed by the initial findings.

Other

- Patients with scoliosis secondary to congenital or neuromuscular disorders may also have significant comorbidities including cognitive dysfunction, learning difficulties, generalised muscular spasticity or atrophy, and bowel dysfunction. These need to be considered when formulating the anaesthetic plan.

The patient in question has idiopathic scoliosis, mild restrictive lung disease and no signs of right-sided cardiac failure. What are your key concerns when anaesthetising this patient?

- *Positioning:* This depends on whether a posterior or anterior approach is used. In the posterior approach, the prone position will be employed, requiring satisfactory patient padding and support to prevent pressure sores. A reinforced endotracheal tube will need to be correctly checked and secured, and the eyes should also be well protected with padding and goggles. With an anterior approach, the patient will be supine with the spinae accessed via a thoracotomy.
- *Blood loss:* Anaemia should be corrected prior to surgery. There is a known risk of major haemorrhage in spinal surgery, so tranexamic



acid and cell salvage are routinely used. Large bore intravenous access should be easily accessible. Increases in intra-abdominal pressure should be minimised due to the risk of epidural vein engorgement contributing to additional blood loss.

- *Intraoperative monitoring:* AAGBI monitoring should be in place together with invasive blood pressure, central venous pressure and cardiac output monitoring. EEG monitoring should be used where a TIVA anaesthetic technique is employed. Specialist nerve monitoring is also essential to identify and prevent damage to the spinal cord – both somatosensory and motor-evoked potentials are commonly performed.
- *Duration of surgery:* Prolonged procedural time means that temperature monitoring and warming are essential, particularly given the risk of blood loss and patient exposure.

How do anaesthetic agents affect neuromuscular monitoring?

- Volatile agents (at >0.5 MAC) affect both somatosensory and motor-evoked potentials.
- Neuromuscular blocking agents affect motor-evoked potentials.
- Propofol had a dose-dependent increase in effect on motor-evoked potentials.
- Opioid agents have no effect on either somatosensory or motor-evoked potentials.

What is the wake-up test?

- The wake-up test involves lightening anaesthesia to the point at which the patient is able to respond to commands, and this procedure is done after spinal rod placement to ensure that nerve function has been preserved.
- It is not routine, particularly with the use of neuromuscular monitoring.

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11

PERIOPERATIVE MEDICINE

CASE: DIABETES MELLITUS

A 35-year-old female patient has been listed for an urgent laparoscopic cholecystectomy for ascending cholangitis. She has a history of type I diabetes mellitus but no other medical problems. She has a heart rate of 128, a blood pressure of 83/67 and has been vomiting.

What are your key concerns when assessing this patient on the ward?

- Observations indicate that she may be severely dehydrated and/or septic so will need urgent assessment and resuscitation prior to an anaesthetic.
- Diabetic ketoacidosis may also be present which requires investigation and rapid intervention.
- The history of vomiting increases the aspiration risk at induction (necessitating a rapid sequence induction).
- The patient is a type I diabetic and will need a thorough medical history including the duration, treatment and blood glucose control as well as any associated micro or macro-vascular complications.
- Given the history of cholangitis and vomiting, she may require an intravenous insulin and dextrose infusion perioperatively.

Why is this patient at higher risk of complications during the perioperative period?

- Perioperative sepsis is an indicator for increased morbidity, mortality and postoperative complications.
- Any micro or macro-vascular complications of diabetes, particularly cardiac or renal comorbidities, increase the risk of both medical and surgical complications during the perioperative period.
- This patient is at high risk of hyper or hypoglycaemia due to the lack of oral intake, infection and iatrogenic causes, such as incorrect or unsuitable insulin prescribing or administration.
- Patients with pre-existing poor glucose control or inappropriate perioperative glucose control are at higher risk of surgical-site infections and poor wound healing.
- Patients with diabetes are more prone to electrolyte imbalance, particularly if being treated for diabetic ketoacidosis.

When you see the patient on the ward, her blood glucose level is 32 mmol/L. How do you proceed?

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Initial approach

- Rapid ABCDE assessment and escalation to senior surgical and medical teams and intensive care if appropriate.
- Ensure large-bore intravenous access.
- Early investigations should include an arterial blood gas (with lactate), blood ketone level, full set of baseline bloods, septic screen and bedside observations.
- Multidisciplinary discussion regarding urgency of surgery and treatment of likely diabetic ketoacidosis.

Initial treatment

- Apply 100% oxygen via a non-rebreathe mask.
- Recognition and treatment of suspected sepsis should focus on the "sepsis six":
  - Intravenous antibiotics.
  - Fluid resuscitation.
  - Urinary catheter.
  - Blood cultures.
  - Lactate.
  - Oxygen.
- Follow the local guidelines for management of diabetic ketoacidosis, to include:
  - Fixed rate insulin infusion (0.1 U/kg/hour).
  - Resuscitative fluids – regimen of 0.9% sodium chloride (± potassium chloride). The patient may need several litres of fluid and should be continually reassessed.
  - 10% dextrose (or similar) should be considered when the capillary blood glucose level has decreased to a suitable level.
- Capillary blood glucose and ketones should be monitored frequently.
- Strict fluid balance charting.
- Treatment of the underlying cause is essential but should be discussed with seniors owing to the complex nature of this case. Postoperative high dependency or intensive care and early assessment by the inpatient diabetic team should be considered.

The patient undergoes a laparoscopic cholecystectomy the following day. What is your plan for postoperative analgesia?

- Intravenous fentanyl boluses in recovery titrated to effect.
- Regular postoperative co-codamol with tramadol as rescue analgesia.
- Judicious use of NSAIDs due to risk of acute kidney injury.
- Buccal prochlorperazine.
- Opioid sparing agents if possible to minimise gastrointestinal side effects and return the patient to oral intake and their regular insulin therapy soon as possible.

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CASE: SCLERODERMA

A 45-year-old female is listed for an urgent fixation of her ankle on the trauma list. She has a history of scleroderma and has never had an anaesthetic. You are asked to review her prior to her procedure.

What is scleroderma?

- Autoimmune, multi-system disease that is caused by an increase in collagen production.
- Typically occurs in females between the age of 30 and 50 years.
- Can be either limited or diffuse with various effects on physiological systems.
- "CREST" syndrome is limited: calcinosis, Raynaud's, oesophageal dysmotility, sclerodactyly and telangiectasia.
- Diffuse scleroderma:
  - Pulmonary: interstitial fibrosis and pulmonary hypertension.
  - Cardiac: pericarditis and pericardial effusion.
  - Renal: glomerulosclerosis.
  - Gastrointestinal: dysmotility and malabsorption.
  - Musculoskeletal: joint contractures and arthritis.

What are the main concerns when anaesthetising this patient?

Airway

- This patient is high risk for a difficult airway due to facial deformity and contractures in severe disease. A suitable plan should be made given findings of a thorough airway assessment.
- Increased potential for aspiration due to reflux secondary to oesophageal dysmotility that should be incorporated into the airway plan.

Respiratory

- Interstitial fibrosis and restrictive lung disease could make ventilation challenging.
- Pulmonary hypertension increases the risk of perioperative morbidity and mortality.

Cardiovascular

- Cardiac involvement can include hypertension, left-sided cardiac failure, arrhythmias and pulmonary hypertension. Careful assessment

with a low threshold for investigations and discussion with the multidisciplinary team are key when pre-assessing this patient.
- Susceptible to vasospasm if hypothermic. Meticulous temperature monitoring and warming are essential.

General

- Joint contractures can lead to difficult patient positioning. Consider positioning the patient in the correct surgical position while awake so as not to move them once anaesthetised.
- Venous access may be challenging due to scleroderma skin changes.
- Regional anaesthesia may be favourable but challenging due to musculoskeletal degeneration.
- Consider postoperative high dependency or intensive care due to challenging management in a high-risk patient.
- Potential for drug interactions if the patient is on regular treatment.

The patient takes 10 mg prednisolone daily. How should this be managed during the perioperative period?

- Due to the risk of adrenal insufficiency, steroid replacement is necessary:
  - 100 mg intravenous hydrocortisone at induction followed by an infusion of 200 mg hydrocortisone over 24 hours.
  - Continue the hydrocortisone infusion postoperatively if the patient remains nil by mouth.
  - When the patient resumes eating and drinking, give a double dose of hydrocortisone (or equivalent) for up to a week after surgery.

The patient states that she has been feeling increasingly short of breath during the last few weeks. How do you proceed?

- Thorough history focusing on the patient's associated symptoms including chest pain, limitations on daily activity, ankle swelling, syncope, fatigue and triggers.
- Patient examination (cardiovascular and respiratory).
- Ensure a low threshold for investigations due to the risk of bilateral cardiac involvement and pulmonary hypertension, to include:
  - ECG (essential).
  - Echo.
  - Chest X-ray.
- Early discussion with multidisciplinary team regarding the timing of surgery, the implications of the patient's comorbidities on surgery and an anaesthetic, and perioperative management. Senior clinician involvement is essential due to complexity of this patient.

Surgery is delayed and the patient's echocardiogram shows raised pulmonary arterial pressures. What are the physiological goals when anaesthetising a patient with pulmonary hypertension?

- Avoid increases in pulmonary vascular resistance through prevention of hypoxia, hypercapnia, hypothermia, acidosis and pain.
- Maintain coronary perfusion pressures by monitoring and preserving cardiac output and systemic vascular resistance. Blood loss should be corrected rapidly.
- Minimise arrhythmias and maintain normal heart rate and regularity.
- Ensure close and invasive monitoring of blood pressure and cardiac output.

What is your choice for induction of anaesthesia in this patient?

Clearly, this is a very high-risk patient that requires senior support and a careful multidisciplinary plan as discussed above. Your plan should be safe and well thought out.

- The options for anaesthesia include both general and regional techniques. Given the patient's cardiovascular and respiratory comorbidities, a regional technique is favourable, though may be challenging secondary to the musculoskeletal complications of disease.
- Ensure patient consent, AAGBI monitoring (with intra-arterial blood pressure monitoring), resus equipment, difficult airway trolley and emergency drugs readily available, including vasopressor and inotropic support.
- An experienced senior anaesthetist should be present.
- Ensure careful patient positioning and padding of pressure points.
- Carry out a regional anaesthetic technique: a spinal with a popliteal nerve block/catheter.

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CASE: ANAEMIA

A 61-year-old female is undergoing major abdominal surgery for ovarian malignancy. She has a history of rheumatoid arthritis but is otherwise well. Her preoperative assessment blood test results show a haemoglobin level of 9.0 g/dL.

How do we define anaemia clinically?

- The World Health Organisation has classified anaemia as having a haemoglobin level of <13.0 g/dL (males) and 12.0 g/dL (non-pregnant females).

What are the common causes of anaemia?

- Macrocytic anaemia (MCV >96 fl):
  - Vitamin B12/folate deficiency.
  - Alcoholic liver disease.
  - Drugs e.g. phenytoin.
  - Myelodysplasia.
- Normocytic anaemia (normal MCV):
  - Acute haemorrhage.
  - Anaemia of chronic disease.
  - Chronic renal failure.
  - Pregnancy.
  - Hypothyroidism.
- Microcytic anaemia (MCV <80 fl):
  - Iron deficiency.
  - Thalassaemia.
  - Sideroblastic anaemia.

Likely causes of anaemia in the above patient are anaemia of chronic disease (rheumatoid arthritis); possible chronic internal haemorrhage due to malignancy, and side effects of drugs used in the management of both conditions.

What are the risks associated with anaemia during the perioperative period?

- Increased duration of hospital stay.
- Higher incidence of postoperative intensive care requirement.
- Increased postoperative complications e.g. venous thromboembolism, wound infections and sepsis.
- Increased likelihood of need for perioperative blood transfusion, and subsequent risks.
- Overall increase in morbidity and mortality.

What is meant by the term "blood management"?

- Identification and multidisciplinary assessment of patients at risk of perioperative anaemia.
- Strategy that encompasses guidelines and measures that can be used to manage these patients optimally before, during and after their procedure.

How can this patient be optimised prior to surgery with regard to her low haemoglobin?

- Identify likely causes of anaemia through investigations (haematinics and red cell morphology).
- Consider agents to improve her haemoglobin level:
  - Oral or intravenous iron supplementation (if iron-deficient).
  - Erythropoietin.

- Thorough medical and drug history to detect modifiable risk factors for bleeding.
- Optimise the patient's physiological reserve through optimal nutrition, exercise and lifestyle changes.
- Planning for surgery:
  - Senior led care.
  - Minimally invasive procedure if possible.
  - Strict surgical haemostasis intraoperatively.
  - Cell salvage if appropriate.

The estimated blood loss from the procedure is 800 mL, and the patient's postoperative haemoglobin is 7.6 g/dL. She is given one unit of packed red cells in recovery. Five minutes into the transfusion, she feels hot, sweaty and generally unwell. How you do proceed?

- Immediate review and early escalation to seniors if appropriate.
- Stop the blood transfusion while undergoing a rapid ABCDE assessment of the patient to ascertain the cause of her symptoms.
- Check that the packed red cells match the patient's name and ID band and blood group as per local guidelines.
- Maintain patency of cannula with crystalloid.
- Consider paracetamol if pyrexial.
- Review of notes and observations since transfer into recovery.
- Contact blood lab/consultant haematologist.
- Return the given blood to the lab.
- Blood tests including full blood count, clotting and group and save.
- Conduct other relevant investigations and escalate to appropriate individuals based on initial assessment of the patient.
- Potential causes of the patient's symptoms include:
  - Non-haemolytic febrile transfusion reaction.
  - Allergic transfusion reaction.
  - Haemolytic transfusion reaction.
  - Conditions unrelated to transfusion e.g. sepsis, anaphylaxis, and cardiac event.

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CASE: MAJOR ABDOMINAL SURGERY

A 65-year-old gentleman is being reviewed in the preoperative anaesthetic clinic prior to admission for a robotic anterior resection for malignancy in 6 weeks. He has a history of hypertension for which he takes captopril and is a smoker. He has previously had surgery for an inguinal hernia.

What do you understand by the term "prehabilitation"?

- An evidenced-based approach targeting high-risk patients, which encompasses medical and lifestyle changes to increase a patient's physiological reserve preoperatively.
- The goal is to decrease the risk of postoperative complications and enhance the quality of recovery postoperatively, particularly after a major operation.

How would you counsel this patient prior to his procedure?

Prehabilitation

- Enrol the patient onto a local multidisciplinary prehabilitation programme and explain the importance of improvements that can be made; use surgery/malignancy as a "teachable moment" for the patient to make lifestyle changes.
- Explain the importance of nutrition and refer to the dietician if appropriate; the patient may have a poor diet due to malignancy, side effects of medication or pre-existing medical conditions.
- Smoking and alcohol cessation can have a dramatic effect on perioperative risk, and counselling should be offered to the patient for both if appropriate.
- Physical exercise is key preoperatively to increase perioperative physiological reserve.
- Psychologist input may help manage these interventions and offer tools for mood assessment throughout.

Risk

- The risks of major surgery and anaesthesia should be discussed with the patient, including the specific risks associated with particular procedures and the potential postoperative complications and expected recovery timeline.
- Risk stratification can be carried out using a number of different tools to quantify probabilities for the patient but not used as the sole method of explanation.

Perioperative anaesthetic management

- Options for anaesthesia and analgesia should be discussed with the patient, as well as techniques that may be used to minimise the perioperative risk.

- This includes optimisation of physiological parameters, a multimodal analgesia regimen, early postoperative mobilisation and physiotherapy and senior led care.

How can this patient's risk be quantified preoperatively?

Scoring systems

- ASA (American Society of Anaesthesiologists).
- Lee's Revised Cardiac Index (assesses risk of cardiac complications after a non-cardiac procedure).
- POSSUM score (Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity).
- SORT (Surgical outcome risk tool).

Functional assessment

- CPET.

How can this patient's CPET results be used to direct perioperative management?

- Preoperative risk quantification and stratification using an assessment of cardiac and pulmonary function in unison.
- To facilitate shared decision making between the patient and multidisciplinary team.
- To establish a focus for prehabilitation and medical optimisation.
- To allow direction of intraoperative management based on risk.

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CASE: VASCULAR ACCESS SURGERY

A 59-year-old female patient is listed for creation of an arterio-venous fistula for pre-emptive renal replacement therapy. She has a history of hypertension, type 2 diabetes mellitus and a raised BMI.

What are the most common causes of chronic kidney disease?

- Diabetes mellitus.
- Glomerulonephritides.
- Pyelonephritis.
- Chronic hypertension.

- Polycystic kidney disease.
- Renal vascular disease.

What are the options for renal replacement therapy in patients with end-stage renal failure?

- Continuous ambulatory peritoneal dialysis.
- Haemodialysis.
- Renal transplant.

What is disequilibrium syndrome?

- Disequilibrium syndrome is a collection of symptoms that may occur in new haemodialysis patients, including headache, visual changes, nausea and vomiting, confusion, agitation, seizures and coma.
- It is thought to occur due to rapid changes in serum urea and electrolyte levels, which may lead to cerebral oedema and rapid signs of neurological changes.
- New dialysis patients should be carefully assessed and monitored, and their treatment protocols increased gradually to avoid the development of disequilibrium syndrome.

You are asked to review this patient prior to her procedure. What are the key aspects in her history that will determine perioperative management?

Renal disease

- The duration and any previous treatment should be determined, including any earlier procedures for renal replacement therapy. If the patient has had a renal transplant, her immunosuppressant status should be noted and discussed with the renal team prior to her anaesthetic.
- The cause of the patient's renal disease should be established as it may impact on care during the perioperative period.

Comorbidities

- A history of hypertension may predispose the patient to ischaemic heart disease or peripheral vascular disease. A thorough cardiac history should be taken including any ischaemic events or symptoms suggestive of cardiac failure.
- Given the history of type 2 diabetes mellitus and end-stage renal failure, both micro- and macro-vascular complications are likely. These should be explored, together with current compliance with treatment and blood sugar control.
- The patient's weight will have both physiological and practical implications during the perioperative period, due to the associated comorbidities, anaesthetic procedural challenges and the risk of postoperative complications.
- Renal dysfunction will predispose her to electrolyte imbalance, clotting dysfunction and a normocytic chronic anaemia that will need to be checked prior to an anaesthetic.

Drug history

- Anti-hypertensive medications such as ACE inhibitors may need to be stopped prior to her procedure to minimise the risk of significant perioperative hypotension.
- Hypoglycaemic agents may need regimens tailored during the perioperative period.
- Immunosuppressive agents should be continued.

How would you anaesthetise this patient?

There is no right answer to this question – be able to justify and explain your answer, ensuring that it is a safe approach for induction.

- Ensure AAGBI monitoring, resus equipment, difficult airway trolley and emergency drugs are readily available.
- Given the patient's comorbidities and the type of surgery, a regional anaesthetic would minimise the risks associated with a general anaesthetic. In addition, a nerve block is often favoured by the surgeons due to its vasodilatory effects improving fistula patency during the perioperative period.
- A regional nerve block also avoids the challenges of agent choice and dosage for anaesthesia and analgesia, which need to be modified in patients with end-stage renal failure.
- Sedation can also be offered to the patient, carefully titrated to avoid the risk of respiratory depression and airway obstruction.

You carry out an axillary nerve block. 40 minutes into the procedure, the patient is complaining of discomfort. How do you proceed?

- Alert the surgeons and ask them to stop as soon as feasible.
- Determine the location and type (e.g. pain and pressure) of discomfort.
- If the discomfort is felt in the arm, ask the surgeons to inject local anaesthetic at the site of discomfort.
- Administer intravenous analgesia, cautious of respiratory depression with opiates.
- If discomfort persists at all stages, offer a general anaesthetic; risks to be discussed with the patient and a senior alerted for help with induction if necessary.
- Document actions and assess the patient in recovery and on the ward following their procedure.

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CASE: NECK OF FEMUR FRACTURE

An 83-year-old female has been admitted with a proximal femoral fracture and has been listed for an urgent hemi-arthroplasty on the trauma list. She has a history of hypertension and previous breast cancer. She was confused in the emergency department.

What are the key concerns for the perioperative management of this patient?

This is a frail, elderly patient with a significant bony injury and a high risk of perioperative mortality, which increases significantly with the length of delay to surgical repair.

Comorbidities

- Cardiac history: The patient has a history of hypertension, which requires further investigation due to the possibility of ischaemic heart disease or previous cardiac events. If treated with ACE inhibitors, these should be stopped as soon as possible prior to surgery to avoid the risk of significant perioperative hypotension but should not be a reason to delay surgery.
- History of breast cancer creates the possibility of a pathological fracture, particularly if recently diagnosed.
- Confusion in the emergency department could indicate a diagnosis of either delirium or dementia, both of which should be managed accordingly during the perioperative period. Capacity to consent for the procedure will need consideration.

Frailty

- Multidisciplinary/specialist orthogeriatric team should do a frailty assessment as it increases the risk of perioperative complications.
- Cause of fracture should be determined – falls can indicate frailty and underlying conditions should be identified and managed appropriately to reduce falls risk.

Neck of femur fracture

- High-risk procedure in high-risk patient; local or national guidelines should direct patient care.
- Surgery should take place within 48 hours of admission into hospital, unless patient presents with reversible and time critical conditions e.g. severe anaemia, electrolyte disturbance and uncontrolled diabetes.
- Multidisciplinary, senior perioperative management is key for safe and optimal management of this patient.

Anaesthetic management

- A thorough preoperative history, examination and investigations are crucial but should not delay surgery within the required time.

