SECTION 1 Clinical anaesthesia

CHAPTER 1 Preoperative management

Gwenda Cavill and Karen Kerr

The safe conduct of anaesthesia requires meticulous preoperative assessment, preparation and planning. In the case of elective procedures this should occur well in advance of surgery, allowing a comprehensive review of concurrent disease, medication and social issues. This is often carried out in a dedicated preoperative assessment clinic by a multidisciplinary team comprising nursing and medical staff as well as pharmacists and specialist technicians.

While patients undergoing emergency surgery may not benefit from such a structured approach to their preoperative management, they must nevertheless undergo rigorous systematic review and preparation to ensure optimum care.

Preoperative assessment

Screening

When elective surgery is first planned, a screening questionnaire may be used to provide information regarding comorbidity that may require early preoperative review or intervention. A need for additional specialist input can be identified and acted upon at this stage.

Preoperative assessment clinic

During subsequent preoperative assessment a general medical history is taken, detailing concurrent disease and its management.

- Correspondence in the clinical notes may provide a useful outline of a disease process, giving some indication of its stability, as well as information on previous hospital admissions, current medication and recent investigation results.
- A history should be taken of previous anaesthetic experience. A family history of problems associated with anaesthesia must be noted and may require further investigation.
- The patient's general health should be assessed. In particular a history of reflux should be noted, along with smoking and alcohol habits.
- A history of recreational drug use may be appropriate.
- A list of current medication, including dosage and recent changes, is essential, along with a history of any allergic or other adverse drug reactions. The nature of the allergy or reaction should be recorded.

Fundamentals of Anaesthesia, 4th edition, ed. Ted Lin, Tim Smith and Colin Pinnock. Published by Cambridge University Press. © Cambridge University Press 2017.

- Particular attention must be paid to drugs requiring specific perioperative management, such as anticoagulants or insulin.

A general physical examination must be carried out prior to anaesthesia and surgery.

- Of particular importance is a focused examination of the cardiorespiratory system. This aims to ensure control of conditions such as hypertension, but also to detect features such as new cardiac murmurs. The latter may require further investigation.
- A functional assessment is particularly important in patients with cardiorespiratory disease. This will be considered in more detail below.
- An assessment of the cervical spine should be made in patients with conditions likely to limit neck movement. Radiological examination is seldom necessary, but limitation of movement should be defined and recorded. The presence of neurological symptoms or signs will require further evaluation.
- The presence and location of any loose or damaged teeth should be noted, as well as dentures, crowns and orthodontic appliances.
- Airway assessment is of fundamental importance, and is generally carried out at the time of the anaesthetist's preoperative visit.

Preoperative assessment of functional capacity

Functional capacity (what a patient can physically do) not only describes exercise tolerance but gives an indication of functional reserve (the extent to which that patient can be physically challenged). This is particularly important in the preoperative assessment of surgical patients with cardiac disease.

Gross limitation or deterioration of functional capacity is of particular significance, and indicates the need for further assessment, including investigation and specialist opinion. When considered along with clinical (mainly cardiac) factors and the planned surgical procedure, an estimate of functional capacity helps us to make an assessment of perioperative risk.

We can express functional capacity in so-called *metabolic equivalent* (MET) units (Figure 1.1). A MET is expressed in terms of oxygen utilisation, and quantifies the estimated amount of energy expended at different levels of physical activity.

Figure 1.1 MET units

1 MET equates to 3.5 millilitres of oxygen per kilogram body weight per minute	
Metabolic equivalents of common daily activities	
1 MET	walk 100 metres on level ground
4 MET	climb a flight of stairs or walk up a hill
> 10 MET	strenuous exercise

A functional capacity corresponding to < 4 MET (unable to climb a flight of stairs) is associated with increased perioperative risk. A more detailed assessment can be made by referring to an activity scale such as the Duke Activity Status Index. The answers to series of questions related to daily activities provide a score related to functional capacity. Great care is needed in making such assessments, as function may be limited by factors such as arthritis or neurological disease. In such cases more specific symptoms such as orthopnoea or paroxysmal nocturnal dyspnoea are helpful in identifying cardiac disease as the factor limiting functional capacity.

