Anaesthesia: what a surgeon needs to know

ABSTRACT

Surgeons and anaesthetists work closely together, sometimes in challenging circumstances. To help surgeons cooperate with anaesthetists to deliver high quality care for patients, a working knowledge of modern anaesthetic practice is useful. The specialty of anaesthetics is developing rapidly, and periodic updating of this knowledge is likely to be required.

This article provides an update of anaesthetic practice for surgeons, covering the varied roles of anaesthetists, preoperative assessment, management on the day of surgery (induction, maintenance and reversal of anaesthetic), general anaesthesia, the role of regional blocks and sedation. It also discusses safety issues, the management of frail patients and future challenges.

Anaesthetists comprise the largest single hospital specialty (Workforce and Facilities Team, 2017). Most of their work concerns perioperative anaesthetic care of the surgical patient. Many anaesthetists have important additional roles (*Table 1*).

Surgeons and anaesthetists need an understanding of each other's roles and working practices to deliver high quality care in varied and often stressful circumstances. This review outlines the working practice of anaesthetists for the benefit of surgeons.

Table 1. The roles of the anaesthetist

Preoperative preparation of surgical patients
Administration of elective and emergency anaesthesia
Resuscitation of patients in the emergency department
Obstetric and labour anaesthesia and analgesia
Intensive care medicine
Transport medicine
Pre-hospital medicine
The provision of sedation and anaesthesia for patients undergoing procedures outside the operating theatre
Pain medicine: ■ Relief of postoperative pain ■ Acute pain medicine ■ Chronic and cancer pain management

Preoperative assessment

The complexity of the assessment varies widely from the routine assessment of the uncomplicated patient before elective surgery to the resuscitation of patients before urgent emergency surgery. The aims of the preoperative assessment are (Hilditch, 2012):

- To evaluate the patient's medical and surgical conditions
- To obtain suitable investigations or further assessments
- To optimize the patient's conditions
- To provide information for patients regarding their treatment
- To plan perioperative care.

Assessment before elective surgery

Preoperative assessment clinics reduce perioperative mortality (Kamal et al, 2011), so all patients scheduled for elective surgery should attend one. The patient's current medical, surgical and drug histories are reviewed. Baseline observations are recorded, and further investigations are performed if indicated.

Most clinics are led by specialist nurses, but complex patients and those scheduled for major surgery will attend a consultant-led anaesthetic clinic (Association of Anaesthetists of Great Britain and Ireland, 2010). An assessment of risk is made which may require further investigations such as cardiopulmonary exercise testing or referral to other specialities.

Preoperative clinics also allow patients' concerns and expectations to be addressed (Yentis et al, 2017). There is the opportunity to discuss risks and benefits and allow joint decision making.

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Assessment before emergency surgery

A similar process is attempted before emergency surgery, but with significant time pressure. Tandem assessments often take place involving both anaesthetic and surgical teams (Association of Anaesthetists of Great Britain and Ireland, 2010). Effective communication is essential to explain to the patient and relatives the anaesthetic options, risks and individual factors, and to document the shared decision. Anaesthetists often assist in prioritizing emergency cases when several patients require surgery.

Assessment of the airway

Assessment of a patient's airway is of great importance before the patient is anaesthetized. An estimate of the degree of difficulty to intubate the patient can be obtained by following the mnemonic 'LEMON' (Look, Evaluate, Mallampati, Obstruction, Neck). Look for facial trauma, large incisors, a beard or large tongue. Evaluate the interincisor, hyoid-mental and hyoid-thyroid cartilage distances in fingerbreadths using the 3-3-2 rule. Assess the Mallampati score (a visual assessment of the distance between the base of the tongue and roof of the mouth; class I–IV). Assess for obstruction to intubation by identifying the presence of epiglottitis, peritonsillar abscess or trauma. Assess neck mobility, understanding that neck extension (often impaired in the arthritic elderly) facilitates intubation.

