Critical incidents: the respiratory system

Edward TC Miles

Timothy M Cook

Abstract

Respiratory complications are expensive, not just in terms of the overall litigation burden faced by anaesthetists but also, far more importantly, the mortality and morbidity burden faced by our patients. Critical incidents arising in the respiratory system can cause rapid deterioration if left unchecked: trauma to airway structures can be debilitating or even life-threatening; hypoxaemia may result in damage to other organ systems, most notably the brain. Each patient carries their own risk profile, as well as unique ideas, concerns and expectations of their anaesthetist. An understanding of the potential critical incidents that may impact the respiratory system, a patient-centred approach to discussing these risks, and familiarity with the procedures for mitigating harm are all necessary components of safe, effective practice in anaesthesia.

Keywords Airway failure; airway injury; airway obstruction; aspiration; can't intubate, can't oxygenate; lung-protective ventilation; pneumothorax; respiratory complications

Royal College of Anaesthetists CPD Matrix: 1B02; 1C01; 1C02; 1F01; 2A01; 2A06; 3A01

Learning objectives

After reading this article, you should be able to:
- describe the critical incidents which may impact the respiratory system
- summarize the risks of respiratory complications to a non-medical (patient) audience
- formulate a management plan to reduce the risk of respiratory complications during anaesthesia

Critical incidents in the respiratory system can rapidly precipitate deterioration in other areas of the body; they represent a significant source of morbidity and mortality in anaesthesia. In the UK, a review of cases logged with the National Health Service Litigation Authority (NHSLA) between 1995 and 2007 found adverse airway and respiratory system events accounted for 12% of anaesthesia-related claims, and 53% of deaths. A thorough understanding of the possible respiratory system complications which may arise during anaesthesia is fundamental to its safe delivery.

A recent judgement of the UK's Supreme Court highlights the need for clinicians to better tailor discussions of potential complications to the individual patients with whom they consult. Crucially, one can no-longer rely on the so-called Bolam test (whether an esteemed body of medical opinion would uphold a decision) when weighing-up which information to share and which to omit in the consenting process. Information which is considered 'material' to a patient's decision-making no longer simply includes that which any reasonable person might require in order to arrive at an informed choice, but with which the *individual* facing the decision might be likely to attach particular significance. The aim of this review is to describe the potential respiratory system complications of anaesthesia, illustrate how these can be mitigated for and, where possible, provide quantitative information regarding the risk of occurrence as a reference for clinicians.

Registries of medical litigation claims can teach us the value placed on events by the legal system, but offer little insight into the true epidemiology of such incidents. Large investigations, such as the Fourth National Audit Project of the Royal College of Anaesthetists (NAP4), provide a useful resource for understanding the rates of more serious complications. However, less serious, more frequent complications may also be notable and of importance to patients despite being considered 'common-place' by many anaesthetists.

Oropharyngeal injury

Cuts or bruising to the lips or tongue occurs in approximately 5% of anaesthetics; however, it is likely that there is significant under-reporting of such events. The risk of damage to a tooth is approximately 1:4500. Laryngoscopy is the commonest cause: careful, detailed preoperative assessment and documentation of the teeth, coupled with care during airway management, reduces the risk of dental damage. Rolled swabs placed between the lateral molars as a 'bite-block' can provide protection from biting and grinding during emergence. Conversely, an oropharyngeal adjunct may prevent occlusion of an airway from biting, but poses a risk to teeth.

The estimated frequency of sore throat after anaesthesia is 20% where supraglottic airway devices (SADs) are used, increasing to 40% with cuffed tracheal tubes (TTs). Insertion of gastric tubes, temperature probes and suction apparatus may cause further trauma, increasing risk. In most cases symptoms are mild and short-lived, but they may prove a source of complaint or litigation in the context of extended severity and chronicity, or where the patient uses their voice professionally.

Lubrication and correct size selection of airway devices, including laryngoscopes, can reduce shearing forces applied to the tissues with which they come into contact; a meticulous approach to correct placement and inflation pressures is also paramount. High-volume, low-pressure cuffs are preferred for TTs and pressure gauges should be used to appropriately titrate the air in both TTs (<30 cmH_2O) and SADs (≤ 60 cmH_2O).

***Edward TC Miles** MA MSci MBChB Specialist Trainee, Royal United Hospital Bath NHS Foundation Trust, UK. Competing interests: none declared.*

***Timothy M Cook** BA MBBS FRCA FFICM is Consultant in Anaesthesia and Intensive Care Medicine, Royal United Hospital Bath NHS Foundation Trust, UK. Competing interests: none declared.*

Please cite this article in press as: Miles ETC, Cook TM, Critical incidents: the respiratory system, Anaesthesia and intensive care medicine (2016), http://dx.doi.org/10.1016/j.mpaic.2016.10.005

There have been case reports of damage to the laryngeal, glossopharyngeal and hypoglossal nerves caused by direct pressure from SADs compressing the structures of the oropharynx. The i-gel™ is associated with a lower incidence of sore throat than cuffed devices. Clumsy laryngoscopy, especially with curved blades and stylets, can cause pharyngeal injury or perforation. In trained hands, videolaryngoscopy may reduce the incidence of hoarseness and minor tissue trauma.