A number of baseline investigations may be carried out at the time of preoperative assessment. These typically include a full blood count, electrolytes and a 12-lead electrocardiogram (ECG). Pulmonary function tests may prove helpful in some patients with respiratory disease. There are, however, comprehensive guidelines available to minimise unnecessary investigations in fit young patients. Further investigation must be guided by underlying disease and functional status. Additional blood tests, for example, might be required to assess thyroid or liver function.

In some cases there may be a need for radiological investigation, echocardiography and, occasionally, cardiopulmonary exercise testing. Such investigations should only be sought following discussion with experienced clinicians. These investigations place a heavy demand on technicians and may themselves carry risks for the patient. The likely benefits must therefore be carefully weighed up.

Some patients with serious comorbidity may be referred by the preoperative assessment clinic at this stage for further assessment by a senior anaesthetist.

Written information regarding anaesthesia and specific surgical procedures is often provided to patients at this time.

Preoperative visit

A preoperative visit by an anaesthetist is essential, and increasingly occurs on the day of surgery. Such a visit provides an opportunity for introductions, confirmation of medical conditions and an explanation of the anaesthetic role.

A general medical and surgical history is often already available, and can be discussed in further detail. Specific issues regarding previous anaesthesia and associated problems are discussed. Earlier examination findings should be available following preoperative assessment. Examination of dentition and neck movement, along with an assessment of the airway, must be made at this stage. A plan of care, including proposed anaesthetic technique, postoperative analgesia and fluid management, can be outlined to the patient.

A discussion regarding the risks and benefits of proposed procedures is usually much appreciated. This also provides an opportunity to discuss any concerns the patient may have regarding specific issues such as postoperative nausea and vomiting, and duration of immobility following regional anaesthesia.

An effective preoperative visit should do much to allay anxiety, leaving the patient well informed and confident in those caring for him or her. It may well preclude the need for premedication.

The airway

Failure to achieve adequate oxygenation and ventilation is responsible for a significant proportion of anaesthesia-related morbidity and mortality. Inadequate ventilation and difficult intubation are everyday hazards in anaesthesia and can prove catastrophic. Given the fundamental importance of adequate oxygenation, recognition of the 'difficult to ventilate' patient is essential. A number of factors are associated with difficulty in mask ventilation:

- Obesity
- Beard
- Edentulous
- Snoring
- Age > 55

Ease of intubation has been graded according to the best possible view obtained on laryngoscopy (Cormack & Lehane 1984; see Figure 2.4). Grades 3 and 4 are difficult intubations:

- Grade 1: whole of glottis visible
- Grade 2: glottis incompletely visible
- Grade 3: epiglottis but not glottis visible
- Grade 4: epiglottis not visible

The reported incidence of difficult intubation varies, but is around 1 in 65 intubations. Despite careful history and examination, 20% of difficult intubations are not predicted. The consequences may be disastrous. A history of previous difficult intubation is important, but a history of straightforward intubation several years earlier may be falsely reassuring as the patient's weight, cervical spine movement and disease process may all have changed. Some congenital conditions may predict a difficult intubation, e.g. Pierre Robin syndrome, Marfan's syndrome or cystic hygroma. Pathological conditions can make intubation difficult, e.g. tumour, infection or scarring of the upper airway tissues.

Airway assessment

As airway assessment, investigation and management becomes increasingly refined, the search for a single, reliable predictor of the difficult airway continues. A number of bedside tests are available to the anaesthetist wishing to make an assessment for features which might predict potential airway difficulties. However, unexpected airway problems can and do arise despite the ever-increasing array of assessment tools available to us. This should be borne in mind at all times.

In the modified Mallampati scoring system the patient sits opposite the anaesthetist with mouth open and tongue protruded. The structures visible at the back of the mouth are noted (Mallampati *et al.* 1985, Samsoon & Young 1987), as follows:

- Class 1: faucial pillars, soft palate and uvula visible
- Class 2: faucial pillars and soft palate visible, uvula masked by base of tongue
- Class 3: only soft palate visible
- Class 4: soft palate not visible

The Wilson risk factors may provide additional predictive information on the airway. The Wilson risk factors each score 0–2 points, to give a maximum of 10 points. A score greater than 2 predicts 75% of difficult intubations, although as with the Mallampati system there is a high incidence of false positives. The Wilson risk factors (Wilson *et al.* 1988) are:

- Obesity
- Restricted head and neck movements
- Restricted jaw movement
- Receding mandible
- Buck teeth