- Anaesthetic technique should be directed by patient assessment and importantly management should focus on minimising physiological disturbances during the perioperative period.
- Neuraxial blockade should be used where appropriate with calculated risk/benefit balance for an individual patient.
- The evidence supporting regional over general anaesthesia is limited, but dictates careful and judicious use of any anaesthetic or analgesic agents. However, there is an overall increase in mortality with the use of heavy sedation/general anaesthesia together with a regional technique.

Analgesia

- A multimodal approach to analgesia is key in patients with a proximal hip fracture, avoiding the use of NSAIDs and high doses of opioid-based medications.
- Regional techniques should be used where appropriate but should not limit physiotherapy postoperatively.

What is frailty?

- Frailty is described as a group of symptoms that suggest a decline in systemic physiological reserve and function. Typical features of frailty include:
  - Loss of muscle mass (sarcopenia).
  - Generalised weakness.
  - Slow gait.
  - Decreased activity levels.

How can frailty be assessed?

There are a number of frailty scoring systems that can be used, for example:

- Rockwood Frailty Index – detailed scoring system including assessment of comorbidities, mental health, cognition and functional status.
- Edmonton Frail Scale – patients are scored based on their medication, balance, mobility and cognition.
- Clinical Frailty Scale – patients are scored based on their comorbidities and vulnerability.

What are the challenges associated with pain management in elderly patients?

- Assessment of pain difficult due to:
  - Cognitive impairment.
  - Visual/hearing impairment.
  - Speech impairment.
- Concomitant pain due to pre-existing comorbidities.
- Limited options for analgesia due to side effects or effects on physiological systems.
- Variable compliance with medication.

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CASE: CARCINOID

A 61-year-old male patient is undergoing abdominal surgery for removal of a carcinoid tumour.

What is a carcinoid tumour?

- A neuroendocrine tumour that arises from enterochromaffin cells.
- Classified according to their location based on the embryonic gut origins:
  - Foregut – lungs, bronchus and stomach.
  - Midgut – small intestine, appendix and proximal colon.
  - Hindgut – distal colon and rectum.
- Hormone secreting tumours; the majority of tumours produce and secrete serotonin. However, the effects of excess hormones do not usually manifest as they are metabolised in the liver prior to entering the circulation.

What is carcinoid syndrome?

- Occurs in approximately 25% of patients with a carcinoid tumour.
- In asymptomatic patients, the vasoactive substances produced by the localised gut tumours are metabolised in the liver, so there are no systemic symptoms.
- If the carcinoid tumour metastasizes to the liver and rest of the body, the vasoactive substances such as serotonin and histamine enter the bloodstream to produce the stereotypical systemic carcinoid symptoms:
  - Flushing.
  - Diarrhoea.
  - Lacrimation.
  - Rhinorrhoea.

How would you assess this patient prior to his procedure?

History

- A full and thorough medical history is necessary, focusing on the potential implications of the carcinoid tumour on the patient's bodily systems.

- The history should also include a routine medical and anaesthetic history with details about regular medications, social history, allergies and airway.
- Disease complications can include:
  - Cardiovascular: right-sided cardiac disease.
  - Respiratory: wheeze and bronchospasm.
  - Gastrointestinal: diarrhoea (leading to dehydration and electrolyte disturbance).
  - Skin: flushing.
  - General: malnutrition, cachexia.

Examination and investigations

- These should be directed by findings from the patient history and previous appointments and should include:
  - Baseline blood tests including full blood count (anaemia), electrolytes, liver function tests and clotting.
  - Chest X-ray.
  - ECG and echo to rule out right-sided cardiac involvement.

What are the anaesthetic goals for management of this patient?

- Provide a smooth perioperative course for major abdominal surgery including analgesia.
- Minimise the systemic complications of vasoactive mediator release during tumour handling.
- Avoid the use of anaesthetic agents that may exacerbate carcinoid symptoms or cause a carcinoid crisis e.g. morphine/atracurium causing histamine release.

During tumour resection the patient's blood pressure falls to 64/23 and you notice increased airway pressures. How do you proceed?

- Initial management is to alert the theatre team, call for senior help and apply 100% oxygen.
- Rapid ABCDE assessment to form a differential diagnosis. Consider the likelihood of a carcinoid crisis and treat early if probable.
- Intravenous bolus of 20 μg octreotide, followed by further boluses titrated to effect. Small doses of phenylephrine or vasopressin can also be considered if resistant to the initial treatment.
- Fluid bolus and close monitoring of cardiac output.
- Consider concomitant effects of potential large blood loss.

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12

REGIONAL ANAESTHESIA

CASE: POSTOPERATIVE NERVE INJURY

You are asked to review a 41-year-old male patient in the anaesthetic clinic who presents with left arm weakness and numbness. He underwent left shoulder surgery 1 week ago with an interscalene nerve block and a general anaesthetic. He is otherwise well.

What are the potential causes of this patient's symptoms?

Anaesthetic

- Direct damage due to regional anaesthetic needling.
- Intraneural injection of local anaesthetic solution.
- Haematoma caused by needling.
- Perioperative hypotension (unlikely cause of local symptoms).

Surgical

- Direct nerve or tissue damage due to surgical procedure or retractors.
- Pathology secondary to surgery, such as haematoma formation.
- Poor perioperative positioning/padding.

Other

- Cerebrovascular event (localised).
- Local nerve ischaemia secondary to haematoma formation.
- Exacerbation of pre-existing comorbidities e.g. carpal tunnel syndrome.

How would you assess this patient in clinic?

The purpose of assessing the patient is to identify a treatable cause, guide management and document how the neurological deficit progresses.

- Take a full history of the patient's symptoms including the duration, variation in symptoms over time, exacerbating or relieving factors and associated symptoms, as well as a medical and social history.
- Examine and document the current sensory and motor deficit. Attempt to localise symptoms to a particular nerve root or bundle in order to aid diagnosis. Examine the site of needling and operation; this may reveal a haematoma.
- Review the anaesthetic chart, operation note and postoperative observations chart.
- Discuss the patient with an anaesthetic consultant and the relevant surgical team following the initial assessment to determine the likely

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cause, any relevant investigations that should be done and how the patient should be managed, including an apology and the appropriate escalation if likely iatrogenic.
- Consider a referral to neurology if appropriate, and follow up.

What are the risk factors associated with perioperative nerve injuries?

Patient factors

- Comorbidities e.g. hypertension, peripheral vascular disease, diabetes mellitus, multiple sclerosis.
- Smoking.
- Anatomical variation in local structures.

Anaesthetic factors

- Performing the block under general anaesthetic.
- Haemodynamic instability secondary to hypotension, hypovolaemia, hypoxia or hypothermia.
- Inexperience.

Surgical factors

- Type of surgery: neurosurgery, cardiac, abdominal and orthopaedic surgical procedures.

How can peripheral nerve injuries be classified?

The Seddon classification can be used to classify nerve injuries.

- Neuropraxia – damage to the myelin sheath only.
- Axonotmesis – damage to myelin sheath and axons.
- Neurotmesis – damage to myelin sheath, axons and nerve itself.

What investigations may aid in the diagnosis of this patient's symptoms?

- Electromyography.
- Nerve conduction studies.
- Magnetic resonance imaging.
- Ultrasound.

How can the risk of peripheral nerve injuries be minimised in patients undergoing shoulder surgery?

- Thorough medical history preoperatively to detect high-risk patients.
- Avoidance of perioperative haemodynamic instability.
- If a regional technique is used, several strategies can be employed to reduce the risk of peripheral nerve injuries:
  - Use of ultrasound with in-plane needling, ensuring that the needle shaft and tip are always visible.
  - A regional nerve block can be carried out in awake patients, so they are able to identify paraesthesia or pain during the procedure.
  - Use of a peripheral nerve stimulator.

- Adequate patient padding and neutral positioning, including limitation of excess movement at the shoulder joint, where the brachial plexus is at risk.
- Using alternative techniques to regional anaesthesia (although the benefits of a block must be considered as well as the risks when making an anaesthetic plan).

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CASE: CAUDAL ANAESTHESIA

A 2-year-old male patient is undergoing hypospadias repair surgery. You are asked to review him prior to his procedure.

What are the key aspects in the preoperative assessment for this patient?

History

- This is a young child, so the history will be taken from the parent/guardian. It is important to engage the child and put them at their ease.
- Birth history, vaccinations and a family history of anaesthetic problems should be emphasised.
- Infections are common in children and a reason to delay surgery. Ask about coryzal symptoms, fevers and contact with unwell individuals.

Examination

- Examinations may need to be pragmatic depending on the cooperation of the child.
- Airway assessment.
- Review observations, in particular the child's temperature.
- Check that the patient has been recently weighed.

Investigations

- No specific investigations should be required unless indicated by the patient's medical history.

What are the benefits of caudal anaesthesia?

- Excellent analgesia during the perioperative period.
- Safe and straightforward procedure.

- Avoidance of side effects of opioid-based analgesia.
- Caudal catheters can be used for prolonged blockade if appropriate.
- Minimal haemodynamic instability.

How would you perform a caudal block in this patient?

- Ensure access to a checked anaesthetic machine, trained assistant and full resuscitative capabilities.

Prior to the procedure

- Obtain consent from the parents.
- Apply AAGBI monitoring.
- Perform a general anaesthetic.
- Position the patient: left lateral with knees flexed to chest.
- Full asepsis using a hat, mask, sterile gloves, sterile drapes and chlorhexidine 0.5% spray.
- Calculate the correct dose/volume of local anaesthesia based on the patient's weight and the Armitage formula (0.5 mL/kg 0.25% bupivacaine for a sacro-lumbar block).

During the procedure

- Identify the sacral hiatus – forms an equilateral triangle with the posterior superior iliac spines.
- Insert a 22G cannula in a cranial direction through the sacral hiatus until a "click" is felt to indicate passage through the sacrococcygeal membrane.
- Advance the cannula and remove the needle.
- Allow the cannula to drain under gravity looking for blood or CSF drips.
- Aspirate the cannula again looking for blood or CSF.
- If no blood or CSF is seen, inject the local anaesthetic solution.
- Palpate the skin over the sacrum during injection. This will detect a cannula incorrectly positioned in the subcutaneous tissue.

Postoperative

- Warn the nurses and parents that the patient may have weak/numb legs and an unsteady gait.

How can the duration of the block be prolonged?

- Higher concentration or volume of local anaesthetic (ensuring the maximum safe dose is not exceeded).
- Use of a caudal catheter to enable additional local anaesthesia to be administered.
- Many different drugs have been added to the local anaesthetic in caudal blocks, including fentanyl, clonidine and ketamine. The ketamine must be a preservative free preparation to avoid neurotoxicity.

What are the complications associated with caudal analgesia?

- Block failure.
- Leg weakness.
- Urinary retention (although unlikely to be an issue as the patient would be catheterised intraoperatively).
- Intravenous injection and local anaesthetic toxicity.
- Dural puncture/intrathecal injection.
- Epidural haematoma/abscess.

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CASE: WRONG-SIDED BLOCK

A 35-year-old male patient is undergoing rotator cuff repair surgery after sustaining an injury while playing cricket. He is otherwise well, has no allergies, and has never had an anaesthetic before.

What are the options for anaesthetising this patient?

- General anaesthetic.
- General and regional anaesthetic combined.
- Regional anaesthesia awake or with sedation.

What are the advantages of regional anaesthesia alone in patients undergoing shoulder surgery?

There is no consensus in surgeons or anaesthetists in the place for awake shoulder surgery under regional anaesthesia and how it compares to combined regional and general anaesthesia. The provision of this service is dependent on a team that are engaged and provide it regularly. There are some patients where it will be the safest option.

Regional anaesthesia

- Represents an additional choice to the patient.
- Provides excellent pain control during and after surgery.
- Allows for a shorter duration of surgery/inpatient stay.
- Avoids the side effects of opioid-based analgesic agents e.g. nausea, vomiting and constipation.
- Avoids the side effects and complications of general anaesthetic e.g. airway compromise, dental damage, postoperative pulmonary complications and hypotension.

- Allows patients to eat and drink straight after surgery.
- Facilitates a rapid turnover of patients, improving efficiency and decreasing costs for hospital.

How would you anaesthetise this patient?

There is no right answer to this question, as long as you are safe. However, given the direction of the questions, a regional approach would be a good answer!

Preoperative

- Perform a standard anaesthetic assessment. There is nothing in the history above that suggests significant pathology to investigate.
- Consent to the technique explaining the benefits, risks and potential complications.
- Apply full monitoring as per the AAGBI minimum monitoring standards.

Interscalene regional block

- Position the patient supine, head up and neck rotated to contralateral side.
- Ensure full asepsis, including a hat, mask, sterile gloves and chlorhexidine 0.5% spray.
- Using a linear ultrasound probe, identify the brachial plexus at the level of the subclavian artery and follow it in a cephalad direction until the C5-C7 nerves can be identified travelling as a discrete bundle.
- "Stop before you block" moment: Confirm the correct block on the correct side for the correct patient.
- Inject local anaesthetic into the skin.
- Using an in-plane approach, inject a sufficient volume of bupivacaine to surround the nerves (10–15 mL 0.5% bupivacaine should be sufficient) using a 50 mm echogenic block needle.
- Assessment of patient following regional block to ensure no complications.

What is meant by an "in-plane" approach?

- The needle is inserted into the skin at the lateral aspect of the ultrasound probe, ensuring that the needle tip and shaft are both visible throughout the procedure.

What are the potential complications associated with an interscalene block?

- Block failure.
- Phrenic nerve blockade.
- Horner's syndrome.
- Recurrent laryngeal nerve blockade and hoarse voice.
- Nerve injury.
- Prolonged weakness/numbness.

- Local anaesthetic toxicity.
- Wrong-sided block.

You perform the interscalene block and review the patient 5 minutes later. Unfortunately, the block was performed on the incorrect side. What are the factors that may contribute to a wrong-sided block being done?

Surgical

- Surgical mark on the incorrect side.
- Consent form indicating the incorrect side.

Anaesthetic technique

- Block performed after induction of general anaesthesia.

Situational factors

- Prolonged period between the WHO checklist and regional block.
- Surgical mark not visible while the block is being done.
- Inexperienced anaesthetist.
- Failure to perform a "stop before you block" moment.
- Human error due to distractions, time pressure, fatigue, stress or anxiety.

How would you manage this incident?

Since 2018, a wrong-sided block has been classified as a "never event", and as such is going to cause a great deal of anxiety to the patient and the practitioner. It will also derail the operating list. It should be managed with honesty and humility.

- Declare the mistake to the patient, anaesthetic assistant, anaesthetic and surgical consultants and theatre team.
- Apologise to the patient. Ensure that they are kept safe e.g. monitored if they have had any sedative medication, or woken up safely if they have had a general anaesthetic.
- Discuss with a senior anaesthetist and the theatre team regarding how to proceed; almost certainly the operation will have to be postponed.
- Document conversations with the patient and team.
- It may be appropriate for another anaesthetist to take over the case/list.
- Discuss with supervisor and medicolegal team if appropriate.
- Report the wrong-sided block as a critical incident according to local protocols.
- Discuss the issue with educational supervisor/college tutor as to whether further support or training is needed.

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CASE: RIB FRACTURES

A 79-year-old male patient is admitted to the emergency department after a fall. He has a history of ischaemic heart disease and prostate cancer but is normally well and mobile. What is your initial management?

A fall could be minor or very serious depending on the context, cause and mechanism. Without further information, assume it is a major trauma as it is better to be overprepared than under.

- The patient needs to be assessed with a full "hands-off" handover to the trauma team unless there is catastrophic bleeding or a life-threatening event.
- A primary survey should be performed to include treatment of each body system as indicated. It would follow an ABCDE approach.
- A trauma CT scan is the priority in order to determine the location of injuries and further interventions required.
- Transfer of patient to appropriate location: ward, intensive care unit or theatre for further treatment and management.

The patient is alert and gives a history of tripping over his cat at home onto the tiled kitchen floor. He is complaining of pain in his right chest. What are your concerns?

- Cause of the fall – likely mechanical, but other factors should be investigated e.g. syncope.
- Duration of his chest pain; if prior to the fall, the pain could indicate a myocardial ischaemic event; if following the fall, it could suggest a pneumothorax and/or rib fractures.
- Other injuries due to the fall.

A trauma CT scan shows four right-sided rib fractures and no other internal injuries. Which ribs are most commonly fractured?

- Ribs 1–3 tend to be protected by the clavicle and shoulder joint, so usually require a high-impact force to be fractured.
- Ribs 4–10 are most commonly fractured.
- Ribs 11 and 12 are less likely to be fractured, as they are relatively flexible.

What are the priorities in the management of this patient?

Rib fractures are associated with serious lung complications and a high mortality. Mortality increases with age, number of rib fractures, flail chest and lung contusion. The priority here is risk mitigation, which can be achieved in several different ways.

Analgesia

- Multimodal analgesia should be administered, including simple analgesia, opioids and other adjuncts such as lidocaine patches and

gabapentin. Regional anaesthesia may be especially helpful where the above measures are insufficient to allow coughing, deep breathing or physiotherapy.
- Early aggressive regional anaesthesia has been shown to reduce mortality, with the best evidence base for thoracic epidurals and paravertebral blocks. However, other chest wall blocks are becoming popular and are used on many units.
- Local guidelines or rib fracture pathways should ensure a stepwise approach to analgesia.

Assessment

- A multidisciplinary approach is vital for effective management of elderly patients with rib fractures, including review by appropriate medical teams, orthogeriatricians, physiotherapy, senior nursing staff, anaesthetists and the acute pain team.
- History: Should focus on comorbidities, falls, frailty and medications (particularly the use of blood thinners).
- Examination: Look for signs of flail chest, contusions and other lung pathology. A full respiratory examination should be conducted to assess the effect of the injury on the patient's oxygenation and ventilation.
- Investigations: Depending on the situation, it may be useful to take blood for an arterial blood gas, full blood count, urea and electrolytes and a clotting screen.

Location

- Given the high mortality, this patient should be managed on a high dependency unit.

Ventilation

- The patient is at high risk of atelectasis, pneumonia and respiratory failure due to hypoventilation and a poor cough secondary to pain.
- Initially, the patient should be prescribed supplementary oxygen with nasal cannulae or a facemask to maintain adequate saturations.
- High flow nasal cannulae or non-invasive ventilatory techniques should be considered if the above is not effective and the patient becomes hypoxic or hypercapnic.
- Early respiratory physiotherapy is key, focusing on techniques such as deep breathing and coughing, and incentive spirometry.

What regional techniques can be considered in this patient?

- Serratus anterior block/catheter.
- Paravertebral block/catheter.
- Erector spinae plane block/catheter.
- Thoracic epidural.

What are the benefits of a paravertebral catheter compared to a thoracic epidural in this patient?

- Analgesia from a paravertebral catheter is equally effective as a thoracic epidural.
- Avoids the side effects and risks associated with epidurals e.g. dural puncture, sympathetic blockade and urinary retention (particularly in a patient with prostate cancer).
- A paravertebral block is easier to perform with ultrasound guidance.
- The patient can remain mobile, which may decrease the risk of other complications e.g. venous thromboembolism.

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13

SEDATION

CASE: DENTAL EXTRACTION

A 26-year-old female patient is undergoing extraction of two wisdom teeth under sedation. She is otherwise well and has no allergies.

What is conscious sedation?

- Conscious sedation can also be described as moderate sedation.
- It is a "drug-induced depression of consciousness".
- Verbal contact is maintained throughout the procedure using either verbal commands or light touch.
- The patient remains spontaneously ventilating, haemodynamically stable and is able to maintain their airway without any interventions such as airway manoeuvres or adjuncts.

What are the key issues when pre-assessing this patient for her procedure?

- The patient should be carefully assessed to confirm her suitability for conscious sedation, with a focus on the airway, cardiovascular and respiratory systems, and body mass index. Relative contraindications to sedation include:
  - Morbid obesity.
  - Severe comorbidities e.g. cardiovascular disease, liver disease, lung disease.
  - Learning difficulties.
  - Inability to stay still e.g. resting tremor.
  - Severe needle phobia.
- A thorough social and psychological assessment is key; the patient needs to be well informed that she will remain conscious throughout, and therefore be aware of what is going on around her e.g. drilling sounds and voices.
- Patients should be fasted as if they were undergoing a general anaesthetic, in case of the need for airway intervention and induction of anaesthesia.

When carrying out conscious sedation, how can the risks to the patient be minimised?

Choice of agent

- The choice of drug should be determined by the patient's comorbidities, the length of the procedure and the anaesthetist's familiarity with the agent.

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- Ideally, only one drug should be used throughout the procedure to decrease the effect of synergism and augmentation of side effects such as respiratory depression when agents are used in combination.

Location

- Dental procedures are often carried out in remote locations, and the anaesthetist should ensure that they are familiar with both the routine and emergency equipment and drugs, and how to escalate should assistance be required in an emergency.
- An appropriate recovery area should be available prior to the patient's discharge.

Personnel

- The clinician carrying out the procedure should not be in charge of sedating the patient concurrently.
- Adequate numbers of trained staff are required including recovery nurses and an anaesthetic assistant.

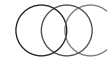
Monitoring

- AAGBI monitoring should be used, to include pulse oximetry, cardiac monitoring and non-invasive blood pressure monitoring. End tidal carbon dioxide can be used to monitor ventilation.
- Clinical signs such as the response to verbal and tactile communication should be used, and a trained anaesthetist should be present throughout the whole procedure.