Upper airway and oesophageal injury

Laryngeal injury

The vocal cords and posterior laryngeal structures may be injured in up to 1% of intubations, affecting mostly young, fit patients during routine uncomplicated intubation, accounting for around one-third of airway trauma claims against anaesthetists. Injuries include granulomas, nerve palsies, arytenoid dislocations and fractures; subglottic stenosis and granulomas are rarer. Harm may be temporary or permanent and may interfere with speech, swallowing and occasionally with breathing. Injury to the posterior laryngeal components from an SAD is less common. Use of excessively large tubes or inflation of a cuff across the laryngeal inlet is prime causes of injury. Solutions include avoiding intubation where it is not indicated, using videolaryngoscopy where possible to avoid blind (bougie) techniques, selecting smaller TTs and optimally managing and monitoring cuff pressure and position during use.

Tracheal injury and oesophageal injury

These injuries are rare, but are associated with significant mortality owing to mediastinitis. Oesophageal intubation with a TT can be enough to cause perforation; both oesophagus and trachea may be injured by (mis)use of stylets, TTs and bougies. Avoidance of oesophageal intubation, scrupulous use of airway adjuncts and early detection of symptoms (e.g. chest pain, surgical emphysema) and treatment after potentially injurious events reduces harm.

Lower airway injury

Barotrauma to the lower airway may result from mismanagement of the upper airway, in particular from inappropriate methods of oxygen delivery. Microscopic barotrauma occurs when positive pressure ventilation is applied with too large tidal volumes creating or exacerbating acute lung injury (see Section Lung injury as a consequence of controlled ventilation). Macroscopic barotrauma (air leak, pneumothorax, pneumomediastinum, surgical emphysema) can occur when a high-pressure source of gases is applied to the airway without a route for egress.

High-pressure sources include gas cylinders (400 kPa), wall oxygen (400–600 kPa) and 'jet ventilation' equipment (e.g. Sanders injectors and Manujets, 100–400 kPa). In contrast, an anaesthetic machine's fresh gas outputs supplies at approximately 2–6 kPa, increasing to 30–40 kPa on 'flush' mode although this varies between machines. Whilst it is raised gas pressures which *cause* injury, damage is hastened and more severe with increased flow rates.

Danger is greatest when a long hollow device is placed deep in the airway and oxygen is administered from a high pressure source. Examples are the Aintree intubation catheter (AIC) and hollow bougies used in airway exchange, or an airway exchange catheter (AEC) left *in situ* after extubation. If the distal portion of such a device becomes wedged, there is no escape path for delivered gas and barotrauma may result. Ensuring the tip remains above the carina will protect against 'wedging' and subsequent injury.

On balance AECs, AICs and hollow bougies should be reserved for airway exchange; on the rare occasions when oxygen delivery *via* these devices becomes necessary, care must be taken to maintain the tip above the carina and low-pressure gas sources must be used.

Lung injury as a consequence of controlled ventilation

Positive pressure ventilation may cause injury by effects of volume (volutrauma), pressure (barotrauma) and repeated inflation/deflation (shear/atelectrauma). Positive pressure leads to migration of inflammatory cells into the alveolae and release of cytokines. There is also a decrease in surfactant, an increase in production of mucus and a decrease in the efficiency of the mucociliary transport mechanisms. Already injured lungs are at particular risk of further injury. Emerging evidence suggests that 'lung protective ventilation' may have a role in the operating theatre and in elective major surgery, as well as in the intensive care unit (ICU).

Lung protective ventilation involves: low volumes (6–7 ml/kg ideal body weight); relatively high positive end-expiratory pressure (PEEP) to maintain a position on the steep part of the compliance curve; avoidance of high mean airway pressures, through use of pressure controlled ventilation; avoidance of excessively high fractions of inspired oxygen (F_iO_2); reduced periods of disconnection; and use of recruitment manoeuvres such as 'sighs' or periods of continuous positive airway pressure (CPAP) at 30-minute intervals. Such protocols are associated with a lower incidence of postoperative pulmonary complications and reduced length of stay. Which components of the 'package' are most important, and how long after extubation protection persists, remains unclear.

Hypoxaemia

The NAP4 point estimate for the risk of death or brain damage from failure of oxygenation during anaesthesia was approximately 1:151,000 anaesthetics. Where a TT was used, complications of airway management during anaesthesia resulted in 1:110,000 patients dying or suffering brain injury. The corresponding rate for SADs was 1:202,000, and 1:154,000 for face mask (FM) anaesthesia. The duration and severity of hypoxaemia required to cause death or organ failure is dependent on many factors. In NAP4 some patients came to harm from relatively short periods of apparently modest hypoxaemia whilst others survived prolonged and severe events (e.g. up to 30 minutes of $SpO_2 < 70\%$).

Hypoxaemia will most likely first be detected by a fall in the oxygen saturations in the presence of an otherwise adequate pulse plethysmogram. More occult presenting signs include pallor with cyanosis, tachycardia with hypertension (early in adults), bradycardia (in young children, or late in adults), other arrhythmias and electrocardiograph (ECG) disturbances or, in extreme cases, cardiac arrest. Causes of hypoxaemia include

Please cite this article in press as: Miles ETC, Cook TM, Critical incidents: the respiratory system, Anaesthesia and intensive care medicine (2016), http://dx.doi.org/10.1016/j.mpaic.2016.10.005