Undertaking a thorough airway assessment helps prevent emergency scenarios arising from an inability to intubate the patient.

On the day of surgery: before the anaesthetic

The anaesthetist reviews the medical and preoperative assessment notes on the ward. The type of anaesthetic planned is guided by the type and duration of surgery, patient comorbidities, patient choice and the anaesthetist's preferences. Consent must be obtained for anaesthesia after discussion of the risks and options available to the patient; this may be recorded on the anaesthetic chart or the patient's notes. Medications are checked to ensure the patient is physiologically optimized for the operation; the timing, dosage and half-lives of anticoagulants and antiplatelet agents influence the decision of when to operate on a patient and a planned operation may be postponed if these are not appropriately addressed.

Risk scoring is widely used to predict the risk of postoperative complications. These indices are derived using logistic regression analysis and subsequently validated by assessing their association with specific outcomes. Examples include the American Society of Anaesthesiologists (ASA) score, Lee's Revised Cardiac Risk Index (Lee et al, 1999), and the Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSuM). Although these scoring systems are good at stratifying patients into risk categories, they are poor at predicting individual risk (Minto and Biccard, 2014). Furthermore, these tools suffer from performance bias (where high risk individuals are given improved care compared to those who score as low risk), but serve as useful aids to discussing treatment options with patients. The choice of type of anaesthetic is strongly influenced by risk scoring.

ASA grading is part of the World Health Organization checklist for every patient. The ASA score ranks patients based on chronic disease status and estimates the chance of a complication occurring. An ASA score of I equates to 2000 complications in 100 000 cases, an ASA score of V equates to 71 000 complications per 100 000 cases (Hackett et al, 2015). The score does not draw on other relevant factors such as age, number of medical comorbidities identified or perioperative care facilities available.

On the day of surgery: in the anaesthetic room

The theatre list starts and ends with a team brief following the World Health Organization surgical safety checklist. The anaesthetic and surgical plans are reviewed. Operating department practitioners are skilled health-care professionals who provide anaesthetic care and support in the perioperative setting. Their required qualifications include a 3-year university degree in operating department practice.

Induction of general anaesthesia is performed and regional anaesthetic blocks are given in the anaesthetic room. The minimum UK monitoring standard (Association of Anaesthetists of Great Britain and Ireland guidelines) includes measurement of oxygen saturation, blood pressure, a three-lead electrocardiogram, capnography and temperature (Checketts et al, 2016)(*Figure 1*).

Once transferred to the operating table, patients are warmed (hypothermia is linked to increased morbidity and mortality; Lyder, 2003) and positioned carefully. Poor positioning can cause tissue and nerve damage. Prophylaxis to avoid deep vein thrombosis is documented, usually according to a protocol using pharmacological agents and mechanical methods.

Figure 1. Anaesthetic monitoring equipment. From left to right: blood pressure cuff, 3-lead electrocardiogram, oximeter probe.

Choice of anaesthetic technique

This is determined by surgical, anaesthetic and patient factors.

Surgical factors

The site and duration of the surgery are important. Central neuraxial blockade using spinal or epidural block can be used for pelvic or lower limb procedures, combined with either sedation or general anaesthesia. Regional anaesthesia in the form of nerve or plexus blocks can be considered for both the upper and lower limbs.

The use of a limb tourniquet can have several effects (Deloughry and Griffiths, 2009):

1. Increased systemic vascular resistance raises arterial blood pressure and central venous pressure. Cardiac failure and cardiac arrests have been reported following bilateral thigh tourniquets
2. On deflation of the tourniquet, the end-tidal carbon dioxide increases as hypercapnic blood from the ischaemic limb enters the circulation
3. The body's core temperature gradually increases following tourniquet inflation (~0.5°C) as a result of reduced heat loss from the ischaemic limb. On deflation, the body's temperature will transiently decrease as heat is redistributed
4. Tourniquet inflation will cause a hypercoagulable state as a result of catecholamine release and platelet aggregation
5. Tourniquet deflation results in a small rise in the potassium and lactate concentration of the blood, lowering its pH.