During the procedure, the dental surgeon alerts you to a sudden increase in the volume of blood in the suction and in the patient's mouth. The patient starts coughing and her saturations decrease to 87%. What is your immediate management?

This is an anaesthetic emergency, and should be dealt with quickly and safely.

- Alert the theatre team immediately. This is an anaesthetic emergency, likely aspiration of blood.
- Call for urgent senior help and ask for the airway trolley.
- Suction any excess blood in the patient's airway and place her in a head down, left lateral position.
- Ventilate the patient using a facemask with 100% oxygen.
- Cricoid pressure can be applied if the patient is not vomiting.
- If there is no improvement, or the patient continues to deteriorate, intubate and ventilate the patient. Suction the airway using a suction catheter prior to positive pressure ventilation.
- Order an urgent chest x-ray and consider chest physiotherapy/ bronchoscopy if there is any evidence of consolidation on imaging or chest auscultation.



- Further management should be directed by the patient's observations and clinical examination, but there should be a low threshold for critical care input.

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14

TRAUMA AND STABILISATION

CASE: MAJOR TRAUMA

A 23-year-old male cyclist is admitted to the emergency department following a road traffic collision with a car travelling at 50 mph on a dual carriageway.

How is major trauma defined?

- The Injury Severity Score (ISS) is used to define major trauma, with a score of more than 15 suggesting major trauma.
- To calculate the ISS, the body is divided into six regions, and injuries in each area are scored on a scale of 1 (minor injury) to 6 (not survivable).
- The three highest scores are squared and added together to give the final result.

How would you approach this patient?

- A patient with major trauma is usually taken directly to a major trauma centre, where a trauma team should be assembled in the emergency department and briefed prior to the patient arriving, for rapid assessment and treatment.
- A "hands-off" handover to the trauma team should be done if the patient does not require any immediate life-saving treatment.
- A primary survey should be carried out by multiple medics on the team to identify any life-threatening injuries. This should be fed back to the trauma team leader.
- The priority is to reduce the time from the injury to definitive care, so only absolutely necessary interventions should be performed, such as securing the airway and gaining adequate intravenous access.
- If the patient is stable, a trauma CT (head to pelvis) should be performed to guide further management.
- The patient should be transferred to an appropriate location for definitive or supportive treatment e.g. theatres, intensive care unit, trauma ward.

On examination, the patient has oxygen saturations of 90%, and paradoxical breathing is noted. He is tender to palpation on the right side of his chest, which is bruised. His arterial blood gas demonstrates a type 1 respiratory failure.

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What are the potential causes for these findings?

Respiratory

- Pneumothorax.
- Haemothorax.
- Pulmonary contusion.
- Diaphragmatic rupture.
- Tracheal/bronchial rupture.

Cardiovascular

- Cardiac tamponade.
- Damage to the thoracic aorta.
- Cardiac contusion.

Musculoskeletal

- Flail chest.
- Sternal fracture.

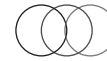
What are the strategies available for minimising blood loss in this patient?

Management of catastrophic bleeding should be the priority, using the following measures.

- Stop the bleed following the haemostatic ladder: direct compression of the wound; application of a compression dressing; and packing with haemostatic agents. If the above measures fail, consider a tourniquet. Limb immobilisation and pelvic binding should be considered if internal bleeding is suspected. For cavity haemorrhage (e.g. abdominal bleeding), early damage control surgery may be necessary, aimed at controlling the bleeding rather than physiological restoration of function. If appropriate and available, consider interventional radiology.
- Replace the volume that has been lost: rapid blood transfusion using an appropriate device (e.g. Level 1 infuser or Belmont) through a suitable large bore intravenous line. Bedside clotting testing (e.g. TEG) should be used to guide further transfusion.
- Facilitate clotting: tranexamic acid, active warming and calcium.

The arterial gas shows a blood glucose level of 14.9 mmol/L. Why might this be?

- The patient has undergone major trauma, leading to activation of the stress response.
- Increased plasma catecholamine and glucocorticoid levels secondary to the stress response facilitate gluconeogenesis and glycogenolysis, causing the plasma glucose levels to increase.



The patient desaturates to 84% and his blood pressure drops to 65/43. There are no breath sounds on the right and his trachea is deviated to the left. How do you proceed?

- This is likely a tension pneumothorax, which is a life-threatening emergency.
- Alert the multidisciplinary trauma team immediately.
- The urgent treatment is a thoracostomy performed in the 4th or 5th intercostal space in the mid-axillary line. Following decompression, a chest drain will be required.
- Decompression of the pneumothorax will likely restore the patient's normal physiology. However, if the patient deteriorates further, a careful plan is required prior to intubation and ventilation taking the following into account:
    - The patient is currently haemodynamically unstable, and both induction and positive pressure ventilation may lead to a cardiac arrest.
    - Surgical decompression can be done during induction, which requires appropriate preparation.
    - Continuous reassessment of the patient is necessary. Intubation should be considered prior to a transfer to prevent a challenging emergency intubation during the transfer. However, it might be safer to continue resuscitative measures first to reduce further cardiovascular collapse on induction.

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15

INTENSIVE CARE MEDICINE

CASE: PANCREATITIS

A 42-year-old male patient is admitted to intensive care with severe pancreatitis. He has a history of hypertension, chronic back pain and alcohol excess.

How is a diagnosis of severe pancreatitis made?

- A diagnosis of pancreatitis requires two of the following three criteria to be fulfilled:
  1. Severe epigastric abdominal pain consistent with a diagnosis of pancreatitis.
  2. An increase in serum lipase or amylase at least three times the upper limit of normal.
  3. CT abdominal scan findings suggestive of pancreatitis.
- Severe pancreatitis suggests the presence of organ failure or local complications for more than 48 hours, and often requires management on a high dependency or intensive care unit for supportive therapy.

What causes Cullen's sign?

- Cullen's sign is seen as darkened discolouration and oedema surrounding the umbilicus.
- It is caused by retroperitoneal haemorrhage tracking through subcutaneous fat and abdominal planes.

How would you manage this patient on admission to intensive care?

- Take a detailed handover from the parent team including any investigations and treatment.
- Carry out an ABCDE assessment to establish the need for time-critical interventions and escalation of care environment, in consultation with seniors as appropriate.
- Take a thorough medical and social history, examine the patient and ensure appropriate baseline investigations are done including an arterial blood gas, renal function and markers of infection.
- Management of this patient will be largely supportive and should include:
  - High flow oxygen and further ventilatory support if indicated.
  - Fluid resuscitation due to ongoing insensible losses and intravascular volume depletion.
  - Blood pressure support with vasopressors if required.
  - Early enteral feeding and ulcer prophylaxis.

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  - Correction of electrolyte disturbances and blood glucose control.
  - Analgesia for patient comfort and to minimise the effect of abdominal pathology on ventilation.
- Consider administering agents to prevent alcohol withdrawal given the patient's history (chlordiazepoxide is commonly used).

What are the complications in patients with severe acute pancreatitis?

Local complications

- Pancreatic/local fat necrosis.
- Haemorrhagic pancreatitis.
- Pancreatic pseudocyst formation.
- Pancreatic abscess.

Systemic complications

- Pleural effusion.
- Systemic thromboses e.g. portal vein/splenic vein thrombosis.
- Major abdominal haemorrhage.
- Intra-abdominal hypertension/abdominal compartment syndrome.
- Malnutrition.
- Diabetes mellitus.
- Prolonged stay on intensive care and associated risks.
- Overall increase in morbidity and mortality.

The patient deteriorates and requires intubation and ventilation. A week later, his repeat CT scan shows findings suggestive of pancreatic necrosis. How should he be managed?

- Continue supportive treatment as above.
- Ensure multidisciplinary involvement of the surgical team to ascertain the best course of management.
- Consider parenteral nutrition if not absorbing enteral feeds.
- Any surgical intervention should be delayed until 3–4 weeks after the initial diagnosis due to the increased risk of mortality with early surgery.
- If indicated (for management of suspected infected necrosis or abscess) opt for minimally invasive techniques initially if appropriate e.g. percutaneous drainage.
- Administer antibiotics only if there is suggestion of infective necrosis (liaising with microbiology).

What are the long-term consequences of a prolonged stay in intensive care?

- Weakness and loss of muscle mass.
- Sleep disturbance.
- Cognitive dysfunction/decline.
- Anxiety/depression.

- Long-term pathology: chronic kidney disease, heart failure, pulmonary fibrosis.
- Complications of prolonged intubation/tracheostomy e.g. phrenic nerve weakness and tracheal stenosis.
- Chronic pain.
- Chronic pressure sores.

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CASE: SEPSIS

You are asked to review a 36-year-old female patient in the emergency department who has presented with lethargy and feeling generally unwell. Her partner says she has been confused and feverish. Her oxygen saturations on air are 95%, her respiratory rate is 29, her heart rate is 122 and her blood pressure is 83/52.

What are the priorities in the management of this patient?

This is a sick patient who needs immediate assessment and treatment.

Assessment

- Carry out a rapid ABCDE assessment including a focused history and examination, treating any pathophysiology concurrently.
- Recognise the relevant indicators of sepsis and form a differential diagnosis based on the patient assessment to direct investigations.
- Escalate to senior medical and critical care teams as appropriate.

Investigations

- Attach continuous bedside monitoring and consider early invasive blood pressure monitoring (but this should not delay treatment).
- Do a urine dipstick and culture if appropriate.
- Order a portable chest X-ray (to take place in the emergency department).
- Blood tests should include a full blood count, urea and electrolytes, clotting and blood cultures. A venous or arterial blood gas should be done as soon as possible (note the lactate).

Treatment

- Titrated supplementary oxygen therapy.
- Fluid resuscitation through large bore intravenous access. Start with 30 mL/kg crystalloid initially, but the patient may need several litres and should be reassessed following each bolus/infusion.

- Broad-spectrum intravenous antibiotics according to the local guidelines and suspicion of the likely source.
- Catheterise and strict monitoring of fluid balance.
- Consider vasopressor agents early if not fluid responsive.
- Refer and transfer to critical care if appropriate.

What are the qSOFA criteria?

- The quick Sequential Organ Failure Assessment scoring system uses three criteria to assess the risk of morbidity and mortality in patients with sepsis:
  1. Respiratory rate ≥22.
  2. Altered mental status.
  3. Systolic blood pressure <100 mmHg.
- Each criterion receives a score of 1, and a score of 2 or more indicates an increased risk of mortality and a prolonged critical care stay.

What is the definition of sepsis?

- A life-threatening organ dysfunction due to a dysregulated host response to infection (*2016 3rd International Consensus*).

What are the physiological targets in the early management of sepsis?

- Mean arterial pressure >65 mmHg.
- Lactate <4 mmol/L with lactate clearance.
- Individualised approach to cardiovascular system manipulation: adequate fluid resuscitation and assessment of cardiac function to determine whether inotropic agents are required.

The patient requires vasopressors to maintain her systolic blood pressure, and she is admitted to intensive care where she is intubated. How can the risk of ventilator-associated pneumonia be decreased?

- The measures within the ventilator care bundle aim to lower the risk of a patient developing a ventilator-associated pneumonia, and include:
  - A daily sedation hold.
  - Elevation of the head of the bed.
  - Regular monitoring of endotracheal tube cuff pressures.
  - Sub-glottic suction of secretions.
  - Excellent hand hygiene when handling airway equipment.
  - Use of closed circuits.

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CASE: PATIENT CARE FOLLOWING A CARDIAC ARREST

A 49-year-old male patient is admitted following a cardiac arrest in the community. He underwent three cycles of CPR and shocks for a VF rhythm. The post-ROSC ECG demonstrates widespread ST segment elevation. He is intubated and ventilated and admitted to intensive care following cardiac catheterisation, during which a clot was removed from the left anterior descending coronary artery.

What are the key aspects for post-resuscitation care in this patient?

- Take a full collateral history and carry out a systematic examination. Update the family and determine the general wishes of the patient, including advanced statements or directives.
- Continue treatment for the likely cause of the cardiac arrest (myocardial infarction) with close cardiology team involvement, including appropriate medication as directed.
- Optimise ventilatory and haemodynamic strategies with appropriate monitoring to ensure favourable physiology to minimise secondary brain injury and cardiac work.
- Ensure neuroprotective measures including treatment of pyrexia and seizures and blood glucose control. Targeted temperature management should be discussed.
- Consider further investigations when the patient is stable e.g. CT head, EEG and echo.

How is targeted temperature management carried out?

- Ensure continuous core body temperature monitoring e.g. oesophageal temperature probe.
- The patient should be well sedated and can be paralysed to prevent shivering and other involuntary movements.
- Surface cooling measures e.g. ice packs, wet towels or specific proprietary devices.
- Specialised intravascular systems can be used to monitor and finely control core temperature.

What is the "post-resuscitation" syndrome?

- The post-resuscitation syndrome consists of four elements that contribute to further pathological responses after cardiac arrest:
  1. Secondary brain injury.
  2. Cardiac dysfunction/stunning.
  3. Systemic ischaemia and reperfusion injury.
  4. Continuation of the pathological process that triggered arrest.

The patient remains intubated and ventilated for 2 days. How should prognostication take place?

- Neurological prognostication should take place at least 72 hours following the cardiac arrest to allow for targeted temperature management to take place, and for potential reversibility of ongoing pathological processes.
- Prior to prognostication, restoration of normal physiology should be attempted as best as possible to allow for an accurate diagnosis.

Clinical examination

- Sedation hold with regular neurological assessment including GCS.
- Poor prognostic indicators include: absence of ocular reflexes (pupillary, corneal blink), absent/abnormal motor response and ongoing seizure activity.

Investigations

- CT head looking for indicators of hypoxic brain injury.
- EEG – burst suppression and seizure activity are negative prognostic indicators.
- Somatosensory evoked potentials (specifically N20s).
- Blood markers of tissue damage e.g. neuron-specific enolase levels >33 μg/L on days 1–3 are strongly associated with a poor outcome.

If you are asked further about somatosensory-evoked potentials, it should be noted that:

- *Bilaterally absent short latency peaks (N20 peaks) have a 100% predictive value for poor outcome (death/severe disability) with a false positive rate of nearly 0% and narrow confidence intervals.*
- *SSEP is the most reliable test to predict poor outcomes in this patient group but does not predict good outcomes.*
- *The pre-test probability for poor outcome is essential; use the test only for patients who remain unconscious following a hypoxic ischaemic insult. The test has been validated for use as early as 24 hours after a cardiac arrest.*
- *SSEP testing is not affected by sedatives, analgesics, paralysing agents or metabolic insults.*

The CT scan suggests widespread ischaemia effects likely representing severe hypoxic brain injury in this context. What criteria need to be met before brainstem death testing can take place?

- No likely reversible cause of apnoea e.g. biochemical/metabolic causes, residual sedatives or neuromuscular blockade, hypothermia.
- Stable physiology prior to undertaking the tests.
- Testing should be performed by two doctors familiar with the process, fully registered with the General Medical Council for at least 5 years, with at least one consultant.
- There should be an identified precipitating cause of brainstem death.

How is the apnoea test carried out?

- Pre-oxygenate the patient with 100% oxygen.
- Disconnect the ventilator and oxygenate the patient through a catheter in the trachea (5 L/minutes).
- Observe the patient for signs of respiratory effort for 5 minutes.
- Ensure a rise in $PaCO_2$ by >0.5 kPa, from a starting baseline of $PaCO_2$ >6 kPa and pH <7.4.

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CASE: MALNUTRITION

A 43-year-old male patient is admitted to intensive care following an emergency laparotomy for a ruptured infected appendix. He is a smoker and drinks 40 units of alcohol a day. He is intubated and ventilated.

Why is this patient at high risk of malnutrition?

- Likely abdominal sepsis with poor oral intake prior to his recent illness.
- Major abdominal surgery is associated with a postoperative ileus.
- This is a high-risk patient that has had a major procedure and will likely need a prolonged stay in intensive care and hospital.
- Alcohol excess suggests possible poor long-term nutritional status and possible chronic liver disease (causing decreased absorption of essential nutrients).

What are the systemic complications associated with malnutrition?

- Overall increase in morbidity and mortality.
- Decreased muscle mass, leading to poor mobility and increased risk of venous thromboembolism.
- Low respiratory drive and function associated with respiratory failure and pneumonia.
- Increased time on the ventilator and difficult weaning.
- Poor wound healing and increased risk of wound infection.
- Refeeding syndrome.

What are the standard daily nutritional requirements for a 70 kg adult?

Energy	2500–3000 calories (25 kcal/kg)
Nitrogen	7–14 g
Glucose	210 g
Lipid	140 g
Sodium	70–140 mmol
Potassium	50–100 mmol
Calcium	10 mmol
Magnesium	10 mmol
Phosphate	10 mmol

What is your plan for nutrition in this patient?

Assessment

- This patient is at high risk of malnutrition and refeeding syndrome given his surgical and social history, therefore an urgent dietician assessment is needed to determine the best regimen.
- The patient should be examined for signs of malnutrition e.g. body mass index, muscle mass, dentition, skin and hair health.
- Investigations should include regular electrolytes to monitor for signs of refeeding syndrome. A low serum creatinine reflects low muscle mass, and low urea is often associated with prolonged malnutrition.
- Carry out a multidisciplinary discussion with the surgical team to ensure an appropriate method of feeding is instigated.

Treatment

- Insert a nasogastric tube and check for correct positioning according to recognised standard clinical guidelines as advised by NICE.
- Estimate the appropriate feed composition based on the patient's weight.
- Ensure an appropriately restricted dose of feed initially to minimise the risk of refeeding syndrome.
- Monitor the patient for signs of malabsorption and consider interventions as necessary.

Two days after enteral feeding is started, the patient has high aspirate volumes. How would you manage this?

- Review the patient and documentation of aspirate volumes since the feed was started. Discuss the regimen options with the dietician and a senior intensivist. Enteral feeding may still be continued, perhaps at a lower rate depending on the gastric residual volumes.
- Consider pharmacological prokinetic agents e.g. metoclopramide and erythromycin.
- Review the position of the nasogastric tube and consider nasojejunal positioning.
- Consider parenteral nutrition if the above measures fail.

What are the complications of parenteral nutrition?

Line-related complications

- Infection.
- Bleeding/haematoma.
- Pneumothorax.
- Thrombosis.

Feed-related complications

- Electrolyte disturbances.
- Refeeding syndrome.
- Fluid overload.
- Poor blood glucose control.
- Stress ulcers.

How can the risk of stress ulcers be minimised?

- Pharmacological agents e.g. histamine receptor antagonists, proton pump inhibitors, sucralfate (rarely used due to difficulty in administration).
- Nasogastric (enteral) feeding.
- Optimal oxygenation.

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CASE: ABDOMINAL COMPARTMENT SYNDROME

You are asked to review a 64-year-old male patient who was admitted to the intensive care unit 1 day ago following an emergency laparotomy for excision

of ischaemic bowel. He has a BMI of 42 and has a history of hypertension. He remains intubated and ventilated, is oliguric, and is now demonstrating worsening acidosis on his arterial blood gas.

What are the potential causes of deterioration in this patient?

- Sepsis.
- Fluid imbalance/hypovolaemia.
- Low cardiac output state/hypotension.
- Acute kidney injury.
- Electrolyte/metabolic disturbance.
- Raised intra-abdominal pressure.

What is abdominal compartment syndrome?

- A sustained increased in intra-abdominal pressure above 20 mmHg, with consequent signs and symptoms of organ dysfunction.

Normal intra-abdominal pressure is ~5 mmHg, and intra-abdominal hypertension is defined as a pressure above 12 mmHg.

What are the risk factors for the development of abdominal compartment syndrome?

Poor abdominal wall compliance

- Lung pathologies causing increased thoracic pressure.
- Major abdominal surgery.
- Prone positioning.

Increased abdominal content

- Ileus.
- Severe ascites.
- Pneumoperitoneum (iatrogenic/pathological).
- Pancreatitis (due to local complications e.g. pseudocyst formation or indirectly secondary to fluid resuscitation/ileus).
- Intra-abdominal bleeding (abdominal aortic aneurysm, trauma, retroperitoneal haematoma).

Fluid and electrolyte imbalance

- Burns.
- Trauma.
- Metabolic disturbances.
- Persistent hypotension.
- Hypothermia.
- Massive transfusion.
- Deranged clotting.
- Severe sepsis/shock.

Patient factors

- Age.
- Raised BMI (particularly central obesity pattern).

How can this patient's intra-abdominal pressure be measured?

Intra-vesical measurement

- Ensure the patient is catheterised and supine. Drain the catheter fully and clamp.
- Connect the patient's catheter to a 3-way tap and a pressure transducer (zeroed).
- Inject 20–25 mL of 0.9% sodium chloride into the bladder and measure the pressure at the end of expiration.

The patient's intra-abdominal pressure consistently measures above 25 mmHg. What are the potential systemic complications?

- Decreased cardiac output, venous return and contractility through cardiac compression.
- A further drop in abdominal perfusion pressure, causing:
  - Ischaemic bowel.
  - Acute liver injury.
- Difficulty ventilating due to poor pulmonary compliance and increased thoracic pressure.
- Acute kidney injury secondary to poor perfusion and obstruction of the venous supply and ureters.
- Increased length of intubation/ventilation and stay on intensive care, with its associated risks.
- Overall increase in morbidity and mortality.

How would you manage this patient?

Assessment

- ABCDE assessment focusing on the risk factors/causes of raised intra-abdominal pressure.
- Serial monitoring of intra-abdominal pressure.
- Cardiac output assessment/monitoring to optimise fluid resuscitation and the use of vasoactive substances.
- Consider the need for diagnostic imaging.