A number of tests of neck and jaw movement may be used to evaluate these further:

- Inability to flex the chin onto the chest indicates poor neck movement. Once the neck is fully flexed, a patient should be able to move his or her head > 15° to demonstrate normal occipitoaxial movement.
- Limitation of neck (atlanto-occipital joint) extension may be predictive of difficult intubation. The normal angle of extension is > 35°.
- Reduced jaw movements are demonstrated by poor mouth opening (particularly if of less than two fingers' width) and by inability to protrude the lower teeth beyond the upper.
- Limited mouth opening clearly creates potential airway difficulties, and may reflect limitation of temporomandibular joint movement. This may be evident as a reduced inter-incisor distance (the distance between the lower and upper incisors). A distance of < 3.5 cm is predictive of a difficult airway.

The mandibular space length and its measurement have received much attention in the quest to accurately predict airway difficulties:

- The *thyromental distance*, described by Patil in 1983, is the distance between the chin and the thyroid notch with the neck fully extended. A distance of < 6.5 cm (about three finger breadths) predicts difficulty.
- The *sternomental distance* was described by Savva in 1994; it is the distance from the suprasternal notch to the chin with the neck fully extended. A distance of < 12 cm predicts difficulty.
- The *hyomental distance* is that from the chin to the hyoid bone. A distance of < 4 cm (about two finger breadths) predicts difficulty.

No one test can predict airway difficulties with a high degree of sensitivity or specificity, but a combination of tests may be helpful. Careful assessment of the airway and consideration of more than one factor is therefore recommended. The modified Mallampati classification produces a high incidence of false positives. A thyromental distance of < 6.5 cm and Mallampati class 3 or 4, however, predicts 80% of difficult intubations.

Radiological features may aid prediction of a difficult intubation, but they are not routinely performed. These include:

- Reduced distance between occiput and spine of C1 and between spines of C1 and C2
- Ratio of mandibular length to posterior mandibular depth > 3.6
- Increased depth of mandible

Other rarely used investigations include indirect laryngoscopy, ultrasonography, CT and MRI imaging.

American Society of Anesthesiologists (ASA) scoring system

The ASA scoring system describes the preoperative physical state of a patient (Saklad 1941) and is used routinely for every patient in the UK. It makes no allowances for age, smoking history, obesity or pregnancy. Anticipated difficulties in intubation are not relevant. Addition of the postscript E indicates emergency surgery. There is some correlation between ASA score and perioperative mortality, although it was never intended for use in perioperative risk prediction. Definitions applied in the ASA system are given in Figure 1.2.

Figure 1.2 ASA classification

Code	Description	Perioperative mortality
P1	A normal healthy patient	0.1%
P2	A patient with mild systemic disease	0.2%
P3	A patient with severe systemic disease	1.8%
P4	A patient with severe systemic disease that is a constant threat to life	7.8%
P5	A moribund patient who is not expected to survive without the operation	9.4%
P6	A declared brain-dead patient whose organs are being removed for donor purposes	

Preparation for anaesthesia

Premedication

As more day surgery is performed and more patients are admitted to hospital close to the scheduled time of surgery, premedication has become less common. The main indication for premedication remains anxiety, for which a benzodiazepine is usually prescribed, sometimes with metoclopramide to promote absorption. Premedication serves several purposes: anxiolysis, smoother induction of anaesthesia, reduced requirement for intravenous induction agents, and possibly reduced likelihood of awareness. Intramuscular opioids are now rarely prescribed as premedication. The prevention of aspiration pneumonitis in patients with reflux requires premedication with an H_2 antagonist, the evening before and morning of surgery, and sodium citrate administration immediately prior to induction of anaesthesia. Topical local anaesthetic cream over two potential sites for venous cannulation is usually prescribed for children. Anticholinergic agents may be prescribed to dry secretions or to prevent bradycardia, e.g. during squint surgery.

Preoperative factors

Starvation

It is routine practice to starve patients prior to surgery in an attempt to minimise the volume of stomach contents and hence decrease the incidence of their aspiration. Aspiration of solid food particles may cause asphyxiation, and aspiration of gastric acid may cause pneumonitis (Mendelson's syndrome). Guidelines for preoperative starvation are becoming less restrictive as more information becomes available. Milky drinks are not allowed because their high fat content increases gastric transit time.

