Principles and practice of thoracic anaesthesia

Katheryn J Fogg

Abstract

Thoracic anaesthesia is a large field. This review concentrates on anaesthesia for major thoracotomy and lung resection, which is most usually carried out for malignant disease. This is a relatively small patient population, but procedures carry significant mortality of up to 6% for pneumonectomy. Physiological changes that occur during anaesthesia and one lung ventilation (OLV) are discussed, and the optimal ventilatory management of these patients is covered. Postoperative management of analgesia and chest drains is also discussed, as is the pathophysiology of acute lung injury (ALI) which may occur after lobectomy or pneumonectomy. Aspects of video-assisted thoracoscopy (VATS) and lung volume reduction surgery (LVRS) are also mentioned.

Keywords Acute lung injury; analgesia; drainage; one lung ventilation

Royal College of Anaesthetists CPD matrix: 2A01, 2E01, 2G01, 3G00

Learning objectives

After reading this article, you should be able to:

- understand assessment and basic intraoperative management principles
- manage one lung ventilation using lung protective strategies
- plan postoperative recovery for these patients

Major pulmonary resection is sometimes undertaken for infective or other non-malignant disease, but the great majority of patients undergoing lung resection do so for cancer. (Table 1). These patients are often elderly, current or former heavy smokers and thus likely to have other smoking-related disease. Careful preoperative selection and optimization are essential for good postoperative outcomes. Over the last decade there has been a huge increase in thoracic surgical activity, and despite patients' increasing age and comorbidity, operative mortality has remained unchanged, and procedure-related complications have almost halved. There has been a steady increase in the use of minimally invasive surgery, for example video-assisted thoracoscopy (VATS) lobectomies for primary lung cancer have risen from 7% to 13.8%. Better outcomes are achieved in high-volume hospitals where procedures are performed by thoracic surgeons. Post-thoracotomy acute lung injury (ALI) has become the leading cause of death, with an incidence of 2–5%.

Preoperative assessment

The patient's general clinical state should be evaluated including other comorbidities, weight loss, changes in exercise capacity, and anaemia. Weight loss of more than 10% and low serum albumin are markers of advanced disease, and indicate increased perioperative risk. All patients should undergo simple spirometry and pulse oximetry. A forced expiratory volume in 1 second (FEV_1) greater than 1.5 litres is considered adequate for lobectomy, whereas an FEV_1 of 0.8 litres or less would be considered a contraindication to lung resection apart from in the special situation of lung volume reduction surgery (LVRS). Resting arterial blood gases (ABG) on air may be useful, and high-risk patients will require more extensive pulmonary function testing including diffusing capacity (DLCO), predicted postoperative FEV_1, and exercise testing either in the form of shuttle walk testing, stair climbing, or measurement of oxygen consumption during exercise (VO_2 max). Results from this cardiopulmonary exercise testing (CPEX) may allow more targeted postoperative care planning as regards to intensive care or HDU requirement, as well as determining those individuals who have such poor physiological reserve that the risks of the procedure outweigh any possible benefit.

Intraoperative management

Induction of anaesthesia may be conducted in a fairly standard manner, with intravenous agent plus opiate and non-depolarizing muscle relaxant. If rigid bronchoscopy is performed by the surgeon prior to intubation then intermittent boluses of anaesthetic or a target controlled infusion technique will be needed. Subsequent intubation is usually with a double-lumen endotracheal tube (DLT). These tubes allow each lung to be independently ventilated, or collapsed and re-expanded at will. The bronchial cuff also protects each lung from contralateral contamination. The DLT should be checked clinically and with a fibreoptic bronchoscope at the time of insertion, and then again

Thoracic surgical results from 38 UK centres 2010–2011

	Numbers	Deaths (%)
Lung resection for primary malignancy:		
Pneumonectomy	430	17 (4)
Lobectomy/bilobectomy	3351	84 (2.5)
Segmentectomy/wedge resection	664	5 (0.8)
Other non-malignant lung resection	1897	21 (0.9)
Pleural procedures:		
Thoracotomy and decortication	828	11 (1.3)
Other pleural procedure including closure of air leak	920	18 (0.5)
VATS lung resection for malignancy		
Wedge	273	1 (0.4)
Lobectomy	475	5 (1.1)
Pneumonectomy	1	0 (0)
VATS resection non-malignant	1551	8 (1.9)
VATS pleural procedures	5419	76 (0.7)

From database of the Society for Cardiothoracic Surgery, UK and Ireland.