Treatment

- Largely supportive, ensuring optimal positioning (reverse Trendelenburg), ventilation, feeding and fluid balance of patient.
- Consider nasogastric and flatus tubes to decompress if appropriate.
- Ensure adequate sedation and paralysis to prevent increases in pressure due to ventilator dysynchrony or coughing.
- Adjust the cardiovascular physiology to optimise abdominal perfusion pressure and flow.
- Consider renal replacement therapy if indicated.
- Multidisciplinary discussion with the surgical team to assess the risks and benefits of a decompression laparostomy, which should be considered in patients with intraperitoneal fluid, abscess or blood.

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CASE: ACUTE RESPIRATORY DISTRESS SYNDROME

A 76-year-old gentleman was admitted to the intensive care unit 4 days ago with shortness of breath secondary to a right lower lobe pneumonia. He was intubated and ventilated. He has a history of COPD, ischaemic heart disease and a hiatus hernia. You are asked to review this patient due to worsening type 2 respiratory failure.

What are the potential causes of his deterioration?

Equipment factors

- Inappropriate ventilator settings.
- Malpositioned endotracheal tube.
- Blocked endotracheal tube or circuit.

Disease factors

- New ventilator-associated/aspiration pneumonia.
- Sepsis.
- Over-sedated patient.
- Acute respiratory distress syndrome (ARDS).

How is ARDS diagnosed?

- The 2012 Berlin definition can be used, which includes four criteria that need to be met for a diagnosis of ARDS to be made:
  - Acute onset of symptoms (within 1 week of physiological insult or trauma).
  - Bilateral pulmonary infiltrates (on chest X-ray or CT).
  - Hypoxia with PEEP of at least 5 cm H_2O.
  - Symptoms not explained by cardiac failure.
- ARDS can be defined as mild, moderate or severe depending on the degree of hypoxia. This is calculated using the PaO_2/FiO_2 ratio:
  - Mild: $PaO_2/FiO_2 \leq 39.9$ kPa.
  - Moderate: $PaO_2/FiO_2 \leq 26.6$ kPa.
  - Severe: $PaO_2/FiO_2 \leq 13.3$ kPa.

What are the common causes for the development of ARDS?

Pulmonary

- Pneumonia.
- Pulmonary contusion.
- Airway burns/smoke inhalation.
- Vasculitis.
- Drowning.

Extra-pulmonary

- Sepsis.
- Massive blood transfusion.
- Polytrauma.
- Pancreatitis.
- Burns.
- Toxins.

The patient assessment suggests a diagnosis of ARDS. What is your initial approach to management?

- Ensure lung protective ventilatory strategies, to include:
  - Tidal volume ≤6 mL/kg.
  - Plateau pressures <30 cm H_2O.
  - PEEP >5 cm H_2O.
  - Respiratory rate 20–30.
  - Permissive hypercapnia (raised $PaCO_2$ if the pH >7.2).
  - Titrated oxygen targets.
- Supportive management:
  - Identify and treat the underlying cause.
  - Consider neuromuscular blockade.
  - Elevate the head of the bed.
  - Judicious use of fluids.
- If the above measures do not demonstrate improvement, consider:
  - Prone position ventilation.
  - Extracorporeal membrane oxygenation.

What are the common complications associated with placing patients in the prone position on intensive care?

- Pressure sores/ulcers.
- Facial oedema.
- Haemodynamic instability.
- Ocular oedema or injury.
- Nerve damage.
- Accidental removal of endotracheal tube and intravenous lines.
- Difficulty maintaining renal replacement therapy access.

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CASE: UPPER GI BLEED

You are asked to review a 46-year-old male patient in the emergency department who presented with a major upper gastrointestinal bleed. He has a history of alcoholic liver disease.

What is your initial management for this patient?

- Carry out an immediate ABCDE assessment and resuscitation as appropriate, including continuous monitoring and 100% oxygen with a non-rebreathe mask. This should include an airway assessment to gauge the need for intubation.
- Insert at least two large bore intravenous cannulae and administer fluid boluses as appropriate.
- Activate the major haemorrhage protocol to ensure readily available blood products, and that haematology, porters and the medical team are aware of the patient.
- Take bloods including clotting and cross match. Carry out bedside testing if possible (Haemocue, TEG).
- A focused history and examination of the patient may determine the cause and severity of the bleed:
  - Medical history.
  - Drug history.
  - Previous GI bleeds.
  - Peripheral stigmata of chronic liver disease.
- Discuss the patient with the gastroenterologists and theatre team regarding endoscopy as soon as he is stable.
- Consider pharmacological therapy:
  - Terlipressin (given the potential for a variceal bleed).
  - Reverse anticoagulants if appropriate e.g. vitamin K, prothrombin complex, protamine (if inpatient on heparin).
  - Tranexamic acid.
  - Proton pump inhibitor infusion.
  - Administer antibiotics if endoscopy intervention includes variceal banding.

What are the indications for intubation in this patient?

- Severe bleeding leading to airway compromise.
- Severe haemodynamic instability.
- Hepatic encephalopathy/confusion and poor compliance of treatment.

- Need for endoscopic intervention.
- Cardiac arrest.

What are the common causes of upper GI bleeds?

- Ulcers (oesophageal, gastric, duodenal): drug causes (NSAIDs), infective (*H. pylori*) and stress.
- Oesophageal/gastric varices secondary to portal hypertension.
- Mallory-Weiss tear.
- Malignancy.
- Post-surgical.

How can the risk of re-bleeding and death be predicted in this patient?

- The Rockall score can be used to assess the risk of mortality and further episodes of bleeding in this patient. It uses five categories, each of which are given a score from 0 to 3:
  - Age.
  - Presence of shock (heart rate and systolic blood pressure).
  - Comorbidities.
  - Diagnosis.
  - Endoscopy findings.
- A score of >7 suggests a 35% risk of mortality, which is increased if the patient has another episode of bleeding.

The patient is having ongoing episodes of haematemesis, and he requires transfer to theatre for an urgent endoscopy. He has a history of varices. What are the treatment options for this patient?

- Endoscopic variceal band ligation (1st line).
- Endoscopic variceal sclerotherapy.
- Balloon tamponade if the above measures fail.
- Transjugular intrahepatic portosystemic shunt (semi-elective, following stabilisation with balloon tamponade).

What are the risk factors for the development of stress ulcers in patients on intensive care?

- Invasive ventilation.
- Severe shock states.
- Deranged clotting.
- Patient with severe burns.
- Neurological trauma e.g. traumatic brain or spinal injuries.
- Pre-existing gastrointestinal ulcers.

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CASE: ACUTE CONFUSION

You are asked to review a 68-year-old gentleman who was admitted to intensive care 3 days ago following an emergency laparotomy for small bowel obstruction. He has a history of hypertension, diverticular disease and is a smoker. He is confused and trying to climb out of his bed.

What are the potential causes of confusion in this patient?

- Pre-existing comorbidities e.g. dementia.
- Alcohol ± nicotine withdrawal.
- Electrolyte disturbances.
- Infection.
- Hypoglycaemia.
- Hypoxaemia.
- Encephalopathy (hepatic, uraemic, sepsis).
- Drug side effects (anaesthetic/sedatives).
- Postoperative cognitive decline.
- Cerebrovascular event.

What is delirium?

- An acute disturbance of consciousness and altered cognitive state that may demonstrate a fluctuating course over a short period of time.
- Delirium can be hyperactive, hypoactive or mixed.

What are the risk factors for the development of delirium in this patient?

Patient factors

- Increased age.
- History of hypertension.
- Smoker.
- May have visual or hearing impairment due to his age.

Illness factors

- Potential for electrolyte or metabolic disturbance postoperatively.
- Possible pyrexia or sepsis.
- Postoperative anaemia.
- Side effects of medication.
- Poor sleep as inpatient.
- Decreased mobility in hospital.
- Pain.

How would you assess and treat this patient?

Assessment

- Carry out a rapid initial assessment to determine whether the patient or staff is at risk; if so, an urgent intervention may be required to prevent injury.

- The CAM-ICU scoring system (confusion assessment method for ICU) can be used to assess the patient. This includes the following aspects:
  1. Determining whether the confusion is acute or fluctuating.
  2. Assessing patient inattention.
  3. Establishing conscious level.
  4. Assessing for presence of disorganised thoughts.

For a patient to be CAM-ICU positive (and therefore have a diagnosis of delirium), the first two criteria must be met, together with either the 3rd or 4th criterion.

Treatment

- Avoidance of, and minimising risk factors for delirium. Measures can include:
  - Daily sedation hold.
  - Drug chart review.
  - Treat infection or metabolic disturbances if present.
  - Offer hearing or visual aids if appropriate.
  - Aim for optimal diurnal sleep-wake cycle.
  - Physiotherapy.
- If the above measures fail, pharmacological agents can be considered:
  - 1st line: haloperidol.
  - 2nd line (or if haloperidol contraindicated): olanzapine.

Note that benzodiazepines should be avoided in these patients.

What are the complications in this patient should his delirium remain untreated?

- Overall increase in morbidity and mortality.
- Increased length of hospital stay/duration on intensive care.
- Increased risk of infection.
- Cognitive decline (long-term).

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16

OBSTETRICS

CASE: POSTPARTUM HEADACHE

A 32-year-old female presents 2 days postpartum with a headache. She has a body mass index of 40 but no other medical conditions. She had an epidural inserted during labour and a forceps delivery with no complications.

What are the possible causes of a headache in this patient?

Obstetric causes

- Hypertensive disorders of pregnancy.
- Lactation headache/hormonal changes in oestrogen and progesterone levels.
- Post-dural puncture headache.
- Cerebral vein thrombosis, haematoma or infarct.

Non-obstetric causes

- Common causes: dehydration, tension headache or migraine.
- Infective: meningitis/encephalitis/sinusitis.
- Cerebrovascular: haemorrhage, haematoma, infarct or thrombosis.
- Malignancy.
- Illicit drug use.
- Domestic violence.

How would you manage this patient initially?

- An ABCDE assessment of this patient should be carried out to include a history and neurological examination to determine the cause and rule out any sinister pathology.
- Ensure multidisciplinary team management to involve the appropriate individuals.
- Monitoring, observations and investigations should be done as directed by the initial assessment.

What is posterior reversible leucoencephalopathy syndrome?

- A syndrome is characterised by headache, seizures, altered mental state and visual loss with vasogenic oedema of the white matter affecting the posterior occipital and parietal lobes of the brain. It was first diagnosed in 1996.
- The pathophysiology of PRES is not fully understood, but it is thought to be due to the effects of hypertension on the posterior circulation in

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the brain. Disruption of auto-regulation and local cellular damage are thought to play a part, leading to cerebral oedema.
- In pregnancy, PRES is a rare but serious complication of eclampsia, and management is largely supportive while the underlying cause is treated.
- Diagnosis is by MRI.
- There is a 15% risk of mortality or permanent nerve injury.
- Treatment is with blood pressure control, anticonvulsants and renal replacement therapy if required.

What are the typical findings in the history and examination of a patient with a post-dural puncture headache?

History

- A dural puncture may have been identified at the time of the procedure (although in ~40% of PDPH following an epidural, the dural puncture was not recognised at the time of insertion).
- May be associated with multiple or difficult epidural insertion attempts, and with a low or high BMI.
- Commonly, the headache is fronto-occipital, worse on sitting or standing and improves when lying down (although in 5% of cases there is no postural element).
- Tinnitus, muffled, photophobia and neck stiffness hearing may be present.

Examination

- Nerve palsies (most commonly VIth and VIIIth cranial nerves).
- In equivocal cases, circumferential squeezing of the abdominal may alleviate the headache (caval compression causes expansion of epidural venous circulation, which in term compresses the dural sac, producing an increase in CSF pressure and temporary alleviation of the headache).

Investigations

- Observations and baseline blood tests are usually normal.

What is the initial management of a patient with a PDPH?

- Conservative management should be attempted initially, to include:
  - Hydration (ideally oral).
  - Analgesia (paracetamol and ibuprofen are safe in breastfeeding).
  - Bed-rest is no longer recommended; patients should mobilise as they feel able.
  - Monitoring and assessment either at home or on the postnatal ward.
- If the above measures fail to work, an epidural blood patch should be considered. If tinnitus or other cranial nerve palsies develop, a blood patch should be encouraged.

You are asked to insert an epidural for a patient in labour ward while on call, and note clear fluid profusely leaking from the Tuohy needle. What your immediate management?

In cases of known dural punctures, the immediate management of the patient depends on a number of different factors including the experience of the anaesthetist, the staffing on labour ward and the status of the patient.

Intrathecal catheter insertion

- The epidural catheter can be inserted into the intrathecal space and top-ups administered by an anaesthetist only, with no infusions attached.
- The catheter must be very clearly labelled and handed over to the senior midwifery and anaesthetic teams.
- Expect tachyphylaxis as labour progresses.
- This technique is likely to achieve good analgesia initially, but there is an increased risk of analgesic failure because of a lack of familiarity among the anaesthetic and midwifery staff, and the catheter may also be pulled out of the intrathecal space.

Re-do epidural

- The epidural can be re-attempted at a different space, ideally by a second anaesthetist if the first insertion was particularly challenging, or if the initial anaesthetist feels stressed or tired.
- The patient should be closely monitored by the anaesthetic team due to the potential risk of intrathecal administration of drugs via the initial puncture site. High blocks when topping up for an operative procedure are relatively common. Top-up cautiously.
- Always make sure that the dural puncture is carefully documented. Again inform the patient, and the midwifery and anaesthetic teams.

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CASE: MAJOR OBSTETRIC HAEMORRHAGE

You are asked to review a 25-year-old patient who has just delivered in the birthing suite and is now actively bleeding following an initial estimated 1.2 L blood loss.

What is the definition of a "major obstetric haemorrhage"?

- There is no universally accepted definition, but it is often classified according to one of the following markers:
  - Blood loss >1.5 L.
  - A drop in haemoglobin of >4 g/dL.
  - >4 units of blood required for transfusion.

What are the causes of obstetric haemorrhage?

Antepartum

- Placental abruption (one third of cases).
- Placenta praevia (one third of cases).
- Other causes e.g. uterine rupture (one third of cases).

Postpartum ("Four Ts")

- Tone – uterine atony.
- Trauma.
- Tissue – retained products/placenta.
- Thrombin – coagulopathic state.

How would you manage this patient?

This patient is actively bleeding and approaching the threshold for a major obstetric haemorrhage, hence she needs urgent assessment and intervention. Commonly several different teams are working to resuscitate while simultaneously controlling ongoing blood loss. The suggested management is listed below.

- Put out a major obstetric haemorrhage emergency call to include obstetric, anaesthetic and midwifery teams, blood bank and porters. Alert the consultant anaesthetist early if concerned, or according to local protocols.
- Carry out an urgent ABCDE assessment, apply 100% oxygen via a non-rebreathe mask and insert large bore intravenous access (at least 2 16G).
- Administer crystalloid fluid boluses until blood is available, and send urgent blood samples for full blood count, clotting (including fibronectin) and cross-match. Serial haemocue or blood gases can be done to obtain values for haemoglobin/lactate/calcium. Bedside measurement of clotting should be performed if available. Consider blood products after 2L of crystalloid has been given.

- Administer warmed blood and blood products early using a rapid infuser and liaise with haematology in the case of ongoing major obstetric haemorrhage. Give FFP, cryoprecipitate and/or fibrinogen if indicated. Remember that FFP does not elevate fibrinogen very effectively (the concentration of fibrinogen in FFP is often <2 g/L). Fibrinogen is often low following major placental abruptions and amniotic fluid embolism.
- O-negative blood can be given if cross-matched blood is not available.
- Consider medical and surgical intervention early to treat the underlying cause of the bleeding, and further management of patient should be done on the high dependency or intensive care unit.

What pharmacological agents can be used in the management of massive obstetric haemorrhage?

- Tranexamic acid IV (1 g)over 10 minutes followed by an infusion if indicated.
- Calcium chloride (10 mL, 10%), but the dose can be directed by serial blood gas results.
- Uterotonic agents (if uterine atony is the cause):
  - Oxytocin 5U IV followed by infusion of 40U over 4 hours.
  - Ergometrine 500 mcg intramuscular (or slow IV over 15 minutes).
  - Carboprost 250 mcg intramuscular (every 15 minutes to a maximum of 2 mg).
  - Misoprostol 1 mg rectally.

The obstetric registrar suspects partially retained placenta as the cause of haemorrhage and wants to take the patient to theatre. What are the concerns with regional anaesthesia in this patient?

- Regional anaesthesia in a hypovolaemic patient can lead to severe cardiovascular instability due to sympathetic blockade causing vasodilation.
- Coagulopathy following major obstetric haemorrhage can increase the risk of epidural haematoma if neuraxial blockade is attempted.

What are the goals in the treatment of this patient?

- The goal in this patient is to gain control of the bleeding and ensure normal physiology, using the following indicators:
  - Mean arterial pressure >70 mmHg.
  - Urine output >0.5 mL/kg/hour.
  - Haematocrit >0.3.
  - Platelets $>100 \times 10^9 L^{-1}$.
  - Fibrinogen >2 g/L.
  - Ionized calcium >1.
  - Temperature >36°C.

What are the options for surgical intervention in this patient?

- Evacuation of the uterus.
- Bimanual compression and uterine massage.
- Insertion of an intrauterine balloon (e.g. Bakri balloon).
- Internal iliac artery ligation.
- Uterine compression suture if the abdomen is open.
- Interventional radiology (arterial embolisation).
- Hysterectomy – last resort, and if possible, requires two consultant obstetricians should concur that hysterectomy is needed. However, it should not be delayed if bleeding is immediately life threatening and a second consultant is unavailable.

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CASE: NON-OBSTETRIC SURGERY IN A PREGNANT PATIENT

A 26-year-old female is booked onto the emergency theatre list for drainage of a perianal abscess. She is 30 weeks pregnant.

What added information would you like prior to proceeding with this case?

A multidisciplinary approach should be taken in the care of this patient to include surgeons, anaesthetists, obstetricians and the neonatal team due to the increased maternal and fetal risks associated with surgery during pregnancy.

Anaesthetic factors

- This patient should be reviewed and managed by a senior anaesthetist, conducting a thorough history and examination to determine her comorbidities and risk factors. In addition, take an obstetric history including parity, gestation and any complications of pregnancy.
- The main anaesthetic concerns in this patient are:
  - Increased risk of difficult airway and failed intubation.
  - Avoidance of fetal distress and hypoxia through maintenance of maternal physiology.
  - Aortocaval compression.
  - Risk of premature labour.
  - Care to minimise fetal exposure to medications, and in particular, avoid medications that are known to be harmful to the fetus or increase the risk of premature labour.

Surgical factors

- The patient should be reviewed by a consultant surgeon and the procedure should be delayed if it is not necessary, while recognising that untreated maternal infection can be harmful to the fetus and that fetal wellbeing is ultimately linked to maternal wellbeing.
- If surgery is essential, it should be performed by a senior surgical team.

Obstetric factors

- The obstetric team should be aware that this patient is undergoing surgery, and a consultant obstetrician should be informed.
- If appropriate, perioperative fetal monitoring should be conducted by a senior midwife. Most commonly, this means assessing fetal wellbeing by listening to the fetal heart rate pre- and post procedure. Very occasionally the CTG may be monitored intraoperatively, but it is difficult to interpret if the fetus has also been anaesthetised by the anaesthetic drugs administered to the mother. If intraoperative monitoring is used, a plan should be made of the appropriate course of action if an abnormal CTG is detected. This may vary from simply checking that maternal physiology is optimised, to proceeding to immediate caesarean delivery. If the latter is considered, then all the appropriate teams and equipment must be immediately to hand.
- Consideration of steroids for fetal lung maturation in case of premature labour, and the likelihood of delivery is considered to be high.

If a general anaesthetic is used, the standard for airway control would be tracheal intubation. What factors increase the risk of a difficult airway in this patient?

- Anatomical: increased breast tissue, airway oedema, and left lateral positioning leading to an altered view with laryngoscopy.
- Physiological: decreased functional residual capacity and increased oxygen demand, allowing less time for intubation prior to desaturation.
- Human factors: increased stress and anxiety, limited experience managing obstetric patients under general anaesthesia.

How would you conduct the induction of anaesthesia this patient?

- Ensure emergency drugs and equipment checked including the difficult airway trolley, attach AAGBI monitoring, machine check and patient consent/WHO checklist complete.
- Preparation for rapid sequence induction: trained assistant; senior support; discussion of the airway plan including the plan in the event of a failed intubation; cricoid pressure; suction switched on and accessible; antacid prophylaxis; and appropriate positioning of the patient (head up with left lateral tilt).
- Consider using a videolaryngoscope first-line.

- Pre-oxygenation with 100% for 3 minutes targeting an end tidal oxygen concentration of >85%.
- Induction of anaesthesia with propofol (1.5–2 mg/kg) and suxamethonium (2 mg/kg), with cricoid pressure. Consider an opiate at induction (1–2 mcg/kg fentanyl, or equivalent); the opiate does not pose a risk to the fetus as delivery is not expected, and the risk of a hypertensive response to laryngoscopy is increased in pregnant women, particularly if hypertensive diseases of pregnancy are present.
- Tracheal intubation of the patient with an appropriately sized endotracheal tube (OAA/DAS guidelines recommend a size 7.0 mm ETT as the default for pregnant women); confirmation of placement and maintenance of anaesthesia with sevoflurane/oxygen/air mixture.