Figure 1.3 Starvation guidelines

Adults
• Clear fluids and water up to 2 hours preoperatively • Food, sweets and milky drinks up to 6 hours preoperatively • No chewing gum on day of surgery
Children
• Clear fluids and water up to 2 hours preoperatively • Breast milk up to 4 hours preoperatively • Formula/cow's milk up to 6 hours preoperatively • Food and sweets up to 6 hours preoperatively

There is evidence that chewing gum before surgery significantly increases gastric fluid volume, particularly in children.

Current recommendations for patients undergoing elective surgery are shown in Figure 1.3.

Patients undergoing emergency surgery should be treated as if they have a full stomach. Normal fasting guidance should be followed where possible.

Prolonged periods of starvation give rise to problems. Dehydration may occur, particularly in children and in patients who are pyrexial or who have received bowel preparation. Infants may become hypoglycaemic. In patients with cyanotic heart disease, sickle cell disease or polycythaemia dehydration may precipitate thrombosis. In jaundiced patients the hepatorenal syndrome may be precipitated. It is thus essential that these patients receive intravenous therapy while they are being starved.

Fluid status

Healthy patients can balance daily fluid intake and output. Adults exchange approximately 5% of body water each day, while infants exchange about 15% and so are at greater risk of dehydration. A patient's fluid status may be affected by the underlying disease process or by its treatment (Figure 1.4), and there may be associated electrolyte disturbances. In certain conditions such as trauma, infection or ileus, fluid is redistributed rather than lost from the body, but will nonetheless still require

Figure 1.4 Disturbances of fluid balance

	Increased	Decreased
Input	Excessive IV fluids	Nausea Dysphagia Nil by mouth orders Coma Severe respiratory disease
Output	Sweating Diarrhoea (including bowel preparation) Vomiting Polyuria Haemorrhage Burns	Syndrome of inappropriate ADH secretion (SIADH) Renal impairment

replacing to maintain fluid balance. If patients have been ill for longer periods, malnutrition may also be a problem.

Fluid balance should be assessed preoperatively in all patients who are at risk of disturbances, which is most likely in emergencies. A history of any of the above will direct clinical examination. Postural hypotension, tachycardia and hypotension may be found in volume depletion, while a raised jugular venous pressure (JVP) and peripheral oedema may be found in volume overload. Skin turgor, or fontanelle tension in infants, is a useful guide, and assessment of urine output is very important. Oliguria is defined as a urine output of less than 0.5 mL kg^{-1} per hour. Relevant investigations include serum electrolytes, urea and creatinine. Urea raised proportionally more than the creatinine value indicates dehydration.

Correction of fluid balance

Therapy should be guided by central venous pressure (CVP), urine output, blood pressure, heart rate and electrolyte balance. Where fluid overload is diagnosed, fluid restriction and possibly diuretic therapy are required. If fluid depletion is diagnosed, replacement of the lost fluid, plus maintenance fluids, is required. Hypovolaemia resulting from blood loss necessitates red cell transfusion. If plasma has been lost, as in burns patients, plasma protein fraction (PPF) will be required. Maintenance fluid requirements are 40 mL kg^{-1} per day in adults (greater for children). Excessive administration of 5% dextrose to correct dehydration may lead to hyperglycaemia and hyponatraemia, while excessive administration of 0.9% saline may cause hypernatraemia and peripheral and pulmonary oedema.

Electrolyte disturbances

Disturbances of electroytes may be due to the underlying disease process, to drugs, particularly diuretics, or to iatrogenic causes. It is rare for a patient to exhibit overt clinical signs, but electrolyte disturbances present several potential problems for the anaesthetist (Figure 1.5). It is particularly important to assess the volume status of the patient who has an electrolyte disturbance. Electrolyte disturbances are more likely to be acute and hence more serious in patients presenting for emergency surgery.

Preoperatively, hyponatraemia may be longstanding, commonly due to diuretics, and this situation rarely requires treatment. More acutely, preoperative hyponatraemia is often due to inappropriate intravenous therapy on the ward. Treatment should comprise the administration of intravenous normal saline and, if there are signs of fluid overload, diuretics. Severe symptomatic hyponatraemia has a high mortality, and is seen most commonly as part of the TUR (transurethral resection) syndrome (see Chapter 6). Hyponatraemia should be treated promptly with diuretics and only rarely with hypertonic saline. Too rapid correction of severe acute hyponatraemia may result in subdural haemorrhage, pontine lesions and cardiac failure. Hypernatraemia is mainly a problem when associated with volume depletion, and it should be corrected by administration of 5% dextrose intravenously, taking care not to fluid-overload the patient.