Anaesthetic factors

The anaesthetist may prefer to use anaesthetic techniques that he or she is more acquainted with.

Patient factors

The patient's comorbidities and preferences are important. Respiratory problems affect ventilation and oxygenation under anaesthesia. Cardiovascular comorbidities may make central neuraxial blockade unsuitable because of its haemodynamic side effects: the inevitable block of sympathetic outflow results in vasodilation which can be marked. Younger patients compensate for this by vasoconstriction in areas unaffected by the central neuraxial blockade but these protective mechanisms can be impaired in the elderly, in patients with diabetes and in those who take beta-blockers. Starvation status is assessed as per the European Society of Anaesthesiology guidelines: 2 hours fasting interval for clear fluids and a 6-hour interval for solids is required to undergo general anaesthesia (Smith et al, 2011).

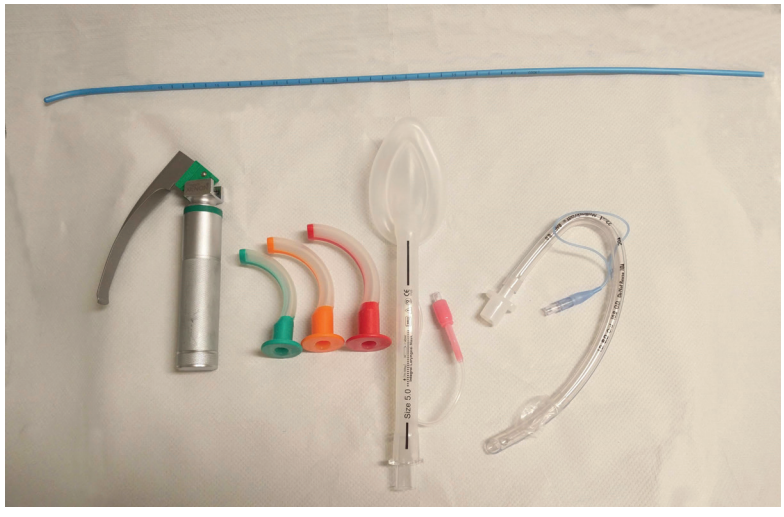

Figure 2. Common airway devices. From left to right: laryngoscope, three oropharyngeal airways, laryngeal mask airway, endotracheal tube. Top: bougie.

General anaesthesia

General anaesthesia is the induction of the patient into a state of unconsciousness (Franks, 2008). Induction of general anaesthesia requires a combination of a strong analgesic and a hypnotic agent with or without a muscle relaxant. The three steps of general anaesthesia are:

1. Induction: the patient enters an unconscious state
2. Maintenance: anaesthesia is maintained through continued administration of anaesthetic agents
3. Emergence: baseline physiology is re-established.

Anaesthesia is maintained using either a volatile anaesthetic agent (e.g. sevoflurane) or an intravenous infusion of propofol. An airway device is used in most cases to ensure airway patency and to allow for controlled ventilation (Cook, 2003). The patient's ventilation needs to be closely monitored and controlled.

Specific physiological parameters monitored during anaesthesia usually include electrocardiogram, pulse oximeter waveform, capnograph waveform, inspired/expired gas and anaesthetic agent concentration, blood pressure, heart rate and temperature.

Supraglottic airway devices which fit the oropharynx (e.g. laryngeal mask airway) are easy to use but do not protect the airway from aspiration of stomach contents. They are unsuitable for long cases, emergencies, unstarved patients or abdominal surgery. An endotracheal tube is the 'gold standard' of airway management but requires paralysis and can be technically difficult to insert (*Figure 2*).