In the case of a failed intubation, what factors would favour proceeding with this particular surgery rather than waking the patient up?

- The Difficult Airway Society has produced a specific obstetric intubation guideline and algorithm that guides the anaesthetist in this situation.
- Factors that would encourage waking the patient include:
  - No maternal or fetal compromise.
  - Junior anaesthetist.
  - Very high BMI.
  - Complex or prolonged surgery.
  - Patient not fasted.
- Factors that favour proceeding with surgery are:
  - Severe maternal or fetal compromise with a threat to life.
  - Consultant anaesthetist.
  - Successful placement of 2nd generation supraglottic airway device.
  - Fasted patient with minimal comorbidities.
- In this particular scenario, in the case of failed intubation, it would be prudent to follow the difficult airway algorithm, which includes calling for urgent senior help, attempting supraglottic airway device insertion and facemask ventilation, and early consideration of waking the patient.

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CASE: HYPOXIA IN A POST-PARTUM PATIENT

A 36-year-old female, who has just delivered, is complaining of dyspnoea. Her oxygen saturations are 88% on room air.

What are the possible causes for hypoxia in this patient?

Anaesthetic causes

- Opiate overdose (remifentanil, or following a general anaesthetic).
- High neuraxial blockade if epidural in situ.

Obstetric causes

- Major obstetric haemorrhage.
- Pre-eclampsia.
- Peripartum cardiomyopathy.
- Amniotic fluid embolus.
- V/Q mismatch (carboprost).

Other causes

- Pulmonary embolus.
- Sepsis.
- Anaphylaxis.
- Exacerbation of asthma.
- Myocardial infarction.
- Structural cardiac problem (valvular or septal defect).
- Arrhythmias.

What is your initial management for this patient?

- This is a medical emergency that requires urgent assessment and intervention. Initial management for this patient includes:
  - Immediate ABCDE assessment prioritising the airway and breathing to determine the cause of hypoxia and facilitate specific treatment.
  - 100% oxygen through a non-rebreathe mask and ensuring large bore intravenous access.
  - Urgent senior anaesthetic and obstetric help, with early consideration of the intensive care team if rapid deterioration.

What are the risk factors for the development of a peripartum cardiomyopathy?

- Increased maternal age.
- Multiparity.
- Ethnic minority (Nigeria, Haiti).
- Twin pregnancy.
- Chronic or new onset hypertension.
- Prolonged tocolysis.

What is the pathophysiology in patients with a peripartum cardiomyopathy?

- The pathophysiology of peripartum cardiomyopathies is complex, and is currently based on a "2 hit" model: a genetic predisposition together with the effect of prolactin.
- Prolactin is broken down into a smaller fragment (16 kDa), which is thought to exert cardiotoxic effects resulting in apoptosis and death of cardiac myocytes.
- Primarily patients display symptoms suggestive of left ventricular systolic dysfunction leading to biventricular dysfunction and cardiac failure.
- The disease cause is thought to be multi-factorial to include immune or hormone mediated, inflammatory and genetic.
- For a diagnosis of peripartum cardiomyopathy to be made, the specific criteria are:
  1. Cardiac failure at the end of pregnancy or up to five months after delivery.
  2. No other likely cause for cardiac failure.
  3. New onset of symptoms.
  4. Left ventricular dysfunction.

An urgent echocardiogram shows an ejection fraction of 32%. What are the next steps in the management of this patient?

- Stabilisation of this patient, referral to the cardiology team and admission to the coronary care or intensive care unit as appropriate.
- Multidisciplinary team management to include obstetricians, tertiary cardiology and anaesthetists.
- Medical management of acute cardiac failure using ACE inhibitors, nitrates, beta blocking agents and diuretics as directed by specialists.
- Supportive therapy and counselling for the patient and her partner.
- Severe cases may require further specialist intervention including the use of intra-aortic balloon pumps, cardiac implantable devices and left ventricular assist devices.
- Anti-coagulation and/or DVT prophylaxis should be considered.
- There is a possible role for bromocriptine in these patients; small studies currently suggest that suppression of prolactin production reduces the severity of PPCM and improves the rate of recovery.

Two years later this patient remains stable on medical therapy. She is keen to have another baby. How should she be counselled?

- Detailed medical assessment to determine her cardiac and other comorbidities, in order to evaluate whether the patient would be able to tolerate the physiological demands of pregnancy.

- Absolute contraindications to pregnancy include pulmonary hypertension and severe cardiac failure, which suggest a high risk of morbidity and mortality.
- The risks of pregnancy should be explained to the patient based on her current status. If her ejection fraction has not recovered to >50%, then the risk of mortality is 25%–50%. If her ejection fraction has normalised, there is a 20% risk of deteriorating left ventricular function during pregnancy.

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CASE: PLACENTA PRAEVIA

A 26-year-old female is being seen in the obstetric clinic. Her 20-week anomaly scan showed placenta praevia.

What is the definition of placenta praevia?

- In 2014, the American Institute of Ultrasound in Medicine recommended a change in the definition to "a condition where the placenta lies directly over the maternal os on a transabdominal or transvaginal ultrasound scan".

What is the definition of a "low lying placenta"?

- A low lying placenta is defined as a placenta whose lowest edge lies within 20 mm of the os, after 16 weeks of pregnancy.

What is the incidence of placenta praevia?

- 1 in 200 pregnancies (but this varies with the definition).
- The incidence is increasing in association with the increasing number of caesarean sections and increased assisted reproductions.

What are the risk factors for the development of placenta praevia?

- Previous caesarean section(s).
- Assisted reproduction.
- Increased maternal age.
- Previous placenta praevia.
- Maternal smoker.

You are asked to review the patient. She identifies as a Jehovah's Witness. What are the key points that you want to discuss with her?

- Ideally, this patient should be reviewed by a consultant anaesthetist in a quiet room, with no other friends or family members present.
- Establish what the patient knows about her condition and the risks associated with placenta praevia including major haemorrhage, hysterectomy and death.
- Establish the patient's wishes with respect to treatment in hospital, focusing on the exact blood products she would and would not accept, to include the use of tranexamic acid and cell salvage.
- Ensure documentation of the exact wishes of the patient in her notes and in an Advanced Directive that is signed and witnessed.

The patient is booked in for an elective caesarean section at 38 weeks of gestation. What can be done to pre-optimise her prior to surgery?

- Regular full blood count and haematinics to allow for enteral or intravenous iron preoperatively if required.
- Consider the use of erythropoietin preoperatively.
- Document the plan for pregnancy and delivery including surgical intervention, to include:
  - Site of delivery.
  - Confirming the patient's wishes at the time of delivery/bleeding.
  - Ensuring a senior obstetric and anaesthetic team.
  - Early use of multi-modal uterotonic agents.
  - Early consideration of interventional procedures in the case of major obstetric haemorrhage.
  - Early use of anti-fibrinolytic agents.
  - Checking the availability of cell salvage and any blood products that are acceptable to the patient.
  - High dependency or intensive care unit postoperatively.

How does cell salvage work?

- Blood is harvested from the surgical field using a large bore, low-pressure suction cannula.
- Amniotic fluid can be collected using a separate suction system.
- The blood anticoagulated to prevent clotting. This is usually achieved with heparin solutions but ACD-A (anticoagulant citrate dextrose) solutions can also be used.
- If enough blood is collected, it is centrifuged, washed and re-suspended in saline before being transfused back into the patient.

What are the concerns with the use of cell salvage in obstetric patients?

- There were previously concerns associated with the risk of amniotic fluid embolism in the use of cell salvage in obstetric patients.

- Some centres advocate the use of leukocyte depletion filters, but it is thought that the usual filtration process is effective in removing amniotic fluid cells from the collected blood.
- Fetal red cells are not distinguished from maternal red cells, so there is a risk of alloimmunisation and anti-D is likely to be required for Rhesus negative mothers with a Rhesus positive fetus. Local guidelines should be adhered to.

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CASE: PREGNANT PATIENT WITH CARDIAC DISEASE

A 32-year-old lady presents to the maternity day assessment unit with decreased fetal movements at 36 weeks. She has a history of rheumatic fever.

What are the different methods available to monitor fetal wellbeing in labour?

- Fetal heart rate monitoring by Pinard, doppler, cardiotocography (CTG) or a fetal scalp electrode.
- Abdominal ultrasound scan to look at fetal growth, amniotic fluid pocket size, blood flow in the umbilical and/or uterine blood vessels and/or fetal cerebral blood vessels.
- Fetal blood sampling – fetal scalp blood can give a measure of lactate and pH.
- Less common – fetal pulse oximetry and electrocardiography.

What features on the CTG suggest an abnormal trace?

The features can be classified into reassuring, non-reassuring and abnormal, and are based around the baseline heart rate (reassuring is 110–160 bpm); baseline variability (reassuring is 5–25 bpm); and decelerations (reassuring is either none, early or variable with no concerning characteristics for less than 90 minutes).

- An abnormal trace is indicated by one of the following features:
  - Heart rate below 100 or above 180 bpm.

- Acute bradycardia or a prolonged deceleration lasting for more than 3 minutes; late decelerations for over 30 minutes; or variable decelerations with concerning features in over 50% of contractions for over 30 minutes.
- Poor or increased baseline variability (<5 for 50 minutes or >25 for 25 minutes).

This patient's CTG shows a non-reassuring trace that settles, and the obstetric team would like to carry out a category 3 caesarean section. When you take a history from her, she describes feeling more tired and short of breath during the last week. A pre-pregnancy echo shows mild aortic stenosis.

How do you proceed?

This is a complex medical patient that requires input from senior obstetricians and anaesthetists, and management of the patient in this situation should include the following.

- A detailed but urgent assessment of the patient including a full history and examination, focusing on the cardiovascular system as well as anaesthetic risk and airway assessment.
- Consider an urgent ECG and echo. A clinical decision has to be made to evaluate the risk to the fetus from delay, compared to the risk to the mother from incomplete information. Whenever possible, these investigations should have occurred earlier in the pregnancy.
- This patient should ideally have been seen during pregnancy by a multidisciplinary team for a decision to be made in terms of her management during and after labour, when she is at highest risk of deterioration.
- Early escalation to consultant anaesthetist and obstetrician.

What are the anaesthetic goals in the management of this patient?

- Appropriate senior multidisciplinary care with consultant anaesthetist, obstetrician and cardiologist (and possibly cardiac surgeon).
- Consideration should be given to the site of delivery including transfer to a tertiary centre prior to delivery. Occasionally delivery is undertaken in the cardiac theatres.
- Monitoring to include invasive blood pressure monitoring.
- Consideration should be given to the effect of changes in heart rate, preload, contractility and afterload, and thus whether fluid loading or running patients with minimal fluid is appropriate. This assessment can also dictate the type of anaesthetic and the type of uterotonic that should be used.
- In this case, a general principle would be to keep heart rate low/normal, maintain contractility and afterload.
- Treat blood loss with blood products early.
- Avoidance of increases in pulmonary vascular resistance and ensure normothermia, good oxygenation and adequate analgesia.

How would you induce anaesthesia in this patient?

Both general anaesthesia and controlled neuraxial blockade have been suggested for use in this patient; the importance lies in maintenance of the anaesthetic goals listed above.

Prior to anaesthesia

- Invasive monitoring to include AAGBI monitoring as well as arterial line and central venous access.
- Ensure left lateral tilt.
- Administer antacid prophylaxis.
- Ensure good and accessible intravenous access.
- Judicious use of fluids and vasopressor agents to maintain blood pressure.
- Give oxytocin as an infusion only and avoid ergometrine and carboprost.
- Cardiac high dependency or intensive care postoperatively.

General anaesthetic

- Rapid sequence induction with agent of choice titrated to effect.
- Maintenance of anaesthesia using sevoflurane and nitrous oxide.

Regional anaesthetic

- Spinal or epidural catheter with careful, slow titration of local anaesthetic and opioid to effect.

How is a combined spinal-epidural performed?

- Ensure patient consent, intravenous access, and AAGBI monitoring.
- There are two main methods of carrying out this procedure:
  - "Needle through needle" – the epidural space is located using a standard Tuohy needle, then a spinal needle is passed through into the intrathecal space at the same level. After the spinal dose is injected, the spinal needle can be removed and the epidural catheter inserted and secured as normal.
  - "Two space" technique – the spinal injection is performed at a level above or below the epidural catheter insertion space. The epidural is usually performed before the spinal.

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CASE: INTRAUTERINE DEATH

A 27-year-old female has been reviewed in the maternity day assessment unit for decreased fetal movements. An ultrasound scan confirms intrauterine death at 34 weeks.

What is the incidence of intrauterine death?

- Approximately 5 per 1000 births.
- Approximately 20% of these (1:1000) occur at or near term (>36 weeks of gestation).
- An early stillbirth occurs between 20 and 27 weeks gestation; a late stillbirth occurs between 28 and 36 weeks gestation.

What are the main causes of intrauterine death?

The main causes are secondary to problems with the placenta and/or the umbilical cord, including abruption and umbilical cord compression.

- Multiple factors can result in poor uterine function, including:
  - Pre-eclampsia.
  - Systemic lupus erythematous or other causes of hypercoagulability.
  - Clotting disorders (haemophilia is high-risk).
  - Maternal medical conditions e.g. diabetes, heart disease, thyroid disease or infection.
  - Alcohol, recreational drug use e.g. cocaine and/or smoking.
- Birth defects (25% of stillbirths).
- Infection: either viral or bacterial directly affecting the fetus, or leading to sepsis in the mother. Common bacteria include group *B streptococcus*, *E. coli*, klebsiella, enterococcus, haemophilus influenza and mycoplasma. Rubella, herpes, Lyme disease and malaria are also well recognised.
- Trauma – can result in uterine injury, rupture, abruption or direct fetal injury.
- Intrahepatic cholestasis of pregnancy (ICP).

Antenatal causes

- Congenital malformations or infections.
- Maternal diabetes mellitus.
- Pre-eclampsia.

Intrapartum causes

- Maternal sepsis.
- Placental abruption.
- Uterine rupture.
- Excessive frequency of uterine contractions.
- Umbilical cord compression.

What are the key aspects in the management of this patient?

Supportive

- Care of the patient and partner to be provided by a senior midwife trained or experienced in intrauterine deaths.
- The patient should be managed in a room ideally located away from the main labour ward.

Method of delivery

- The decision should be made by the senior obstetric team; most of these patients deliver vaginally but a caesarean section may be indicated in some cases.
- Attempts should be made to determine the cause of intrauterine death, as this may affect management of both the current delivery, and future pregnancies.

Pain management

- The anaesthetist should be notified and assess the patient early.
- The patient can be offered a variety of modes of analgesia including oral medication, intravenous agents and neuraxial blockade.
- The patient should be assessed regularly and care should be taken to monitor her clotting and markers of infection. Derangements may preclude neuraxial blockade.

The patient has a heart rate of 135 and a temperature of 39.6°C. You are asked to review her urgently. How do you proceed?

This patient is showing signs of sepsis and needs urgent management including a rapid ABCDE assessment and instigation of treatment according to the local sepsis bundle.

- Immediate review of the patient and early escalation to senior obstetric and anaesthetic teams.
- Management of the patient should be in a high dependency area or intensive care if appropriate.
- Ensure large bore intravenous access, fluid resuscitation, anti-pyretic (paracetamol), and intravenous broad-spectrum antibiotics.
- Monitoring to include basic observations, urine output, full blood count, clotting and serial lactate levels.

What are the risk factors for the development of sepsis in pregnant patients?

Pregnancy results in an impaired immune response, so pregnant women are all more vulnerable to infection.

Obstetric

- Procedures during pregnancy e.g. amniocentesis, cervical suture.
- Prolonged labour or rupture of membranes.
- Caesarean section.
- Retained placenta.

Non-obstetric

- Comorbidities: raised BMI, diabetes mellitus, immunosuppressed state.
- Ethnic minority or poor socioeconomic status.

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CASE: PREGNANCY-INDUCED HYPERTENSION

A 31-year-old primiparous female is found to have a blood pressure of 183/96 mmHg at a routine midwife appointment. She is 37 weeks pregnant and has no other medical conditions.

What is the definition of pregnancy-induced hypertension?

- Pregnancy-induced hypertension is hypertension (more than 140/90 mmHg) that develops after 20 weeks of gestation (more than 140/90 mmHg) but with no proteinuria.

How should this patient be managed?

- Full history and examination focusing on cardiovascular history and risk factors:
  - Check whether the patient had pre-existing hypertension.
  - Any symptoms of hypertension: headache, changes in vision, dizziness.
  - Senior midwife assessment including CTG.
- Urgent medical treatment of severe hypertension according to the NICE guidelines:
  - Admit to hospital.
  - Measure blood pressure every 15 minutes until controlled below 160/110 mmHg.
  - Blood tests: full blood count, liver function tests, renal function (U+E) and PCR.
  - First-line treatment: labetalol PO (200 mg) or IV (50 mg bolus followed by infusion).
  - Nifedipine or methyldopa can be used if labetalol is ineffective or contraindicated. Do not give sublingual nifedipine as excessively rapid hypotension may occur and fetal condition may be compromised.
  - Aim for a blood pressure of <135/85 mmHg.

The patient's blood pressure is controlled and she is discharged home on oral labetalol. Four days later she presents with a severe headache and visual changes.

What is the definition of pre-eclampsia?

- Pre-eclampsia is hypertension (>140/90 mmHg) that develops after 20 weeks of gestation with proteinuria, which is defined as one of:
  - 2+ of proteinuria on a standard urine dipstick on two separate occasions.
  - Urine protein: creatinine ratio (PCR) >30 mg/mmol.
  - Protein >300 mg in a 24 hour urine collection (rarely done).

What are the risk factors for the development of pre-eclampsia?

- Personal or family history of pre-eclampsia.
- Twin pregnancy.
- Increased maternal age (>40 years).
- Pre-pregnancy raised BMI (>35).
- Maternal comorbidities: diabetes, hypertension, renal disease.

What are the goals in the management of this patient?

- Blood pressure control and strict fluid balance prior to delivery.
- Fetal monitoring (CTG).
- Prevention of progression to eclampsia.
- Close monitoring of the patient with senior obstetric, anaesthetic and midwifery input and early escalation when appropriate.

What is the indication for treatment with magnesium sulphate?

- Treatment of eclamptic seizures (4 g IV over 10 minutes followed by an infusion of 1 g/hour for 24 hours).
- Patients with severe symptomatic pre-eclampsia.

The patient is induced and would like an epidural. How do you proceed?

- The decision to site an epidural requires a risk-benefit assessment for the patient. Most individuals will benefit from neuraxial blockade, not only because of the peripheral vasodilation that occurs but also because the analgesia achieved will obtund the hypertension that occurs with contractions.
- Assessment of the patient should include any relative or absolute contra-indications to epidural placement.
- In this case, if the decision to site an epidural is made, the coagulation status of the patient should be verified first. Care must be taken to avoid large fluid boluses and to closely monitor the blood pressure following careful loading of the epidural. Early and judicious use of vasopressor agents should be used in the event of hypotension.

What are the risks associated with an epidural?

Common

- Hypotension.
- Increased incidence of instrumental delivery (not if the concentration of bupivacaine is maintained at 0.1% or below).
- Increased use of uterotonics (oxytocin).
- Increased incidence of maternal pyrexia and therefore antibiotic administration, but no increase in maternal or fetal infection risk.
- Increased duration of second stage of labour (marginal).
- Local bruising and short-term backache (but not long-term backache).

Rare

- Subdural blockade.
- Dural puncture.
- High or total spinal blockade.
- Local anaesthetic toxicity.
- Nerve damage.
- Epidural abscess.
- Epidural haematoma.

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CASE: OBESITY IN A PREGNANT PATIENT

A 34-year-old primiparous female is being assessed in the obstetric anaesthetic clinic. She has a body mass index of 46 kg/m^2.

How is body mass index classified?

According to the World Health Organization, the classification of body mass index is:

Classification	BMI
Underweight	<18.5
Normal/healthy	18.5–24.9
Overweight	25–29.9
Obese class I	30–34.9
Obese class II	35–39.9
Obese class III	40+

Although a BMI of 18.5–24.9 is defined as "normal" by the WHO, this has been re-classified by the NHS to "healthy" as a higher proportion of the population are now in the 25–29.9 category, statistically making this "normal"!

What are the risks associated with obesity in pregnancy?

Obstetric risks

- Increased risk of pre-eclampsia.
- Increased incidence of gestational diabetes.
- Increased risk of caesarean birth.
- Higher likelihood of postpartum haemorrhage.
- Overall increase in morbidity and mortality.
- Increased risk of venous thromboembolism.

Neonatal risks

- Assessment of fetal size and presentation more difficult.
- Increased risk of congenital abnormalities.
- Higher chance of stillbirth, premature birth and miscarriage.

Anaesthetic risks

- Difficult intravenous access.
- Increased risk of difficult or failed intubation.
- Increased risk of a dural puncture during epidural insertion.
- Increased risk of failure of neuraxial blockade.
- Increased risk of high or total spinal with both epidural top-up and spinal anaesthesia for operative procedures.
- Excessive sedation if sleep apnoea present.

What are the risk factors associated with the development of venous thromboembolism in pregnancy?

Pre-existing risk factors

- History of VTE.
- Known thrombophilia.
- Increasing age (>35 years).
- Raised BMI.
- Smoker.

Obstetric risk factors

- Pre-eclampsia.
- Multiple pregnancy.
- Prolonged labour or caesarean section.
- Major obstetric haemorrhage.
- Preterm or stillbirth.

Transient risk factors

- Non-obstetric surgical procedure.