Chronic changes in plasma potassium are well tolerated, but acute changes are associated with ECG changes and cardiac dysrhythmias (Figure 1.6). It is the ratio of intracellular to extracellular potassium that is relevant to myocardial excitability. Where the disturbance is chronic, this ratio will be nearly normal. Hypokalaemia may be treated by giving potassium either orally or intravenously. Care must be taken in the presence of renal insufficiency or low cardiac output states, as hyperkalaemia may result. A flow-controlled pump should be used to control the intravenous infusion rate if the concentration of potassium exceeds 40 mmol L^{-1}, and ECG monitoring will be required, as ventricular fibrillation may occur if hypokalaemia is corrected too quickly. Hyperkalaemia should be treated over several days by the administration of calcium resonium. If ECG changes are noted, or if more rapid correction of acute changes is required preoperatively, insulin (20 units in 100 mL 20% dextrose over 30–60 minutes) may be given. This may be repeated, depending on the next serum potassium. Intravenous calcium (10 mL 10% calcium gluconate) immediately (but temporarily) improves automaticity, conduction and contractility.

Smoking

A heavy smoker is anyone who smokes 20 or more cigarettes per day. Smoking causes several perioperative problems: increased airway reactivity; increased sputum production and retention; bronchospasm; coughing and atelectasis associated with an increased risk of postoperative chest infection. Associated diseases include ischaemic heart disease and chronic obstructive pulmonary disease. Up to 15% of the haemoglobin in smokers combines with carbon monoxide to form carboxyhaemoglobin, reducing the oxygen-carrying capacity of blood. After 12–24 hours of stopping smoking the effects of carbon

Figure 1.5 Problems and causes of electrolyte disturbances

Problems	Causes
Hyponatraemia	
Confusion, fits and coma possible If water excess: hypertension, cardiac failure, anorexia and nausea	Excess water intake (particularly intravenously) Diuretics TUR syndrome Impaired water excretion (SIADH, hypothyroidism, cardiac failure, nephrotic syndrome)
Hypernatraemia	
Rarely symptoms if simple water loss If severe, there may be muscle weakness, signs of volume depletion and coma	Reduced intake (impaired consciousness, unable to swallow, no water) Increased insensible loss (fever, hot environment, hyperventilation) Impairment of urinary concentrating mechanism (diabetes insipidus, hyperosmolar non-ketotic coma or diabetic ketoacidosis)
Hypokalaemia	
Muscular weakness Potentiates non-depolarising muscle relaxants Cardiac arrhythmias Rhythm problems if on digoxin	Diuretics Gastrointestinal loss (diarrhoea, vomiting, fistula, ileus, villous adenoma of large bowel) Recovery phase of diabetic ketoacidosis and acute tubular necrosis Post relief of urinary tract obstruction Reduced intake Cushing's syndrome Hyperaldosteronism
Hyperkalaemia	
Spurious if blood sample haemolysed Cardiac arrest may occur if plasma K^+ > 7 mmol L^{-1}	Acute or chronic kidney disease Shift of K^+ out of cells (tissue damage) Acidosis (particularly diabetic ketoacidosis) Increased intake Drugs impairing secretion (K^+ retaining diuretics) Addison's disease Tissue breakdown (rhabdomyolysis)

monoxide and nicotine are significantly reduced, and after 6–8 weeks ciliary and immunological activity are restored. All smokers should be encouraged to abstain prior to theatre. Nicotine replacement therapy may prove helpful.

Concurrent medical disease

It is important to be aware of any medical condition affecting a patient and to ensure that its management prior to surgery is optimal. Emergency cases present particular problems, as nausea or vomiting may have caused the patient to omit usual medication. An understanding of the pharmacology and possible interactions of concurrent medication with anaesthetic drugs is also essential.