Establishing a definitive airway is not always uncomplicated. The difficult airway trolley contains equipment designed to assist with difficult intubation. The contents of the trolley are outlined in *Table 2*. The Difficult Airway Society published evidence-based guidelines for difficult intubation in 2015 (*Figures 3* and *4*) (Frerk et al, 2015). These guidelines help address the anaesthetic emergency 'can't intubate, can't ventilate', a rare but life-threatening situation which anaesthetists can be faced with. Simulation training is an effective learning resource to improve performance during such rare anaesthetic emergencies (Chang, 2013).

Rapid sequence induction is a method of inducing anaesthesia in the emergency setting (often for emergency surgery) in patients who are at risk of aspiration of gastric contents. The essential steps include preoxygenation,

Table 2. Difficult airway trolley contents

Top of trolley	Flexible intubating fibrescope
Side of trolley	■ Bougies ■ Aintree intubation catheter ■ Airway exchange catheter
Drawer 1	■ Short handle laryngoscope ■ McCoy blade and/or straight blade ■ Videolaryngoscope
Drawer 2	■ Laryngeal mask airway sizes 3,4,5 ■ Intubating laryngeal mask airway sizes 3,4,5 ■ Fibreoptic adjuvants
Drawer 3	■ Face masks ■ Oropharyngeal airways ■ Nasopharyngeal airways ■ Laryngeal mask airway or Proseal laryngeal mask airway sizes 3,4,5
Drawer 4	■ Large bore cannula device ■ Scalpel (No. 20 blade) ■ Tracheal dilator or tracheal hook ■ Bougie ■ Cuffed tracheal tube sizes 6,7
Drawer 5	■ Kink-resistant jet ventilation cannula ■ High and/or low-pressure ventilation system

intravenous induction, cricoid pressure and insertion of a tracheal tube before ventilating the lungs (Sinclair, 2005).

During anaesthesia, additional drugs may be required. Analgesic drugs usually include opioids, paracetamol and non-steroidal anti-inflammatory drugs. Intravenous fluids and anti-emetics are also administered (Enzler et al, 2011).

Regional anaesthesia

Regional anaesthesia is the application of local anaesthetic to a sensory nerve to induce temporary nerve blockade. This avoids many of the complications and side effects of general anaesthesia (e.g. cardiovascular and respiratory compromise) and provides good analgesia in the early postoperative phase. Regional anaesthesia for orthopaedic patients is associated with improved outcome measures (pain control, improved comfort, early mobilization and hospital discharge) (Stundner et al, 2014).

Central neuraxial blockade

Central neuraxial blockade (spinal or epidural anaesthesia) is used for lower limb arthroplasty (hip and knee), obstetric and urological procedures. Local anaesthetic is infiltrated into the subarachnoid or epidural space in spinal or epidural anaesthesia respectively. A side effect is dose-related hypotension. This is managed with intravenous fluid and vasopressors. Post-dural puncture headache is associated with inadvertent puncture of the dura by an epidural needle.

Regional blocks

Regional blocks are commonly used for upper and lower limb surgery, in conjunction with sedation or general anaesthesia. Local anaesthetic is injected around an individual nerve or plexus. An interscalene plexus