- Dehydration.
- Immobility.

How should the above patient be managed in terms of her risk of VTE?

- The risk of venous thromboembolism should be assessed at her booking appointment.
- Depending on the risk, this patient may need thromboprophylaxis during the antenatal period.
- Low molecular weight heparins are the first-line agent in these patients.

The patient has been booked for induction of labour due to gestational diabetes mellitus. What are the important aspects in her management when she is admitted?

Staffing and equipment

- A senior obstetric, midwifery and anaesthetic team should be available and alerted when the patient is admitted.
- Extra equipment may be required e.g. bed, chair and retractors.

Specific anaesthetic management

- Both the anaesthetist and patient should be aware that procedures might be more challenging, including neuraxial blockade, cannula insertion and intubation. The patient should be made aware of the risks associated with this and help should be facilitated early to mitigate these.
- The benefits of an early epidural should be clearly explained to the patient, including avoidance of a general anaesthetic should a caesarean section be indicated; allowing adequate time for insertion and loading; and facilitating easier insertion during the earlier stage of labour.
- If the patient is on thromboprophylactic agents, these need to be omitted appropriately in order to facilitate neuraxial blockade.
- Regular antacid prophylaxis should be given in labour, and the patient should be limited to clear fluid only during labour to decrease the risk of aspiration should a general anaesthetic be required.
- Recovery after a general anaesthetic is a high-risk time for both aspiration and hypoventilation, and the patient should be monitored closely should this be required.

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PAEDIATRICS

CASE: CHILD WITH AIRWAY OBSTRUCTION

A 2-year-old female patient is brought into the emergency department with difficulty breathing. She is otherwise fit and well, has no allergies, was born at term and has had all her vaccinations. You are asked to review her urgently.

What are potential causes of respiratory distress in this patient?

- Infective:
  - Laryngotracheobronchitis (croup).
  - Peritonsillar abscess.
  - Bronchiolitis.
  - Epiglottitis.
  - Bacterial pneumonia.
- Obstructive/non-infective:
  - Foreign body obstruction.
  - Laryngotracheal malacia.
  - Anaphylaxis.
  - Malignancy.
  - Exacerbation of asthma.
  - Pneumothorax.
  - Pulmonary oedema.
  - Pulmonary infiltrates.
  - Non-respiratory cause.

How would you assess her airway?

- Carry out a rapid initial ABCDE assessment to identify airway patency and any imminent risk of complete airway obstruction or respiratory arrest. Escalate to a consultant anaesthetist/ENT early and as appropriate.
- If there is no immediate threat to the airway, avoid worsening the situation by upsetting the child. Consider a quiet room with the child seated on the parent's lap and avoid interventions that may cause distress precipitating total airway obstruction.

History

- Onset and duration, course (step-wise, insidious) of dyspnoea and other associated symptoms.
- Exacerbating and relieving factors.

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- Type of delivery, gestation, post-delivery course (oxygen requirement, NICU, intubation or non-invasive ventilation).

Examination

- General – GCS, rash, activity levels, cough, coryza.
- Chest movement – effort, symmetry, efficacy.
- Signs of respiratory distress – cyanosis, tracheal tug, recession, grunting, drooling.
- Breath sounds – stridor, stertor, grunting, wheeze, crackles.

Investigations

- Respiratory rate and oxygen saturations.
- Temperature.
- Heart rate and blood pressure.
- Chest X-ray – portable. Do not attempt to move the child from a place of relative comfort and safety to obtain departmental imaging.
- Treat with oxygen to maintain saturations of 94%–98% as required.

On examination you note stridor and a barking cough. Her oxygen saturations are 94% but she is alert. What are the likely pathogens underlying her illness?

- A diagnosis of viral laryngotracheobronchitis, or croup (80% of presentations of acute stridor in the UK), is likely.
- The most common cause of this is the parainfluenza virus, but it can also occur due to human coronavirus, adenovirus influenza and respiratory syncytial virus.
- Epiglottitis is less likely as she is up to date with her vaccinations and this is usually caused by Haemophilus influenza type B.

What is the initial treatment for this patient?

Treatment for croup is largely supportive. In this patient, the following measures should be considered.

- Oral dexamethasone (0.15 mg/kg) (should show clinical improvement within 30 minutes).
- Nebulised budesonide (2 mg) if unable to take oral steroids.
- Nebulised adrenaline (400 mcg/kg) (transient improvement for up to 2 hours).
- Humidified oxygen through a facemask.
- Early consideration of intubation and ventilation if any signs of clinical deterioration.

What is the Westley Croup Score?

- The Westley Croup Score was devised to assess the severity of a child's illness based on their GCS, and the presence of cyanosis, recession or stridor.

- The total score denotes a diagnosis of mild, moderate or severe croup that can direct management.

An hour later you review the patient. She is drowsy and has oxygen saturations of 86% despite being on high flow oxygen. What is your plan for airway management?

- Ensure rapid escalation to paediatric and anaesthetic senior teams, ENT surgeons capable of performing a tracheotomy, and discussion with the tertiary paediatric unit and transfer teams.
- Preparation for intubation:
  - Emergency resuscitation and difficult airway trolleys present.
  - Induction and emergency drugs drawn up appropriate to the patient's weight.
  - Airway equipment – have an appropriately sized cuffed oral endotracheal tube (with smaller tubes readily available as airway likely swollen).
  - Full AAGBI monitoring attached.
- Airway plan:
  - Where, when and how should be decided as a multidisciplinary team based upon the urgency of intubation, ease of safe transfer to theatres, a thorough airway assessment and the skill mix of the clinicians.
  - Pre-oxygenate the patient using an Ayre's T-piece with a sensible level of CPAP to splint the airways.
  - Option 1: gas induction with sevoflurane in 100% oxygen.
  - Option 2: IV induction (e.g. with ketamine) and muscle paralysis (rocuronium).

Of note: the FRCA curriculum states the potential use of Heliox in this situation. In practice this is very rarely used. It usually comes as 30:70 oxygen:helium mix (though this can vary). Benefits of its use are due to its relatively high viscosity and low density, the Reynold's number is low, increasing the chance of laminar flow and therefore reduced turbulence and a reduction in respiratory effort. The drawback is that it is hard to source and only 30% oxygen.

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CASE: EMERGENCE DELIRIUM

You are asked to review 3-year-old male patient in recovery following insertion of grommets under a general anaesthetic. He is agitated and restless, and his mother is becomingly increasingly upset by his behaviour.

What are the potential causes of agitation in this patient?

- Pain.
- Hypoxia.
- Hypoglycaemia.
- Residual anaesthetic agent.
- Hunger/thirst.
- Hypothermia.
- Sepsis.
- Need for micturition or defaecation.
- Emergence delirium.

What is your initial management?

- Review the patient in recovery with their anaesthetic chart and a full set of bedside observations including a blood glucose level and temperature to identify or rule out treatable causes.
- Reassure the mother and encourage her to try and soothe the child by holding him on the bed if appropriate.
- Consider location – quiet corner in recovery, familiar faces.
- Ensure adequate analgesia has been given and prescribed perioperatively.
- Escalate to senior paediatric anaesthetist and/or surgeons if any specific concerns.

What is emergence delirium?

- A collection of symptoms that may be displayed in children in the immediate postoperative period.
- This includes disturbances in awareness and interaction with their environment, increased motor responses and hypersensitivity to light and sound.
- Behaviours displayed include confusion, thrashing, screaming, avoiding eye contact and inconsolability.

What are the risk factors for the development of emergence delirium?

Patient factors

- Pre-school age.
- Male.
- Anxiety preoperatively.
- Anxious parent.

Surgical factors

- Ear, nose and throat surgery.
- Eye surgery.

Anaesthetic factors

- Use of short-acting volatile anaesthetic agents e.g. desflurane and sevoflurane.

How can the risk of developing emergence delirium be decreased?

- Parental and child education preoperatively, including play therapy, preoperative assessment and familiarisation with anaesthetic techniques e.g. facemask.
- Consider a total intravenous anaesthetic technique.
- Single dose of propofol (1 mg/kg) at the end of the procedure, prior to emergence.
- Consider the use of intraoperative pharmacological agents e.g. midazolam, clonidine, dexmedetomidine, ketamine, fentanyl.

What are the options for reducing preoperative anxiety in children?

Non-pharmacological

- Preoperative parental and child education e.g. videos, leaflets, pre-admission visit, familiarisation with anaesthetic technique e.g. facemask, cannula.
- Play therapy and discussions with psychologists.
- Distraction e.g. toys, books and familiar videos or music.
- Age appropriate, effective communication with the patient and their parent.
- Presence of a calm parent at induction.
- Involvement of the child in the anaesthetic e.g. choosing a "flavour" of the anaesthetic mask.
- Adjustment of environment e.g. minimal persons in anaesthetic room.
- Deep breathing and relaxation tasks if age appropriate.

Pharmacological

- Benzodiazepines e.g. midazolam (oral or buccal).
- Alpha-2 receptor agonists e.g. clonidine.
- NMDA receptor antagonists e.g. ketamine.
- Opioids.

When is the use of sedative premedication not recommended in children?

- Known or predicted difficult airway or intubation.
- Risk of hypoventilation e.g. obstructive sleep apnoea, raised BMI.
- Aspiration risk e.g. emergency surgery/child that has not been starved.
- Reduced conscious level.

- Sepsis/systemic infection.
- Allergy to anxiolytic medication.

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CASE: NEONATAL EMERGENCY SURGERY

A 17-day-old baby requires an emergency laparotomy for necrotising enterocolitis.

What is a neonate?

- A neonate is a child aged from birth to 28 days of life.

What are the indications for emergency abdominal surgery in neonates?

- Necrotising enterocolitis:
  - Perforation.
  - Failure to respond to non-surgical interventions.
- Small or large bowel perforation.
- Malrotation.
- Gastroschisis.
- Small or large bowel obstruction:
  - Hirschsprung's disease.
  - Meckel's diverticulum.

How should the patient be assessed preoperatively?

This is a high-risk patient with an increased likelihood of perioperative morbidity, mortality and complications. Preoperative assessment should be carried out by an experienced paediatric anaesthetist and discussed with the neonatal multidisciplinary team.

History

- Parental history: pregnancy, health conditions, medication and social history.
- Delivery: type, gestation and complications.
- Birth weight, current weight, and significant perinatal events.
- Any known medical conditions.

- Current physiological status (respiratory/cardiovascular support).
- Treatment so far (non-surgical/surgical) and current medication including whether the patient received IM vitamin K.

Examination

- Airway: oxygen requirement, signs that may indicate a difficult intubation.
- Respiratory: oxygen requirement, work of breathing or ventilatory settings if appropriate.
- Cardiovascular: support, signs of compromise, fluid balance, lines in situ.

Investigations

- Respiratory and cardiovascular observations.
- Arterial (or capillary) blood gas with recent trends.
- Bloods: full blood count, clotting, urea and electrolytes, glucose and cross match.
- Chest x-ray to check the endotracheal tube position if intubated and for signs of infant respiratory distress syndrome.
- Others relevant to the history and clinical findings such as echocardiogram or cranial USS.

What is the normal value of haemoglobin at this age?

- Normal neonatal haemoglobin is 17–20 g/dL due to the presence of foetal haemoglobin, which demonstrates an increased affinity for oxygen due to a reduced amount of 2,3-DPG.
- Blood volume for a term neonate is 90 mL/kg and small volumes of blood loss can be significant in terms of percentage blood volume lost. There is no consensus on appropriate transfusion triggers and this decision must be based upon the individual patient.
- By 6 months of age, the foetal haemoglobin will be largely replaced by adult haemoglobin, leading to a physiological anaemia.

What are the priorities for anaesthetising this patient?

Preoperative

- Personnel: Experienced paediatric anaesthetists, surgeons, neonatologists and trained theatre staff should be present due to the high-risk and specialist nature of this surgery. A preoperative multidisciplinary team brief is essential for careful planning and preparation of each stage.
- Equipment: Ensure appropriately sized paediatric airway equipment including a range of endotracheal tube sizes; the paediatric difficult airway trolley; correctly sized monitoring; devices used for warming both the patient and any infused fluids; and equipment required for transfer.

- Drugs: Both routine and emergency drug doses should be carefully calculated and drawn up prior to the patient being transferred to theatre to prevent any errors.
- Location: Surgery may need to be carried out on the neonatal unit if the patient is too unstable for transfer to theatre, which requires adequate planning.

Intraoperative

- Four-quadrant aspiration of the nasogastric tube prior to induction.
- Preoxygenation followed by induction using an IV, inhalational or combined technique, muscle paralysis and tracheal intubation with controlled lung-protective ventilation.
- Consider invasive blood pressure monitoring and central venous access based upon risk/benefit for the individual patient.
- Fluids: continue dextrose-containing maintenance fluids and monitor and replace ongoing losses with isotonic solutions, guided clinically by cardiovascular status, and bedside investigations. A neonate can have up to 10 mL/kg/hour evaporative losses with an open abdomen. Blood products should be considered early.
- Regular monitoring and maintenance of blood glucose and temperature.
- Intraoperative and postoperative analgesia.

What are the options for analgesia in this patient?

- A multimodal approach should be taken.
- Regular age/weight appropriate intravenous paracetamol.
- IV opioid boluses intraoperatively – dosing dependent on whether the patient will remain intubated postoperatively as there is a high risk of apnoeas in this patient.
- Local anaesthetic infiltration.
- Regional anaesthesia if appropriate (caudal/epidural) – rarely done in practice.
- Opioid infusion ± nurse controlled analgesia.

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CASE: PYLORIC STENOSIS

An 8-week-old male patient is listed for a pyloromyotomy. He was admitted to hospital 3 days ago with vomiting and dehydration. You are asked to review him prior to his procedure.

What is a pyloromyotomy?

- Surgical procedure that is carried out in patients with pyloric stenosis, a condition caused by hypertrophy of the smooth muscles of the pylorus, which leads to a functional obstruction of the gastric outlet.
- The procedure can be performed open or laparoscopically, and involves dissecting the walls of the pylorus muscle down to the mucosa to relieve the obstruction.

What are the risk factors for the development of pyloric stenosis?

- Incidence varies from 0.9–5.1 per 1000 live births.
- Overall unknown cause.
- Five times higher incidence in males compared to females.
- Increased risk with first-born babies, monozygotic twin concordance suggesting a genetic element, and premature infants.

What are the typical signs and symptoms in a patient with undiagnosed pyloric stenosis?

- Most commonly present in the first 4–6 weeks of life.
- Projectile, non-bilious vomiting after feeding.
- Failure to thrive and poor weight gain.
- Dehydration, drowsiness and failure to engage.
- Palpation of an olive-like mass in the right upper quadrant of the abdomen.

How would you assess this patient preoperatively?

History

- Parental history: pregnancy, health conditions, medication and social history.
- Delivery: type, gestation and complications.
- Birth weight, current weight, APGAR scores at birth and events since birth.
- Any known medical conditions.
- Treatment so far and current medication.

Examination

- Basic cardiovascular, respiratory and airway assessment.
- Fluid balance: the patient needs to be appropriately resuscitated prior to the procedure.

Investigations

- Bedside observations to ensure adequate resuscitation and haemodynamic stability.
- Bloods to include urea and electrolytes and serial gases; babies commonly present with a hypochloraemic, hypokalaemic metabolic alkalosis secondary to vomiting and dehydration.
- Ultrasound to confirm the presence of pyloric stenosis.

Why is this patient at increased risk of postoperative apnoeas?

- All babies under 60 weeks gestational age are at higher risk of apnoeas, and should be nursed in an appropriate setting with working apnoea monitors available.
- The vomiting of gastric contents leads to a hypokalaemic, hypochloraemic metabolic alkalosis and dehydration from water loss. The body compensates for this by:
  - Excreting bicarbonate in the urine.
  - Responding to reduced plasma volume by secreting aldosterone to favour retention of sodium and water and excretion of potassium by the kidneys.
  - As dehydration progresses, this becomes the priority and hydrogen ions are excreted by the kidneys in exchange for sodium and water.
  - Ventilation is stimulated by an increase in the concentration of hydrogen ions in cerebrospinal fluid, hence metabolic alkalosis can lead to respiratory depression.
  - Even when the metabolic disturbance in the plasma is corrected, it can take hours before equilibration with cerebrospinal fluid takes place. This explains the higher risk of apnoea in these patients.

How should induction of anaesthesia take place in this patient?

- This is elective surgery – induction should be undertaken after the patient is fully resuscitated and;
  - pH 7.35–7.45.
  - Bicarbonate equal to or under 30 mmol/L (or as per local guidelines).
  - Chloride 95–112 mmol/L.
  - Potassium 3.5–5 mmol/L.
  - Base excess −4 to −2.5 mmol/L.
- Ensure parental consent, WHO checklist, AAGBI monitoring and patency of IV access.
- Preparation for the anaesthetic should include an experienced paediatric anaesthetist, trained assistant, availability of resuscitation/difficult airway trolleys and appropriate doses of routine and emergency drugs.
- Four-quadrant aspiration of nasogastric tube (should be in situ prior to induction). Consider an ultrasound of the stomach to ensure full emptying.

- Inhalational anaesthetic with sevoflurane in 100% oxygen followed by neuromuscular blockade and intubation with an appropriately sized endotracheal tube.
- Controlled ventilation, fluids and warming perioperatively.
- Check the blood glucose regularly perioperatively as the patient is in a starved state and is usually on a maintenance dextrose infusion, so is at a higher risk of hypo/hyperglycaemic episodes.

What is your plan for analgesia in this patient?

- Postoperative pain is not usually severe.
- Regular paracetamol.
- Cautious intraoperative fentanyl.
- Local anaesthetic infiltration or consider regional anaesthesia – bilateral rectus sheath or transversus abdominis plane blocks.

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CASE: INHALED FOREIGN BODY

A 3-year-old male child presents to the emergency department with difficulty in breathing following an episode of coughing while eating breakfast an hour ago. He is otherwise fit and well, has no allergies, was born at term and has had all of his vaccinations. You are asked to review him.

What findings would suggest foreign body obstruction as a cause of his respiratory distress?

History

- The patient is commonly aged under 3 years old or orally fixated (learning difficulties/behavioural patterns).
- Sudden onset of symptoms.
- Witnessed episode of choking.
- Symptoms appear following a meal.
- Dry cough since the onset of respiratory distress.
- Lack of systemic symptoms e.g. fever and prodromal illness.

Examination

- Hypoxia.
- Signs of respiratory distress e.g. stridor and tachypnoea.

- Wheeze.
- Decreased air entry unilaterally.

Investigations

- Chest X-ray: foreign body if radio-opaque, hyperinflation on expiration and atelectasis.

What is the concern with inhalation of peanuts?

- Peanut oil released from the inhaled nut can lead to bronchial irritation, chemical pneumonitis and further complications such as oedema, an empyema or abscess, in contrast to inorganic foreign bodies.

How would you assess this patient in the emergency department?

- Rapid ABCDE assessment to identify airway patency and any imminent risk of complete airway obstruction or respiratory arrest. Escalation to a consultant anaesthetist/ENT early and as appropriate.
- If there is no immediate threat to the airway, avoid worsening the situation by upsetting the child. Consider a quiet room with child seated on parent's lap and attempt to develop a rapport.
- Take a history from the parent including a standard anaesthetic history in case the child deteriorates/dislodges the foreign body and you need to get to theatre urgently.
- Examination – the priority is to not upset or cause further distress to the child. If possible, assess:
  - Chest movement – effort, symmetry and efficacy.
  - Signs of respiratory distress – cyanosis, tracheal tug, recession and drooling.
  - Breath sounds e.g. stridor and wheeze (classically monophonic and low in acute obstruction).
- Investigations (if tolerated):
  - Respiratory rate and oxygen saturations.
  - Heart rate.
  - Chest X-ray.

On examination, there is a right-sided wheeze and decreased air entry on the same side. The patient's oxygen saturations are 94% on room air. The patient is otherwise alert and comfortable. A chest X-ray demonstrates evidence of gas trapping on the right. How do you proceed?

- Discuss the plan with a senior paediatric anaesthetist and ENT surgeons and alert the appropriate theatre team in order to facilitate the appropriate procedure (likely removal of the foreign body via bronchoscopy).
- If the patient is stable, removal of the foreign body can be delayed until he is appropriately fasted.

- The patient should be kept in a quiet location, carefully monitored until transfer to theatre.
- Do not try and attempt intravenous access, upset the child or try to make them lie down/position them against their will.
- Titrate oxygen to saturations of 94%–98% as tolerated.
- A sign of deterioration can include panic, agitation or loss of compliance. In such a situation, bedside observations may be particularly challenging. A change in behaviour should be urgently assessed by a senior member of the ENT and anaesthetic teams.

How would you anaesthetise this patient?

There are many different techniques for induction of anaesthesia for bronchoscopy, but the overriding principles are the same: maintenance of patient safety, oxygenation and anaesthesia. A multidisciplinary approach and good teamwork with the surgeons is key.