Respiratory disease

Viral infection

The commonest respiratory problem of relevance to anaesthesia is viral upper respiratory tract infection (URTI), which causes increased bronchial reactivity, particularly in asthmatic patients, persisting for 3–4 weeks

Cambridge University Press
978-1-107-61238-9 — Fundamentals of Anaesthesia
Edited by Ted Lin , Tim Smith , Colin Pinnock , Edited in association with Chris Mowatt
Excerpt
More Information

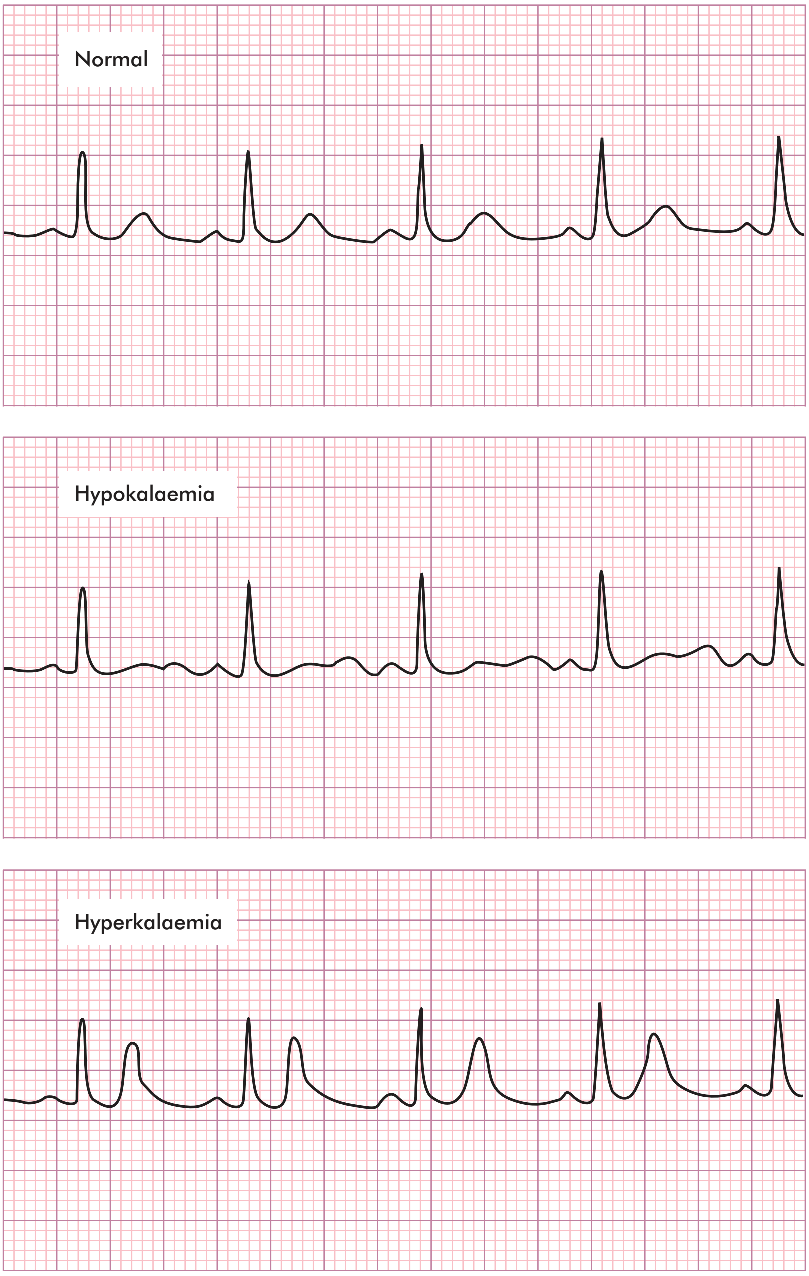

Figure 1.6 ECG changes associated with hypo- and hyperkalaemia

following resolution of the URTI. Current or recent URTI is also associated with an increased incidence of postoperative chest infection. Hence, unless surgery is urgent, such patients should be postponed for 4 weeks.

Asthma

Asthma is common, affecting 10–20% of the population. In many people the condition is mild and requires only occasional treatment, but in others there may be frequent and severe attacks requiring hospital admission and, in a few patients, ventilation on the intensive care unit. There are two main groups, although there is some overlap: **early-onset** asthma (atopic or extrinsic) and **late-onset** asthma (non-atopic or intrinsic). The symptoms of asthma are wheeze, cough, chest tightness and dyspnoea. They are caused by an inflammatory reaction within the bronchial wall which results in bronchospasm, mucosal swelling and viscid secretions. In atopic asthma exposure to allergens results in the formation of immunoglobulin E (IgE), which causes a type 1 or anaphylactic antigen–antibody hypersensitivity reaction.