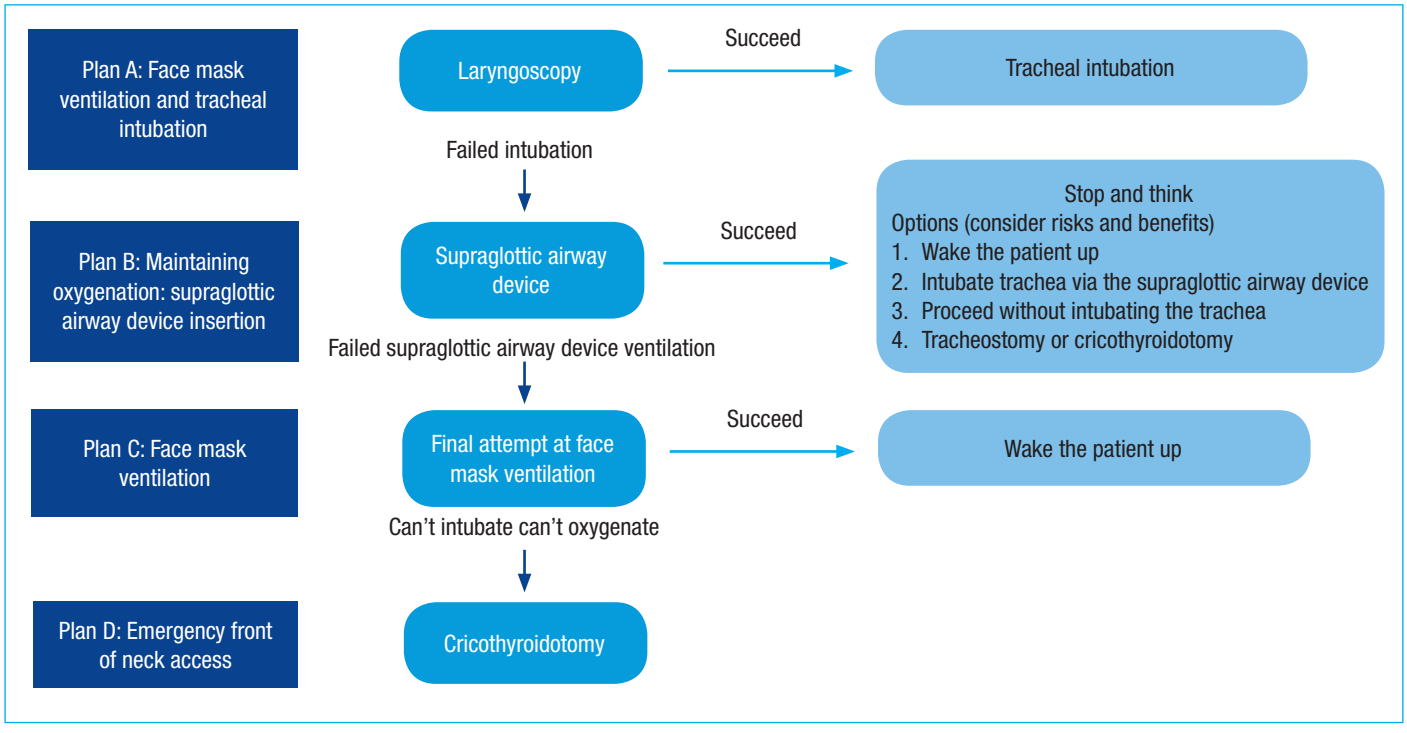

Figure 3. Difficult intubation guidelines. From Frerk et al (2015).

block is commonly used in shoulder surgery and axillary plexus block for hand surgery. For shoulder surgery local anaesthetic infiltration of the deltoid may be equally effective (Sabesan et al, 2017).

Anatomical knowledge is essential for regional anaesthetic techniques. Care must be taken to avoid damage to local structures and to avoid inadvertent intravascular injection. Pharmacological knowledge of the dose and duration of action of the drugs used is also important.

Sedation

Sedation is a spectrum of drug-induced states, from light anxiolysis to full general anaesthesia (Rowe and Fletcher, 2008). Sedation is often used in combination with regional anaesthesia or to reduce stress for the conscious patient. Respiratory support should not be required beyond the provision of supplemental oxygen. Basic monitoring should be used in all cases (Checketts et al, 2016).

On the day of surgery: recovery from anaesthesia

As surgery concludes, the hypnotic anaesthetic agent is discontinued to restore patient consciousness. The degree of muscle relaxation, if used, should be assessed with a peripheral nerve stimulator and may require reversal.

Patients with supraglottic airway devices in place may be transferred to the recovery area when breathing spontaneously. Patients who have been intubated with an endotracheal tube are extubated in theatre before being taken to recovery. The process of extubation can be challenging in patients who are obese, have pulmonary disease or after prolonged surgery. A significant drop in oxygen saturation following extubation may prompt re-intubation.