- Ensure parental consent, WHO checklist, AAGBI monitoring and intravenous access if possible.
- Preparation for anaesthetic should include an experienced paediatric anaesthetist, trained assistant, availability of resuscitation/difficult airway trolleys and appropriate doses of routine and emergency drugs.
- Premedication: avoid sedatives, and consider a weight-appropriate dose of glycopyrrolate to reduce airway secretions.
- ENT surgeons should be scrubbed in theatre.
- Inhalational induction with sevoflurane in 100% oxygen, maintaining spontaneous ventilation to avoid displacing the object further into the airway and avoid ball-valve trapping.
- Direct laryngoscopy to facilitate spraying of cords (above and below) with local anaesthetic (lignocaine 4 mg/kg) once deep anaesthesia. There is a high risk of laryngospasm; therefore, IV access should be ensured.
- Options for maintenance of anaesthesia include:
  - Sevoflurane in oxygen via the anaesthetic circuit connected to the side port of the bronchoscope ± remifentanil infusion.
  - IV propofol infusion ± remifentanil infusion.
  - Dexmedetomidine infusion.
- Continue a high inspired concentration of oxygen and avoid nitrous oxide to prolong apnoeic time and avoid potential ball-valve gas expansion.
- Bronchoscopy and instrumentation of the airway are extremely stimulating and therefore some form of opiate carefully titrated is usually required.
- Dexamethasone IV can be given intra- and postoperatively to reduce airway inflammation.
- A prolonged period in recovery is sensible and postoperative care in a suitable nursing environment to closely monitor for airway deterioration.

- Nebulised adrenaline should be carefully considered; systemic absorption is low.
- If any airway soiling present, prophylactic antibiotics may be required.
- Rarely, the patient may require continued postoperative ventilation and transfer to PICU.

In general, what are the indications for bronchoscopy in paediatric patients?

To aid diagnosis

- Tracheo-oesophageal fistula.
- Treatment-resistant pneumonia.
- Failure to wean from ventilation.

For therapeutic purposes

- Removal of foreign body.
- Mucous suctioning.
- Balloon dilation of airways.
- LASER surgery.

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CASE: POST-TONSILLECTOMY BLEED

You are asked to review a 4-year-old male patient on the paediatric ward, who had a tonsillectomy 11 hours previously. He is bleeding, and the surgeons want to take him back to theatre urgently.

What are the indications for a tonsillectomy in paediatric patients?

- Recurrent/persistent tonsillitis.
- Obstructive sleep apnoea.
- Tonsillar abscess.
- Lymphoma biopsy, or suspicious lump biopsy if unilateral tonsillar hypertrophy (rare).

Which patients are at higher risk for a post-tonsillectomy bleed?

A primary haemorrhage occurs within 24 hours of the procedure and is usually due to venous/capillary ooze from failed haemostasis. A secondary haemorrhage

occurs more than 24 hours from the procedure and is usually due to infection, most commonly 5–10 days postoperatively.

- Patient factors – male, adults (compared to children), indication for tonsillectomy (infectious > obstructive).
- Surgical factors – diathermy technique and coblation for secondary bleed.

What are your main concerns with regards to this patient?

- This is a high-risk paediatric patient.
- Medical and surgery emergency with potential hypovolaemic shock and ongoing blood loss.
- Risk of aspiration from full stomach (swallowed blood and postoperative oral intake) especially during induction of anaesthesia and extubation.
- Potential difficult airway and intubation due to local oedema, swelling and haemorrhage.
- Effect of residual anaesthetic and analgesic drugs prior to a second emergency general anaesthetic.
- Human factors for child, parents and theatre staff: anxiety/stress.

How would you assess this patient on the ward?

- Carry out a rapid ABCDE assessment to identify the risk of airway obstruction and the presence of hypovolaemic shock.
  - The volume of blood loss can be difficult to quantify as the patient swallows it – look for frequent swallowing, blood on pillow, haemostasis or haemoptysis.
- Urgent escalation to a paediatric anaesthetist/ENT.
- Allow the patient to sit upright and encourage spitting blood out.
- Apply 100% oxygen if it does not cause distress to the child.
- Obtain IV access.
- Start resuscitation if any signs of shock are present.
- Take a history from the parents/paediatric team:
  - Events since the procedure.
  - Duration of bleeding.
  - AMPLE history/review anaesthetic chart.
- Examination:
  - General – GCS and signs of active bleeding.
  - Airway.
  - Focused respiratory and cardiovascular examinations including peripheral and central pulses, capillary refill and urine output.
- Investigations:
  - Respiratory rate and oxygen saturations.
  - Heart rate and blood pressure (blood pressure is a less sensitive parameter due to the ability of paediatric physiology to compensate).
  - Temperature.

- Bloods including haemoglobin, clotting and cross match.
- Bedside haemoglobin if available (haemocue or venous blood gas, which will give lactate, haemoglobin and mixed oxygen saturations – <70% is an indicator for increased morbidity and mortality).

On examination the patient has a heart rate of 134 beats/minute, a blood pressure of 81/53 and a delayed capillary refill time. He is drowsy. How would you manage this patient?

Resuscitation

- Given the observations and signs of active bleeding, this patient is in hypovolaemic shock and requires urgent resuscitation prior to transfer and definitive management.
- Call for help – paediatric peri-arrest team and activation of the major haemorrhage protocol.
- Titrate oxygen delivery to saturations of 94%–98%.
- Intravenous access – at least two large bore cannulae (use intraosseous needle early if unsuccessful).
- Attach continuous monitoring.
- Administer 20 mL/kg fluid boluses of isotonic crystalloid over 5 minutes until blood is available; reassess the heart rate and blood pressure after each bolus and repeat if appropriate.
- Cautious suction if severe ongoing bleeding but care as it may disrupt any formed clots.

Preparation for surgery

- Notify the theatre coordinator urgently in order to facilitate preparation of surgical and anaesthetic equipment.
- Notification of senior anaesthetic and ENT team, if not already contacted, and coordinate surgical and anaesthetic plans.

Transfer to theatre

- Monitored transfer to theatre once stabilised with anaesthetist and ENT surgeon present in case of sudden airway obstruction or a major bleed.

What are the options for induction of anaesthesia in this patient?

- Ensure parental consent, WHO checklist, AAGBI monitoring and check patency of intravenous access.
- Preparation for anaesthetic should include the presence of an experienced paediatric anaesthetist, trained assistant, availability of resuscitation/difficult airway trolleys and appropriate doses of routine and emergency drugs.
- Specific equipment should include a large bore nasogastric tube and two suction devices. Blood and blood products should be present in theatre. A smaller-sized endotracheal tube than normal may be required.

- Anaesthetise the patient in theatre with surgeons present and scrubbed.

Gas induction

- Inhalational induction with sevoflurane in 100% oxygen.
- Maintenance of spontaneous ventilation.
- Induction can be done in the left lateral position and a slight head-down position to allow drainage of blood.
- The ongoing effort of breathing can help the anaesthetist identify the relevant anatomy if the airway is bloodied due to rhythmic upper airway movement and bubbles.

Intravenous induction

- Rapid sequence induction with appropriate doses of induction agents, but care must be taken due to the risk of cardiovascular collapse.
- Appropriate induction agents would be ketamine (1–2 mg/kg) and rocuronium (1 mg/kg).
- Gentle positive pressure ventilation due to the risk of aspiration.
- Titration of analgesia may be more difficult in paralysed patients, especially those with OSA.

Other considerations

- Discuss the use of 10 mg/kg tranexamic acid with surgeon – there is weak evidence in post-tonsillectomy secondary bleeds for its use.
- Thorough suctioning of gastric contents to remove swallowed blood once haemostasis is achieved, using a large bore orogastric tube.
- Rule out a nasopharyngeal clot (and risk of dislodgement with postoperative airway instrumentation).
- Extubate awake in the left lateral position.
- A postoperative course of antibiotics, dexamethasone and adrenaline nebulisers may be required.

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18

PAIN MEDICINE

CASE: FIBROMYALGIA

A 45-year-old female presents to the pain clinic with a 4 month history of widespread body pain. She has a history of asthma, for which she takes regular inhalers, and depression, for which she takes fluoxetine.

What is pain?

- As defined by the International Association for the Study of Pain (IASP) in 2020, pain is "an unpleasant sensory or emotional experience associated with, or resembling that associated with, actual or potential tissue damage".

When assessing patients with chronic pain, what are yellow flags?

- Yellow flags are used in patients with pain. They indicate the presence of psychological risk factors for the development of chronic pain. These include:
  - Anxiety and/or depression.
  - The patient favours passive treatment e.g. analgesia and ice packs over active treatment such as physiotherapy.
  - The patient does not carry out usual activities due to fear of exacerbating the pain.
  - Catastrophising of symptoms.

What is fibromyalgia?

- Fibromyalgia is a syndrome characterised by generalised pain and tenderness, together with non-specific symptoms such as fatigue and difficulty sleeping.
- The criteria for a diagnosis of fibromyalgia have been specified by the American College of Rheumatology, to include the following three factors:
  1. Widespread pain index (WPI) ≥7 and symptom severity (SS) scale score ≥5 or WPI 3–6 and SS scale score ≥9 (from a defined scoring system).
  2. Symptoms have been present at a similar level for at least 3 months.
  3. The patient does not have a disorder that would otherwise explain the pain.

What is allodynia?

- Allodynia is the sensation of pain in response to a non-painful stimulus.

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What is hyperpathia?

- Hyperpathia is an exaggerated painful response to a stimulus, with an increased threshold for the said response.

What are the risk factors associated with fibromyalgia?

- There are no specific or defined causes for fibromyalgia, but it is associated with a number of different conditions and risk factors, including:
  - Chronic fatigue syndrome.
  - Irritable bowel syndrome.
  - Interstitial cystitis.
  - Temporomandibular joint dysfunction.
  - Family history of fibromyalgia.
  - Rheumatoid arthritis.
  - Systemic lupus erythematosus.
  - Anxiety, stress and depression.
  - Female gender.

A diagnosis of fibromyalgia is made in this patient after a thorough history and examination are carried out. What are the initial treatment options for her?

Physical

- Physiotherapy.
- Graded exercise therapy.
- Acupuncture.
- TENS.

Psychological

- Cognitive behavioural therapy.
- Pain management programme.
- Acceptance commitment therapy.

Pharmacological

- Antidepressants.
- Simple analgesic agents.

Although they are commonly prescribed, NICE do not recommend the use of anti-neuropathic agents or opioids in the treatment of fibromyalgia. There is also no evidence for the use of ketamine or lidocaine.

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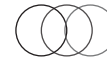

CASE: CANCER PAIN

A 63-year-old gentleman presents to the pain clinic with severe pain. He has recently been diagnosed with metastatic pancreatic cancer.

What are the potential causes of pain in this patient?

- Pre-existing comorbidities or chronic pain condition.
- Direct pain from the tumour-causing inflammation and oedema of the surrounding structures.
- Pain due to treatment (side effect of chemotherapy or radiotherapy, or postoperative pain).
- Pain arising due to complications of the cancer diagnosis e.g. osteoporosis/bone pain.

What is your approach in the assessment of this patient?

- A biopsychosocial approach should be taken to carefully assess the patient's pain.
- A full and thorough history of the patient's pain is required to determine the onset, location, type of pain and effect on the patient's life. This should be followed by the appropriate examinations and investigations.
- Pain management should be multidisciplinary, taking into account the prognosis of the patient and the likely causes of his pain. This should include oncologists, surgeons, palliative care and the acute and chronic pain teams where appropriate.
- The pain is likely to be exacerbated by psychological factors, necessitating an empathetic and holistic approach.

The patient describes severe abdominal and back pain that is worse at night. What are his analgesic options?

Pharmacological

- Simple analgesia: regular paracetamol and NSAIDs.
- Opioids: modified release morphine with immediate release agents for breakthrough pain should be considered early given this patient's severe pain and likely terminal diagnosis. The dose should be titrated carefully to minimise unpleasant side effects. If the patient is palliative, these agents can often be given through a syringe driver.
- Antidepressants or anti-convulsants if there is a neuropathic element to pain.
- Steroids can be used successfully in the management of cancer pain that occurs due to stretching of viscera and local structures. These are often also used following radiotherapy.

- Chemotherapy can lead to a decrease in pain by its direct effect on tumours.
- If the back pain is due to bony metastases, bisphosphonates may be used to target these lesions.

Interventional

- Surgery is a potential, but probably unlikely consideration in this patient due to spread of the disease. However, interventions such as stenting may help alleviate painful and uncomfortable symptoms.
- Radiotherapy may be used to target bony metastases.
- Targeted nerve destruction – coeliac plexus blockade.
- Intrathecal drug delivery may also be considered.

What are the side effects of opioid-based agents?

- Sedation.
- Constipation.
- Nausea/vomiting.
- Pruritus.
- Urinary retention.
- Respiratory depression.
- Worsening of pain (opioid-induced hyperalgesia).
- Myoclonic jerks at very high levels.

What are the complications associated with a coeliac plexus block?

- Hypotension.
- Diarrhoea.
- Major vessel injury (aorta/vena cava) and catastrophic haemorrhage.
- Intravascular injection/local anaesthetic toxicity.
- Damage to abdominal organs.
- Paralysis.
- Sexual dysfunction.

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CASE: CHRONIC PAIN

A 53-year-old female is undergoing an abdominal-peritoneal resection for small bowel cancer. She has a history of hypertension, type 2 diabetes mellitus and chronic back pain, and is a smoker.

What are the key aspects of her history that you would like to explore when she attends the preoperative assessment clinic?

- Cardiac history: duration of hypertension, agents required, and overall control. Explore whether the patient experiences chest pain, shortness of breath, ankle swelling and any other symptoms associated with ischaemic heart disease or heart failure.
- Respiratory history: smoking pack-year history (undiagnosed COPD is a possibility).
- Diabetic history: duration, control and agents including insulin. The presence of macro and microvascular complications may indicate a longstanding history and poor diabetic control.
- Chronic back pain: cause, duration, effect on activities of daily living, and treatment including non-pharmacological and medication used to control pain.
- Other comorbidities and drug/social history, allergies and previous anaesthetic history.
- Concerns and expectations of the patient during the perioperative period.

The patient has a 10-year history of back pain that is managed by the chronic pain clinic. She currently takes regular co-codamol, ibuprofen, rescue tramadol and wears a buprenorphine patch.

What can be done preoperatively to optimise management of this patient's pain during the perioperative period?

- Assessment of the patient's pain and current management, ideally in the pain clinic, but the urgency of her surgery may preclude this.
- Determine the total dose of the above agents that the patient takes on a regular basis as this will need to be continued as a baseline perioperatively. Discuss the patient's previous drug history as she may have tolerated some opioids better than others.
- Explore the effect of the patient's pain on her activities of daily living as she may need extra help/a package of care in the postoperative period when recovering from major surgery.
- Document the above information and discuss with the patient's anaesthetic and surgical team where necessary. Establish a perioperative analgesic plan that should be explained to the patient, so all questions can be answered and concerns discussed prior to surgery.

What is your plan for pain management for this patient during the perioperative period?

There is no right answer to this question, but ensure a multimodal approach to analgesia is taken that includes a range of opioid-sparing techniques. A key aspect of this is to decide whether to continue or remove the buprenorphine patch; either option can be chosen, but show that you have thought about the consequences of both.

Preoperative

- Oral paracetamol (1 g).
- Oral gabapentin (300–600 mg).
- Usual doses of codeine/tramadol, or consider conversion to modified release oral oxycodone if tolerated by the patient.
- Remove the buprenorphine patch following a discussion with the patient. Challenges faced with the presence of the patch in the perioperative period include:
  - Partial antagonism, which may lead to decreased efficacy of full opioid agonists given during the perioperative period.
  - Drug delivery may be unreliable due to the decreased blood supply to the area (causing a decrease), or increased heat in the area, increasing drug delivery.

Intraoperative

- Intravenous paracetamol (1 g).
- Intravenous fentanyl boluses titrated to effect.
- Intravenous lidocaine 1 mg/kg bolus followed by infusion of 1 mg/kg/hour (or according to the local protocol).
- Intravenous magnesium.
- Intravenous ketamine (0.5 mg/kg).
- Regional anaesthesia: spinal anaesthetic with appropriate dose of diamorphine.
- Intravenous clonidine (1–2 mcg/kg).

Postoperative

- Regular paracetamol (1 g).
- Consider NSAIDs.
- Patient-controlled analgesia with an opioid, usually morphine, but both fentanyl and oxycodone could also be considered.
- Modified release oxycodone with immediate release oxycodone as rescue analgesia.
- Tramadol as required.
- Local anaesthetic wound catheters/rectus sheath blocks, or an epidural.
- Anti-emetics and laxatives as required.
- Early review by the acute pain team and management of the patient on the intensive care or high dependency unit. This patient will need regular monitoring of her pain using an objective pain scoring system

and consideration of increased doses or addition of other agents if her pain is not under control. The pain is likely to be exacerbated by surgical trauma, positioning, anxiety and mobility. Early physiotherapy should be encouraged.

What are common signs of opioid withdrawal?

- Yawning (early sign).
- Myalgia.
- Agitation/anxiety.
- Increased sweating.
- Abdominal pain/cramps.
- Nausea/vomiting/diarrhoea.
- Insomnia.

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CASE: CHRONIC POSTOPERATIVE SURGICAL PAIN

A 36-year-old female patient is undergoing a right-sided mastectomy for breast carcinoma. She is a smoker and has a history of anxiety, but is otherwise well.

What is your plan for perioperative analgesia in this patient?

There is no absolute answer to this question – just make sure your answer is multi-modal and includes simple analgesia as well as more complex agents and techniques.

Preoperative

- Oral paracetamol (1 g).
- Oral ibuprofen (400 mg).

Intraoperative

- Regional anaesthesia e.g. serratus anterior plane block.
- Intravenous fentanyl boluses titrated to effect.
- Intravenous magnesium (2–4 g).

Postoperative

- Regular paracetamol and ibuprofen (oral).
- Intravenous fentanyl boluses may be required in recovery.

- Oral morphine.
- Oral tramadol (50–100 mg) for rescue analgesia.
- Early assessment by the pain team/surgical team if the pain does not settle.

What are the risk factors for the development of chronic postsurgical pain in this patient?

- Younger age.
- Female.
- History of anxiety.
- Breast surgery (20%–50% incidence).
- Potential prolonged procedure.
- Risk of nerve damage during the procedure.
- Possibility of radiotherapy postoperatively.

Three months following the initial surgery, this patient presents to the pain clinic with severe right-sided pain.

What factors might indicate that this patient has developed chronic postsurgical pain?

- According to the Macrae and Davies definition, the following factors would suggest that this patient has developed chronic postsurgical pain:
  - Pain that has developed after a surgical procedure.
  - At least 2 months duration.
  - No other cause of pain is likely/other causes have been ruled out.
  - Pain that does not pre-date the surgical procedure.

What are the initial management options for this patient?

A biopsychosocial approach to pain management is recommended after the initial assessment and diagnosis.

Physical

- Acupuncture.
- Physiotherapy.

Psychological

- Pain management programme.

Pharmacological

- Antidepressant drugs e.g. amitriptyline.
- Anti-convulsants e.g. gabapentin, pregabalin.
- Weak opioids e.g. dihydrocodeine, tramadol.

The patient is undergoing a breast reconstruction, and is worried about worsening of her pain. What measures can be taken to reduce this risk?

- Repeated surgery is a risk factor for the development of chronic postsurgical pain, but the following interventions have been suggested to decrease its incidence:
  - Perioperative gabapentin.
  - Postoperative local anaesthetic wound infusions.
  - Regional anaesthesia – paravertebral block.
  - Perioperative ketamine infusion.
  - Management of patient expectations and psychological strategies.

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CASE: FACIAL PAIN

A 58-year-old female presents with a 3-week history of right sided facial pain.

What is a neuralgia?

- Neuralgia is pain that is felt in the distribution of one or more nerves.

What are the potential causes of pain in this patient?

- Infective e.g. sinusitis.
- Dental pain e.g. abscess.
- Neuralgia e.g. trigeminal neuralgia, post-herpetic neuralgia.
- Trauma.
- Malignancy.
- Pain radiating from headache e.g. migraine, cluster headache.
- Vascular e.g. temporal arteritis.
- Temporomandibular joint dysfunction.

What are the typical features seen in a patient with trigeminal neuralgia?

- Pain occurs in the distribution of one or more branches of the trigeminal nerve.
- The pain is severe and described as shooting, burning or stabbing. Attacks typically last between seconds to minutes.
- The pain is often triggered by talking, eating or the feeling of wind on the patient's face.

- The patient is usually asymptomatic in between attacks of pain.
- Trigeminal neuralgia is most common in female patients above the age of 50.

Are there any risk factors associated with trigeminal neuralgia?

- Risk factors include:
  - Pre-existing multiple sclerosis.
  - Age.
  - Previous cerebrovascular event.
  - Hypertension.
  - Charcot-Marie-Tooth disease.
  - Intracranial malignancy close to the trigeminal nerve.

How would you assess this patient?

History

- Thorough history to include comorbidities, drug history and social history.
- History of the pain focusing on onset, nature of pain and triggers.
- Effect of the pain on activities of daily living.

Examination

- Neurological and cranial nerve examinations.

Investigations

- Basic observations and routine bloods can be used to rule out infective causes.
- Imaging can be considered if intracranial pathology or malignancy is suspected.

Based on her history, a diagnosis of trigeminal neuralgia is made. What are the treatment options for this patient?

Medical

- Pharmacological therapy is the first line treatment in patients with trigeminal neuralgia, with carbamazepine as the initial agent of choice. Oxcarbazepine is second line.
- Other drugs that have been used with varying degrees of success include gabapentin, pregabalin, lamotrigine and amitriptyline.

Surgical

- Trigeminal neuralgia can be treated with botox, although mainly if only the ophthalmic branch is affected and in patients where other interventions may be unsuitable.
- Peripheral nerve blockade – a non-invasive technique using alcohol or laser therapy for lysis of the trigeminal nerve branch involved.
- Trigeminal ganglion radiofrequency ablation.