The treatment of mild asthma is the occasional or regular use of inhaled selective β_2-adrenoceptor agonists such as salbutamol or terbutaline. Some patients may be using prophylactic inhaled sodium chromoglycate. In moderate cases regular inhaled corticosteroids are required. More severely affected patients may also be taking oral theophylline or regular oral steroids. Acute exacerbations of asthma may be treated with short courses of high-dose oral steroids. Regular steroids may cause adrenocortical suppression and prevent the normal stress response to surgery, and thus perioperative hydrocortisone cover may be required. Usual bronchodilator therapy should be continued preoperatively. It is common practice to prescribe a preoperative dose of inhaled β_2-adrenoceptor agonist immediately prior to the patient going to theatre, and to ensure that the patient brings his or her inhaler to theatre in case it is required postoperatively. As bronchospasm may be precipitated by anxiety, benzodiazepine premedication is often prescribed. Sedative drugs are contraindicated in anyone experiencing an acute exacerbation of asthma.

Assessment of the severity of asthma may be made from the history: frequency of attacks, whether the patient has ever been admitted to hospital with an attack or has ever required ventilation, whether oral steroids are ever necessary and if so how frequently. Nocturnal cough and frequent waking with symptoms indicate poor control of asthma. A chest radiograph in an asthmatic patient who is currently well is often normal, and is not necessary preoperatively. In longstanding cases there may be hyperinflation of the lungs. Pulmonary function tests provide a useful indication of the degree of airflow obstruction: in particular, the forced expiratory volume in 1 second (FEV_1) and the peak expiratory flow rate (PEFR) are used. If a patient's normal PEFR is known, the current state of the asthma may be ascertained from preoperative measurement of PEFR. If the patient has experienced a recent exacerbation, with an increase in symptoms, reduced PEFR and increased requirement for medication, it is appropriate to postpone elective surgery until the condition has returned to normal, which may take several weeks. Where surgery is urgent, steps should be taken to optimise the patient's condition in the time available by the use of a nebulised β_2-adrenoceptor agonist and, if it is severe, the commencement of enteral or parenteral steroids.

Chronic obstructive pulmonary disease (COPD)

Chronic bronchitis and emphysema are different pathologically but frequently coexist as chronic obstructive pulmonary disease. A patient's condition may fall anywhere in a spectrum from solely chronic bronchitis to solely emphysema, with the majority of patients possessing symptoms and signs of both. The main feature of both diseases is generalised airflow obstruction.

Chronic bronchitis is defined as daily cough with sputum production for at least three consecutive months a year for at least two consecutive years. It develops as a result of longstanding irritation of the bronchial mucosa, nearly always by tobacco smoke. The disease is more common in middle and later life, in smokers than in non-smokers, and in urban than in rural dwellers. Pathologically there is hypertrophy of mucus-secreting glands and mucosal oedema, leading to irreversible airflow obstruction. Air becomes 'trapped' in the alveoli on expiration causing alveolar distension, which may result in associated emphysema. Chronic bronchitis is a progressive disease, worsening with each acute exacerbation. Eventually respiratory failure develops, characterised by hypoxia, polycythaemia, pulmonary hypertension and cor pulmonale. Rarely, chronic hypercapnia may lead to loss of the central response to carbon dioxide, resulting in a 'blue bloater' whose hypoxia is the only stimulus to ventilation. If these patients undergo general anaesthesia they are extremely difficult to wean and to extubate. Symptoms of chronic bronchitis are cough with sputum, dyspnoea and wheeze. Clinical signs include hyperinflation of the chest, variable inspiratory and expiratory wheeze and often basal crackles, which may disappear after coughing. Peripheral oedema and raised jugular venous pressure are found with cor pulmonale, and there may be cyanosis.

Emphysema is defined as enlargement of the air spaces distal to the terminal bronchioles with destructive changes in the alveolar wall. The main cause of emphysema is smoking, although the rare genetic deficiency of α_1-antitrypsin may cause severe emphysema in young adults. The complications of emphysema include rupture of a pulmonary bulla leading to pneumothorax, and later respiratory failure and cor pulmonale may occur. Classically emphysematous patients are described as 'pink puffers'. The only symptom of emphysema is exertional dyspnoea, or dyspnoea at rest as the condition worsens. The main clinical sign of emphysema is a hyperinflated chest.