The postoperative destination of patients is decided during the preoperative team brief. The high dependency unit is suitable for patients requiring ongoing postoperative single organ support or who are undergoing high risk surgical procedures. The intensive therapy unit is suitable for patients requiring postoperative ventilation or multiple organ support. Lack of intensive therapy unit beds is associated with prolonged hospital stay and readmission (Kim et al, 2016).

The patient's anaerobic threshold, a quantitative measure determined by preoperative cardiopulmonary exercise testing, is a good predictor of postoperative mortality attributed to cardiorespiratory problems and can be used to identify patients who would benefit from a high dependency unit or intensive therapy unit recovery bed (Older et al, 1999).

Interestingly, there is limited high-quality evidence that routine postoperative care in a high dependency unit or intensive therapy unit improves postoperative outcomes, mainly because no randomized control trials have addressed this. The benefit of postoperative admission to high dependency unit or intensive therapy unit in high risk surgical patients is suggested instead by observational studies looking at patients refused such admission (Sobol and Wunsch, 2011).

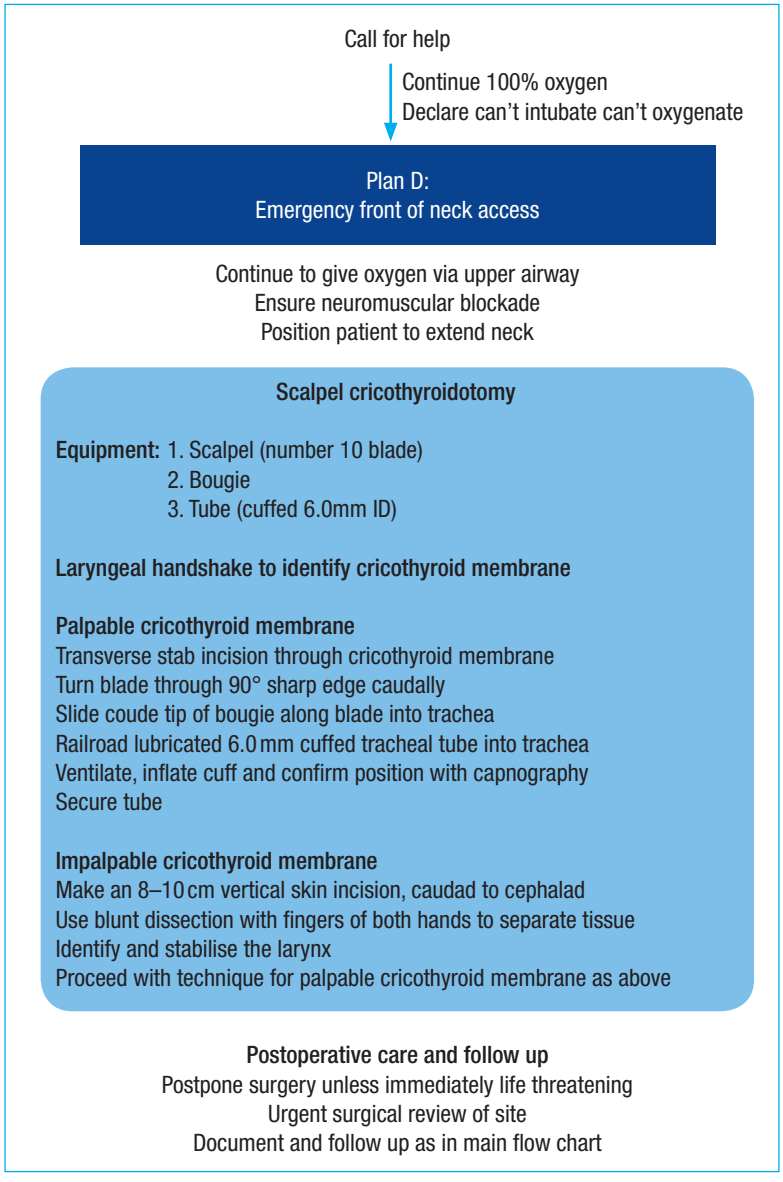

Figure 4. Emergency front of neck access. From Frerk et al (2015).

