Pathophysiology of respiratory disease and its significance to anaesthesia

S Kimber Craig

Zoe Parry

Abstract

Significant changes occur in the respiratory physiology of healthy patients during anaesthesia. In patients with underlying respiratory pathology (e.g. chronic obstructive airways disease) these changes in respiratory physiology may lead to clinical problems during the conduct of anaesthesia and the perioperative period. An understanding of the disease processes that can affect the lungs and pleura allows the anaesthetist to account for the potential complications of these conditions and manage the anaesthetic accordingly.

Keywords ARDS; asthma; COPD; obstructive; pathophysiology; perioperative management; restrictive; risk stratification; trauma

Royal College of Anaesthetists CPD matrix: 1A01, 2A02, 2A03, 2A06

Learning objectives

After reading this article you should be able to:

- perform a thorough preoperative assessment for respiratory pathology and quantify patients' risk of respiratory complications following anaesthesia
- understand the pathophysiological effects of the more common respiratory disease
- adapt your anaesthetic practice to allow for these pathophysiological changes

Preoperative assessment

Symptoms, signs, previous respiratory disease and relevant medications should be identified (Table 1). Patients' functional capacity should be assessed by evaluating both their subjective and ideally objective exercise capacity. An estimation of the metabolic equivalents (METs) that a patient can achieve is recommended; 1 MET equates to the resting oxygen consumption of a 70-kg man and is approximately 3.5 ml/kg/minute. The ability to climb one flight of stairs is equivalent to approximately 4 METs (or 14 ml/kg/minute of oxygen consumption). The American College of Cardiology/American Heart Association (ACC/AHA) guidelines looking at perioperative cardiac risk stratification deem the inability to achieve 4 METs as an important marker of patients at increased risk of perioperative cardiac complications and those who require further investigation.[1] The inability to achieve two flights of stairs identifies patients at increased risk of postoperative cardiorespiratory morbidity and mortality following thoracic and other noncardiac surgery.[2,3]

Objective measures of exercise capacity can be used to help stratify risk in patients where pathology is suggested by the history and examination and also in those with symptoms of reduced functional capacity. These measures include the 6-minute walk test, incremental shuttle walk test, walking pulse oximetry and, where available, formal cardiopulmonary exercise testing. P-POSSUM score (Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity) is being used increasingly to calculate an estimate of morbidity and mortality in a number of surgical groups. It requires 12 physiological and six operative parameters for its calculation. P-POSSUM overpredicts mortality in low-risk groups but may be helpful in risk prediction for higher risk patients.[4]

Patients' risk of pulmonary complications (Box 1) should be estimated based on patient factors and the operative procedure.[5] Using these risk stratification tools means that patients can be appropriately managed by consultant surgeons and anaesthetists, where appropriate, and will help guide decisions regarding the need for postoperative critical care input.

Pulmonary pathology

Restrictive conditions

These are conditions where lung expansion is restricted. This can be due to lung parenchymal abnormalities, diseases of the chest wall and pleura, or neuromuscular conditions.

Pulmonary fibrosis: fibrosis may be idiopathic or secondary to other respiratory (e.g. pneumoconiosis) and systemic conditions (e.g. rheumatoid arthritis). Whatever the aetiology, inflammation and infiltration of alveolar membranes and bronchiolar walls is found. Cellular exudate collects in the alveoli and fibroblasts form collagen at the damaged areas. Lung parenchyma architecture is altered leading to the formation of air-filled spaces, a reduced surface area available for gas exchange and reduced distensibility.

Mechanical restriction: chest wall deformities (e.g. kyphoscoliosis) cause abnormal crowding of ribs and compression of the lung and pulmonary vasculature resulting in restricted ventilation. In obesity and pregnancy the weight of abdominal and chest tissue impairs inspiration and reduces diaphragmatic excursion. In cases of intra-abdominal pathology, pain and abdominal wall rigidity can also limit movement of the diaphragm.

Neuromuscular conditions: conditions such as Guillain-Barré, muscular dystrophies and myasthenia gravis as well as the simple effects of ageing reduce the function of the muscles of

S Kimber Craig *MB ChB FRCA is an Anaesthetic Consultant at Bolton NHS Foundation Trust, Bolton, UK. Conflicts of interest: none declared.*

Zoe Parry *MB ChB is an Anaesthetic Specialist Trainee in the Northwest Deanery, UK. Conflicts of interest: none declared.*

Preoperative assessment and investigation of patients with respiratory pathophysiology

Points in history

Changing or worsening symptoms, e.g. increased cough at night

Smoking history (number of pack years)

Steroid therapy (frequency of short-course doses or long-term use)

Home nebulisers or oxygen therapy

Recent or frequent courses of antibiotics

Previous admissions to hospital and critical care

Symptoms of right or congestive cardiac disease

Symptoms

Dyspnoea

- on exertion/at rest
- orthopnoea
- paroxysmal nocturnal dyspnoea

Cough

- sputum production
- haemoptysis

Chest pain

Peripheral oedema

Wheeze

Signs

General signs

Distressed patient, sitting forward

Respiratory rate and pattern

- Tachypnoea, hypoventilation, stridor, abnormal pattern

Cyanosis, plethoric facies, clubbing, tar-staining to fingers or hair

Obesity, pectus excavatum, kyphoscoliosis

Peripheral oedema, hepatomegaly

Observations

- Increased respiratory rate
- Low SpO_2
- Tachycardia
- Pyrexia

Chest signs

- Dullness or hyperresonance on percussion
- Wheeze, crackles
- Pleural rub
- Absent breath sounds

Investigations

Blood tests

Renal function – urea and creatinine *(linked to postoperative pulmonary complications when elevated)*

Albumin *(low level has strong association with postoperative pulmonary complications)*

Full blood count – WCC *(infection)* and Hb *(polycythaemia, anaemia)*

Clotting, INR *(may be on warfarin, e.g. for PE or pulmonary hypertension)*

Arterial blood gases – oxygen and carbon dioxide concentrations, pH *(ABG analysis may differentiate between patients with chronically elevated carbon dioxide levels and patients with acute decompensation)*

Others

ECG

Lung function tests

PEFR

Consider:

- Chest X-ray
- Echocardiography
- CPET

ABG, arterial blood gas; CPET, cardiopulmonary exercise testing; Hb, haemoglobin; INR, international normalized ratio; PE, pulmonary embolism; PEFR, peak expiratory flow rate; WCC, white cell count.

Table 1