- Microvascular decompression of the trigeminal nerve.
- Gamma knife radiosurgery.

What are the complications associated with microvascular decompression surgery?

- Recurrence of symptoms.
- Aseptic meningitis.
- Hearing loss on the affected side.
- Visual defects.
- Facial numbness.
- CSF leak.
- Cerebrovascular event.
- Haemorrhage.
- Death.

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19

OPHTHALMIC

CASE: PENETRATING EYE INJURY

A 34-year-old gentleman presents to the emergency department following an injury to his face with a broken glass bottle. He is intoxicated but denies any comorbidities, allergies and regular medication. He is listed for emergency surgery due to a penetrating eye injury.

What are your main concerns when assessing this patient?

- The patient is intoxicated, causing challenges for preoperative assessment and the perioperative period:
  - Potential for an incomplete or inaccurate medical and anaesthetic history.
  - Non-compliance with treatment plans, particularly if a local or regional anaesthetic technique is used.
  - An increased risk of aspiration during induction and extubation (alcohol may delay gastric emptying).
  - Possible lack of capacity to consent to the procedure.
  - Potential for additional ingestion of illicit drugs.
  - Pharmacological interaction of alcohol with anaesthetic agents.
- Unknown factors e.g. starvation status, previous anaesthetic and medical history.
- A penetrating eye injury requires careful control of the patient's physiology during the perioperative period; consider early escalation to a consultant anaesthetist.
- The history raises the possibility of other trauma if he was involved in an attack. He will need a primary and secondary survey and relevant investigations if there is evidence of other injuries e.g. bruising and bleeding.
- The urgency of surgery requires a multidisciplinary discussion with surgeons regarding the nature of the injury and potential anaesthetic risks.

What are the risks of delaying surgery in this patient?

- Infection.
- Endophthalmitis.
- Retinal detachment.
- Vitreous loss.
- Blindness.

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What are the options for anaesthesia in this patient?

- The options for anaesthesia in a patient with a penetrating eye injury are:
  - General anaesthetic.
  - Local anaesthetic ± sedation.
  - Regional anaesthetic block ± sedation.

What are the concerns with a regional anaesthetic technique in this patient?

- Poor compliance due to intoxication, including the inability to remain still during block insertion and lie flat.
- Lack of a skilled operator to facilitate the regional technique if during on-call hours.
- Risks of sedation in an intoxicated patient including loss of the airway and aspiration.
- A regional anaesthetic technique may cause increased intraocular pressure that may worsen the penetrating eye injury.

How would you anaesthetise this patient?

Given the risks discussed above, it follows that the safest technique is likely to be a general anaesthetic.

- Ensure patient consent, the presence of a senior anaesthetist and trained assistant, AAGBI monitoring, and routine and emergency equipment and drugs readily available, including antihypertensive medication.
- Consider the location of surgery: Ophthalmic theatres tend to be in remote locations, so ensure all staff are familiar with the facilities. If not, carry out the procedure in main theatres after discussing with the surgical and theatre teams.
- The priority is to ensure adequate oxygen delivery to the tissues, while limiting secondary damage from increased intraocular pressure.
- The choice of induction agents needs to favour lowering of intraocular pressure. Avoid ketamine and suxamethonium to reduce the risk of further damage secondary to transient increases in intraocular pressure. Coughing, straining and surges in blood pressure should be minimised.
- Use of a quick-acting opioid and spraying the vocal cords with a local anaesthetic will help blunt the pressor response to laryngoscopy.

Induction

- Pre-oxygenation with 100% oxygen followed by a rapid sequence induction with cricoid pressure and appropriate doses of alfentanil, propofol and rocuronium would be most suitable in this patient.
- Spray the cords with a weight-appropriate dose of local anaesthetic solution.

- Secure the airway with an endotracheal tube, followed by ventilation with oxygen, air and a volatile anaesthetic agent.
- Avoid tying the tube tie tightly due to the risk of increasing intraocular pressure as a result.

What are the concerns when extubating this patient following his procedure?

- Transient increases in intraocular pressure can cause further secondary damage, so coughing and surges in blood pressure should be avoided.
- In order to minimise the risk of secondary damage during extubation, consider:
  - Extubation while asleep and exchange the endotracheal tube for a laryngeal mask airway.
  - Using a remifentanil infusion while extubating.
  - Postponing extubation and transfer the patient to the intensive care unit.

What are the options for analgesia in this patient?

- Simple analgesia: regular paracetamol and ibuprofen.
- Weak opioids: codeine.
- Strong opioids: oral morphine or tramadol.
- Local and regional anaesthesia.

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20

PLASTICS AND BURNS

CASE: BURNS PATIENT

A 39-year-old male patient is admitted to the emergency department after a house fire with burns to his chest, back and right arm.

How can you calculate the percentage of burns in this patient, and why is this important?

- A Lund-Browder chart can be used to calculate the total body surface area of burns.
- An alternative is to use the "Rule of Nines":
  - The head, right arm and left arm each account for 9%.
  - The back, chest, right leg and left leg each account for 18%.
  - The perineum counts for 1%.
- The percentage of burns will determine the management of the patient including the volume required for fluid resuscitation and the location of definitive care (e.g. tertiary burns unit for adults with >10% dermal or full-thickness burns).

How much fluid does this patient require in the first 24 hours following the burn?

- The Parkland formula can be used to determine the fluid requirement in this patient and is calculated by multiplying the patient weight (kg) by the percentage burns by 4, to give a volume (mL).
- Half of the fluid should be given in the first 8 hours after the burn and the rest in the following 16 hours.
- Hartmann's solution is the choice of fluid in burns patients in most units.

One week following the initial burn, the patient is listed on the emergency list for wound debridement. What are the anaesthetic concerns for this patient?

Preoperative

- The patient's cardiovascular and respiratory comorbidities may be exacerbated due to the burn injury, which can pose challenges for ventilation and maintenance of haemodynamic stability perioperatively. An assessment of current oxygen requirements and cardiovascular support will aid in the formulation of an anaesthetic plan.

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- This patient has been in a house fire, suggesting that airway damage is possible. An airway assessment will help to determine the likelihood of a difficult intubation or ventilation.
- Preoperative investigations should be done to check for anaemia, deranged clotting and renal function.
- Intravenous access is likely to be difficult and limited due to the extent and location of the burns.

Intraoperative

- Temperature: Patients with high percentage burns increase their baseline temperature, so need to be managed in a warm environment with heated blankets. Fluids and blood products should also be warmed.
- Monitoring can be challenging in burns patients, and alternative sites and means for monitoring may be required.
- Ventilation: Lung protective ventilation is routine, but note that high airway pressures are common in patients with chest and neck burns.
- Drugs: Suxamethonium should be avoided due to its effect on extra-junctional receptors.

Postoperative

- The main postoperative concern is good pain management. A multimodal approach should be used with the early consideration of ketamine, neuropathic agents and opioid rotation.

What are the common complications in burns patients?

Immediate complications

- Airway obstruction.

Early complications

- Sepsis.
- Oedema.
- Rhabdomyolysis and renal failure.
- Adult respiratory distress syndrome.
- Venous thromboembolism.
- Malnutrition.

Late complications

- Chronic pain.
- Anxiety and depression.
- Chronic lung disease.

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CASE: BREAST RECONSTRUCTION SURGERY

A 41-year-old female patient is undergoing a mastectomy and immediate autologous breast reconstruction surgery for a localised malignancy. She is a smoker and has a body mass index of 35, but is otherwise fit and well with no known allergies.

What are the benefits of using the patient's own tissues for reconstruction compared to implants?

- Fewer long-term complications.
- Fewer procedures overall despite a longer initial operation.
- Enhanced aesthetics and higher patient satisfaction.

What are the different types of autologous flaps?

- Pedicled: The flap remains attached to the patient during the procedure via a pedicle and is manipulated into the correct position to be used for reconstruction e.g. latissimus dorsi flap.
- Free: The flap is removed from one part of the body and reattached at a different site.

What is the benefit of a DIEP flap over a TRAM flap?

- A deep inferior epigastric perforator (DIEP) flap allows sparing of the rectus abdominis muscles, which means:
  - A decrease in the incidence of postoperative hernias.
  - Preservation of the patient's abdominal strength.
- DIEP flaps are therefore preferred over TRAM flaps.

What are the risk factors for flap failure in this patient?

- Smoking: Cessation should be encouraged preoperatively due to the physiological effects of nicotine and carbon monoxide leading to decreased, poorly oxygenated blood flow to the flap.
- Raised BMI: Weight loss should be advised preoperatively to decrease the risk of postoperative complications and flap failure.

What are the anaesthetic goals for this procedure?

The anaesthetic goals are based on maintaining excellent blood flow to the flap during the perioperative period, which can be targeted according to the Hagen-Poiseuille equation.

- Maintenance of normothermia through adequate patient warming and core temperature monitoring.
- Ensure normovolaemia.
- Preservation of high cardiac output with low-normal systemic vascular resistance.

- Administer adequate analgesia to decrease the stress response to surgery.
- Ensure a plasma haematocrit of 30%–35% for optimal blood flow to flap.

What monitoring would you like for this patient during the perioperative period?

During induction and maintenance:

- Full minimum AAGBI monitoring.
- Core temperature monitoring.
- Invasive blood pressure monitoring.
- Urinary catheter to monitor urine output.
- Cardiac output monitoring.
- Depth of anaesthesia monitoring.

Postoperatively:

- AAGBI monitoring in PACU until awake and stable.
- Flap monitoring: colour, capillary refill, skin turgor, temperature, bleeding on pinprick and Doppler signal.

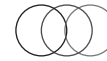
What is your plan for postoperative analgesia in this patient?

- Simple analgesia: regular paracetamol and ibuprofen.
- Opioid-based analgesia: oral morphine or morphine/fentanyl PCA if required.
- Regional anaesthesia: transversus abdominis plane block/catheter.

The surgeon asks for methylene blue dye to be injected. A few minutes later you notice a rash on the patient's chest. Her heart rate is 118 and her blood pressure is now 74/34. How do you proceed?

Given the history and examination findings, this may be an anaphylactic reaction to the methylene blue dye. This is an anaesthetic emergency. A rapid ABCDE assessment should be carried out to determine the cause (and immediate treatment as appropriate for the findings) with appropriate early escalation.

- Alert the theatre team immediately.
- Call for urgent senior help.
- Carry out a rapid assessment of the patient and management according to the anaphylaxis algorithm:
  - Apply 100% oxygen.
  - Stop injection of the dye if ongoing.
  - Elevate the patient's legs.
  - Administer a bolus of adrenaline: 50 µg intravenously with a 250 mL crystalloid fluid bolus. This can be repeated as appropriate, but an infusion should be considered after three boluses.
  - Administer chlorphenamine (10 mg) and hydrocortisone (200 mg) intravenously when the patient is stable.



    - Continuous reassessment and escalation to advanced life support algorithm if the patient deteriorates further. CPR should be commenced if a cardiac arrest occurs or if the systolic blood pressure decreases to less than 50 mmHg.
- Ongoing multidisciplinary discussion with the senior surgeon and a consultant anaesthetist to ascertain the plan for proceeding with surgery and management, based on the patient's haemodynamic stability, the likelihood of flap success and the stage of the procedure.
- Have a low threshold for postoperative management on a higher dependency or critical care unit.
- Consider mast cell tryptase levels when the patient is stable (ideally immediately, at 1–2 hours and more than 24 hours after the reaction).
- Inform the patient and their general practitioner.
- Referral of the patient to the allergy clinic, liaising with the departmental lead for anaphylaxis.
- Report the reaction to the MHRA via the yellow card pathway.

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VASCULAR SURGERY

CASE: ABDOMINAL AORTIC ANEURYSM

A 67-year-old male patient is admitted to the emergency department following a collapse with severe abdominal and back pain. He has a history of hypertension, COPD and type II diabetes mellitus. An emergency CT scan shows a leaking abdominal aortic aneurysm.

What is an abdominal aortic aneurysm?

- A dilated or widened part of the aorta of more than 30 mm within the abdominal cavity.

What are the risk factors for the development of an abdominal aortic aneurysm?

- Male gender.
- Increased age (>65 years old).
- Chronic cigarette smoker.
- Comorbidities: ischaemic heart disease, peripheral arterial disease, hypertension, hyperlipidaemia, COPD, Marfan's syndrome, tuberculosis and Takayasu's disease.
- Positive family history.

How can the risk of a spontaneous rupture be reduced?

- Regular surveillance screening to monitor aneurysm growth.
- Smoking cessation.
- Regular exercise and adequate nutrition/weight loss.
- Pharmacological agents: statins, aspirin, beta-blockers and ACE inhibitors may all play a part in reducing the risk of growth and rupture.
- Good control of blood pressure and blood glucose levels.
- Elective surgery if the aneurysm measures >5.5cm.

The vascular team want to take this patient to theatre urgently. What is your initial management of this patient in the emergency department?

This is a life threatening and time critical case that should be addressed immediately. The patient should be assessed and moved to theatre without any delays. It may be appropriate to commence a blood transfusion while transferring the patient.

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Assessment

- Immediate ABCDE assessment in the emergency department focusing on their conscious level and haemodynamic stability. It might be advisable to accept a lower than normal blood pressure to minimise further bleeding. The patient's GCS should be used as a guide: the patient should remain verbally responsive.
- Continuous bedside cardiac monitoring should be instigated. Insertion of lines should not cause any delays and can be done once the patient has been anaesthetised.
- A rapid history should be taken from the patient or their relative regarding comorbidities, current medication, allergies and previous anaesthetics. An airway assessment should also be done.

Treatment

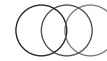
- Insert a minimum of two large bore intravenous cannulae ready for blood transfusion.
- Consider permissive hypotension. If required, a rapid infusion device may be used to restore enough of the circulating blood volume to maintain cerebral perfusion (assessed by GCS as above). The patient's blood pressure itself is not a reliable guide, particularly on the background of hypertension. Crystalloids should be avoided to reduce the risk of coagulopathy.
- Administer analgesia: intravenous opioids titrated cautiously.

Other

- Ensure escalation to the senior anaesthetic, surgical and critical care teams to ensure that the patient receives optimal care; he has a very high risk of morbidity and mortality.
- This patient may be suitable for endovascular repair, which should be discussed early with an interventional radiologist.
- Early discussion with emergency theatre staff is necessary to facilitate rapid and efficient transfer and surgical intervention, including preparation of emergency drugs and equipment e.g. cell salvage, warming and rapid infuser devices.
- Ensure urgent preparation of blood products; consider major haemorrhage protocol activation for easy access and monitoring.
- Facilitate patient transfer to theatre with emergency drugs and equipment.

What is the Hardman index?

- The Hardman index is a scoring system that can be used to predict the mortality of a patient with a ruptured abdominal aortic aneurysm. It takes into account 5 factors:
  - Age >76 years.
  - Serum creatinine >190 µmol/L.
  - Haemoglobin <9 g/dL.



  - Ischaemic changes visible on ECG.
  - Loss of consciousness following hospital admission.
- In the revised index, the risk of mortality increases to 21% with one risk factor, 60% with two risk factors and 78% with three or more risk factors.

Note that SORT and POSSUM are commonly used to assess the risk of perioperative morbidity and mortality in these patients.

How would you anaesthetise this patient?

- This is a high-risk patient with a significant likelihood of perioperative morbidity and mortality. Ideally, at least two senior anaesthetists and ODPs should be present to ensure optimal care.
- Induction of the patient should take place in theatre with the surgeons scrubbed, the patient prepped and draped, and emergency drugs and blood products readily available. This is due to the risk of decompensation on induction of anaesthesia. Clamping the aorta is likely to be necessary for rapid haemorrhage control.
- Monitoring: full AAGBI monitoring, with equipment for a catheter and arterial line ready to be placed after cross clamping, unless the patient is deemed stable enough to tolerate the delay. Temperature, cardiac output and central venous pressure monitoring should be done perioperatively.
- Ensure a minimum of two large bore intravenous access with the rapid infusion device connected and blood immediately available for transfusion. A cell saver should be readily available for use.
- Carry out a rapid sequence induction with the appropriate dose of drugs depending on the patient's haemodynamic stability. Ketamine, fentanyl and rocuronium are commonly used. Induction may lead to significant haemodynamic instability due to the side effects of the anaesthetic agents, positive pressure ventilation and abdominal muscle relaxation. Maintenance of anaesthesia should be done with a volatile anaesthetic agent.
- Following cross clamping of the aorta for haemorrhage control, the patient should be more stable, allowing insertion of auxillary monitoring to include invasive blood pressure, CVP, BIS and core temperature. Blood samples (in particular clotting screen/TEG) should be obtained to guide further treatment, and a normal blood pressure can be restored at this point.
- Management of coagulation should be done following a discussion with the surgeons, to balance the risk of bleeding against the possibility of a clot developing in the aortic graft.
- A nasogastric tube should be inserted due to the likelihood of a postoperative ileus.
- The patient should be transferred to intensive care postoperatively for further monitoring and treatment. It is likely that further stabilisation will be required prior to extubation.

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CASE: CAROTID ENDARTERECTOMY

A 65-year-old male patient is listed for a carotid endarterectomy 8 days after a transient ischaemic attack. He is a smoker with moderate COPD and hypertension and has a hiatus hernia.

What are the indications for a carotid endarterectomy following a cerebrovascular event?

- The NICE 2019 guidelines state that stable patients should undergo urgent imaging to determine the next course of treatment following a stroke or TIA.
- Two large randomised controlled trials were carried out looking at the degree of carotid artery stenosis and intervention:
  - North American Symptomatic Carotid Endarterectomy Trial (NASCET) – criteria determined that patients with 50%–99% stenosis should be considered for surgery.
  - European Carotid Surgery Trial (ECST) – criteria suggested that patients with 70%–99% stenosis should be considered for surgery.
- The criteria used should be specified when the decision is made.

What is a carotid endarterectomy?

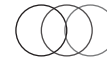
- A procedure that enables removal of atheromatous plaque from the carotid artery.
- It involves dissection of the carotid artery following cross clamping above and below the affected area.

How would you assess this patient preoperatively?

Patients suitable for this procedure benefit from surgery within 2 weeks of the onset of symptoms. This should be balanced against the risks secondary to comorbidities that could be optimised prior to surgery.

History

- Take a full medical history focusing on cardiovascular and respiratory comorbidities and the risk factors for an anaesthetic and further cerebrovascular events.



    - Determine the severity and any current symptoms of COPD, including the ability to lie flat and remain still for a prolonged period of time, as a regional anaesthetic technique may be an option.
    - These patients are likely to have disease present in other organs; have a high suspicion for undiagnosed ischaemic heart disease and renal insufficiency.
- Explore any symptoms or further episodes since the primary TIA.
- Take a full drug and social history, including control with existing agents.
- Ask about previous anaesthetics and airway assessment.

Examination

- Cardiovascular and respiratory examination.
- Airway examination.
- Any neurological deficits due to the previous cerebrovascular event should be clearly documented to enable accurate postoperative monitoring.

Investigations

- Note the oxygen saturation at rest and non-invasive blood pressure. The patient's normal blood pressure should be clearly documented.
- Baseline blood tests: full blood count, urea and electrolytes and clotting.
- The severity of the patient's comorbidities may dictate the need for further investigations such as an echocardiogram, pulmonary function tests and CPET.

What are the options for cerebral monitoring perioperatively?

- An awake patient enables continuous sensory and motor function testing throughout the procedure.
- Cerebral oximetry can be used to monitor brain perfusion.
- A transcranial Doppler probe measures blood flow in the middle cerebral artery.
- Stump pressures can detect cerebral perfusion pressure.
- Electroencephalogram (waveform changes may indicate ischaemia).
- Somatosensory-evoked potentials.
- Near-infrared spectroscopy gives an indication of changes in cerebral oxygenation.

What is the indication for a shunt?

- Cross clamping of the carotid artery relies on blood flow through the contralateral carotid artery and Circle of Willis to maintain cerebral perfusion. The restriction of flow in that artery may suggest the need for a shunt.

- A shunt can be inserted to bypass the area that has been cross-clamped if there are concerns about poor cerebral perfusion. However, the benefits of a shunt need to be weighed up against the potential risks e.g. air embolism and thrombus formation.

What are the options and benefits of a regional anaesthetic technique in this patient?

- The options for a regional anaesthetic in this patient are:
  - Local infiltration (usually inadequate).
  - Superficial cervical plexus block.
  - Deep cervical plexus block.
  - A combination of the three techniques above (most common).
  - Cervical epidural (rarely done in the UK).
- Benefits of a regional technique in this patient are:
  - Allows gold standard monitoring of neurological function and cerebral blood flow perioperatively (assuming awake patient).
  - Avoids the risks of a general anaesthetic in a high-risk patient.
  - Reduced requirement for a shunt as the patient can be monitored throughout.
  - Shorter recovery time and stay in hospital, leading to reduced postoperative complications.
  - Avoidance of haemodynamic instability secondary to administration of anaesthetic agents, reducing the risk of further cerebrovascular events.

It should be noted that the GALA study did not demonstrate a survival benefit with regional anaesthesia over a general anaesthetic.

What is hyperperfusion syndrome?

- A collection of symptoms that may occur following a carotid endarterectomy due to a sudden increase in blood flow to that side of the brain, including an ipsilateral headache and seizures.
- It can lead to focal neurological deficits and intracranial haemorrhage.
- The patient's blood pressure must be very closely monitored and maintained within a defined range to prevent patients developing hyperperfusion syndrome following this procedure.

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