Safety and perioperative care

Historically, anaesthesia was associated with significant morbidity and mortality. There remains a strong culture of patient safety in anaesthetic teaching and practice. Although the mortality rate associated with intraoperative anaesthesia is now low (<1 in 50 000 deaths), the number of preventable deaths continues to cause concern (Ghaferi et al, 2009).

To address these concerns and improve the quality of care there is increasing standardization of care (e.g. use of checklists and guidelines) and inclusion of quality improvement science in anaesthetic practice (Wittenberg and Leitch, 2014).

The National Emergency Laparotomy Audit (NELA), instigated in 2014, set key standards for the perioperative management of patients undergoing an emergency laparotomy to try to improve outcomes (NELA project team, 2015). Information collected includes level of consultant involvement, availability of preoperative computed tomography, serum lactate level, operation time in the day, postoperative location, perioperative complications, unexpected escalation to intensive or higher dependency care, return to theatre, length of hospital stay and 30-day mortality rates.

Advances in perioperative anaesthesia and patient monitoring in the perioperative setting have contributed to improved morbidity and mortality in surgical patients (Buhre and Rossaint, 2003). Monitoring of organ systems includes:

Cardiovascular monitoring

- Basic: electrocardiogram, blood pressure, heart rate
- Advanced: cardiac filling pressures, cardiac output, mixed venous oxygen saturation.

Respiratory monitoring

- Capnometry
- Pulse oximetry.

Depth of anaesthesia

- Electroencephalography
- Patient response to evoked potentials.

Body temperature monitoring

- Inner ear, oesophagus, blood, urinary bladder temperature.

Neuromuscular function monitoring

- Measuring response of a muscle to electrical stimulation of a peripheral motor nerve (e.g. adductor pollicis).

The cardiovascular and respiratory systems are affected during anaesthesia and close monitoring of these vital systems is essential in the perioperative phase. Monitoring the depth of anaesthesia is useful because of the (rare) reporting of patient awareness during anaesthesia but also serves as an aid for accurate anaesthetic drug dosage (Schwilden and Schüttler, 1999). Intraoperative hypothermia causes an increased oxygen requirement during recovery as well as a higher risk of wound infections (Kurz et al, 1996). Neuromuscular blockade can contribute to postoperative pulmonary complications and the use of clinical signs for estimation of neuromuscular function has been shown to be unreliable, mandating the measurement of muscle response to an electrical stimulus.

Although perioperative medicine is supported by a multidisciplinary team of physicians, anaesthetists are well placed to lead this emerging field, possessing an ideal portfolio of training and experience (Grocott and Pearse, 2012).

The importance of ongoing dialogue between surgeons and anaesthetists in the perioperative period cannot be overstated. Both teams can influence the patient's physiology and must work together to achieve this. This is highlighted during damage control surgery, a subset of damage control resuscitation where surgery is used to aid in short-term physiological recovery through close communication between anaesthetist and surgeon.

Elderly patients

The anaesthetic care of the elderly patient can be challenging. Some key issues are highlighted in *Table 3*.

Frailty assessment tools are now frequently used to predict perioperative mortality and guide patient selection for surgery (e.g. Edmonton Frail Scale, PRISMA-7 questionnaire, Easycare assessment) (Shem Tov and Matot, 2017). Frail patients have a reduced ability to respond