The treatment of chronic obstructive pulmonary disease is mostly symptomatic, once the patient has stopped smoking. Bronchodilators are useful if there is an element of reversible airways obstruction. Patients may be prescribed inhaled β_2-agonists, ipratropium bromide and theophylline. Diuretic therapy may be used to control right-sided heart failure. Patients who are hypoxic with pulmonary hypertension may be on domiciliary oxygen therapy, a bad prognostic indicator.

There are no characteristic radiological abnormalities due to chronic bronchitis, but coexisting emphysema may result in the appearance of hyperinflation with low flat diaphragms, loss of peripheral vascular markings and prominent hilar vessels (bat winging) and bullae. The heart is narrow until cor pulmonale develops. The presence of bullae supports the diagnosis of emphysema, and occasionally a giant emphysematous bulla will be seen, in which case surgical ablation may improve symptoms and lung function. Preoperative pulmonary function tests may help determine which of the two pathological conditions predominates. Arterial blood gas analysis is indicated to assess gas exchange if a patient has severe dyspnoea on mild or moderate exertion.

If there is a history of recent onset of green sputum production rather than white, and clinical signs support a diagnosis of chest infection, surgery should if possible be postponed and a course of antibiotics and physiotherapy commenced.

Pulmonary function tests

Peak expiratory flow rate (PEFR) is the rate of flow of exhaled air at the start of a forced expiration, and is measured using a simple flow meter. Reduced values compared to predicted values for age, height and sex indicate airflow obstruction. Serial measurements are useful for monitoring disease progress and for demonstrating a response to bronchodilator therapy.

Spirometric tests of lung function are easy to perform. If a subject exhales as hard and as long as possible from a maximal inspiration, the volume expired in the first second is the forced expiratory volume in 1 second (FEV_1) and the total volume expired is the forced vital capacity (FVC). The measured values are compared to predicted values for age, height and sex. The ratio of FEV_1 to FVC (FEV%) is most useful (normal range 65–80%). Obstructive airways disease, e.g. asthma, reduces the FEV_1 more than the FVC, so the FEV% is low. Restrictive airways disease, e.g. pulmonary fibrosis, reduces the FVC and, to a lesser degree, the FEV_1, so the FEV% is normal or high (Figure 1.7).

Arterial blood gas analysis may be useful, and interpretation should be systematic. Look first at the pH value (acidosis or alkalosis) to determine the direction of the primary change. Although there may be partial compensation for the underlying abnormality, there is never full or over-compensation. Then look at the PCO_2, which is determined by alveolar ventilation. A low PCO_2 (hyperventilation) indicates a respiratory alkalosis or respiratory compensation for a metabolic acidosis. Conversely a raised PCO_2 (hypoventilation) indicates a respiratory acidosis. The PCO_2 does not increase above normal to compensate for a metabolic alkalosis. Next, consider the standard bicarbonate value (HCO_3^-). This is defined as the extracellular fluid (ECF) bicarbonate concentration the patient would have if the PCO_2 were normal. If standard bicarbonate is raised, there is either a metabolic alkalosis or metabolic compensation for a respiratory acidosis. If the standard bicarbonate is low, there is a metabolic acidosis or metabolic compensation for a respiratory alkalosis. The base excess is defined as the number of mmol of HCO_3^- which must be added to (or removed from) each litre of ECF to return the ECF pH to 7.4, if the PCO_2 were normal. A negative base excess (a base deficit) indicates metabolic acidosis, so is found with a low standard bicarbonate; a positive base excess, which is found with a raised standard bicarbonate, indicates metabolic alkalosis. Finally, the PO_2 should be examined. A low PO_2 indicates hypoxaemia and a raised PO_2 indicates that the patient is receiving additional oxygen.

Cardiovascular disease

Hypertension

Hypertension occurs in 15% of the UK population. Although mean systemic diastolic and systolic arterial pressure rise with increasing age, hypertension is defined by arbitrarily set levels. In 97% of these patients the cause is unknown, and they are said to have 'essential' or primary hypertension. In the remaining 3% hypertension is secondary to renal or endocrine disease, coarctation of the