Table 3. Anaesthetic concerns in frail elderly patients

Preoperative care	Medical comorbidities Confusion Pain management Drug history Consent	■ Cardiovascular comorbidities are commonest ■ Most patients in the elderly age group will be American Society of Anesthesiologists (ASA) score II or above ■ Dementia and delirium in hospital ■ Communication difficulties ■ Medication side effects ■ Drug interactions ■ Capacity to consent – may need a consent form for adults who lack the capacity to consent to an investigation or treatment (Consent Form 4) ■ Difficult to establish capacity
Intraoperative care	Fluid balance Temperature	■ Dehydration leading to renal failure ■ Overhydration leading to cardiac failure ■ Impaired ability to increase metabolic rate
Postoperative care	Pressure ulcers Nutrition	■ Reduced mobility ■ Impaired swallowing

to perioperative physiological stresses. For these patients, analgesic and sedative effects are achieved at lower drug doses than those required for younger patients. The duration of action of neuromuscular blocking agents can be variable and unpredictable, so perioperative neuromuscular monitoring is crucial. As age makes patients increasingly vulnerable to such stressors, particularly in the presence of an increased risk of multiple comorbidities, a multidisciplinary approach is required to give them the best outcomes, involving input from GPs, emergency medicine doctors, surgeons, elderly medicine physicians and anaesthetists (Ngwa and Kar, 2016).

Postoperative cognitive dysfunction and postoperative delirium are common in the elderly population and can be difficult to diagnose (Rasmussen et al, 2001). Intervention programmes, geriatrician liaison and targeted postoperative care reduce the incidence of both and improve outcomes (Deiner and Silverstein, 2009).

Current and future challenges for anaesthesia

Anaesthesia is facing several challenges at a number of health-care levels (Peden et al, 2017).

At a patient–clinician level, medication errors and adverse drug events still occur. A large observational study undertaken at a Boston teaching hospital demonstrated that 5% of perioperative medication administrations resulted in an error or adverse drug event, a third of which were 'preventable' adverse drug events (Nanji et al, 2016). A preventable adverse drug event is a result of an error in the use of a drug, for example a coma as a result of a sedative overdose. Further development in evidence-based pathways for systematically identifying perioperative medication errors and implementing solutions is required.

At a specialty level, the role of the anaesthetist in affecting patient outcomes is yet to be clarified. Financial incentives may drive this, rewarding hospitals and anaesthetic departments for improved postoperative patient outcomes in high-volume anaesthesia centres (Peden et al, 2017). There is evidence that an anaesthetic centre's experience and procedure volume can affect re-admission rates (National Emergency Laparotomy Audit, 2016).

At a population level, the ageing western population means that anaesthetists are challenged by frail patients with multiple comorbidities and a lack of physiological reserve, prompting closer collaboration with geriatric physicians. Co-management of elderly patients with a geriatric team has improved outcomes for patients sustaining proximal femoral fragility fractures (Grigoryan et al, 2014). In future these patient needs may prompt the development of new specialties such as the geriatric anaesthetist and the perioperative physician (Grocott and Pearse, 2012).

On a less clinical note, burnout among health-care professionals impairs patient care. This is abundant where clinicians work daily in stressful situations in specialties such as anaesthesia. In the future, a more supportive working environment for all hospital staff needs to be considered (Salyers et al, 2017).

KEY POINTS

- Preoperative assessment of all patients is essential in both the elective and emergency setting.
- Effective communication between the anaesthetist, patient, surgeon, theatre team and ward staff is a key factor in safe and successful care.
- Surgeons should be aware of the risks of anaesthesia.
- The progress of the anaesthetic depends on factors related to the surgical procedure, anaesthetist and the patient's medical status.
- Anaesthesia is facing challenges to improve long-term patient outcomes following surgery.

Conclusions

Anaesthetics is a broad specialty and anaesthetists undertake a number of roles within hospitals. They have many different techniques at their disposal and need up to date and diverse technical skills. Their main future challenges involve the care of frail and elderly patients and increased scrutiny of their influence on outcome. To improve the standards of care, increasing subspecialization is likely in the future, with the creation of new roles such as the geriatric anaesthetist and perioperative physician. Surgeons and anaesthetists are likely to depend on each other's skills increasingly in the future. **BJHM**

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Figures 3 *and* 4 *are reproduced from Frerk et al (2015).*
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