Table 1

***Katheryn J Fogg BA** Hons(Oxon) MBBS FRCA is a Consultant Cardiothoracic Anaesthetist at the Royal Brompton Hospital, London, UK. Conflicts of interest: none.*

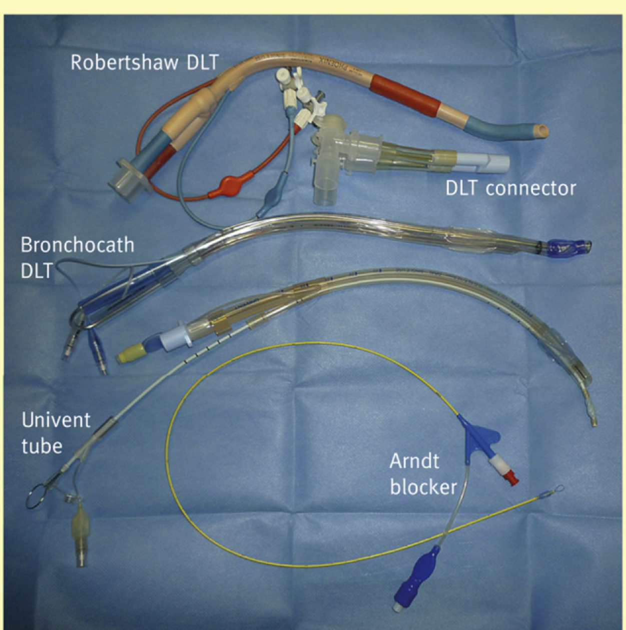
after the patient has been turned into the lateral position. A variety of endobronchial blockers are available which may have advantages in certain situations; such as in children where there is no small enough DLT, or where the tracheobronchial anatomy is distorted by previous surgery. However, they are more easily displaced and lung tissue distal to the blocker cannot be suctioned to facilitate lung collapse. They too require confirmation of correct positioning by bronchoscopy. Examples of commonly used devices are shown in Figure 1. Maintenance of anaesthesia may be with a volatile or intravenous based technique. Monitoring requirements are shown in Box 1.

Pulmonary resection is usually carried out via a lateral thoracotomy incision, with the patient positioned as shown in Figure 2. To stabilize the patient an underbody vacuum beanbag is used, as well as a strap across the pelvis and flexion of the lower leg. Arms should be padded, the head adequately supported with attention to positioning to ensure there is no traction on the brachial plexus, and a pillow placed between the legs. A warm air convective blanket is applied to minimize heat loss, and intermittent compression devices applied to the legs to decrease the risk of deep venous thrombosis.

Ventilation

In the lateral decubitus position during two lung ventilation 40% of cardiac output (CO) is to the non-dependant lung and 60% to the dependant lung. Upon OLV the non-dependant lung is perfused but not ventilated, thus creating a shunt. However surgical retraction and the mechanical effects of atelectasis increase vascular resistance in the operative lung thus decreasing shunt. Hypoxic pulmonary vasoconstriction will also act to decrease shunt, although this effect is attenuated by inhalational agents and vasoactive substances released by surgery. Chronic disease in the operative lung may have already increased vascular resistance, so flow may already be preferentially diverted to the ventilated lung. So, at worst shunt may be 20–25% of CO. However, the lateral decubitus position and the effects of general anaesthesia also act to decrease functional residual capacity, which has an adverse effect upon ventilation in the dependant lung.

OLV is usually straightforward if the tube position, ventilation and CO are optimal. At the commencement of OLV the inspired oxygen concentration (FiO_2) is increased and a pressure-limited mode of ventilation is selected with settings tailored to the individual patient. Over-inflating the lung, with peak inspiratory pressures greater than 25 cmH_2O, or attempts to continue with the same tidal volumes delivered to the single lung (volutrauma), has been shown to be involved in the development of ALI. The aim is to keep minute ventilation unchanged, with normocapnia. In patients with chronic airflow limitation a longer expiratory time may be required to avoid gas trapping, which can cause significant haemodynamic instability and increases the risk of an iatrogenic pneumothorax. Permissive hypercapnia may therefore have to be tolerated in these patients. Positive end-expiratory pressure (PEEP) applied to the dependant lung will improve ventilation/perfusion matching but may increase pulmonary vascular resistance, whilst continuous positive airway pressure



DLT, double lumen endotracheal tube.

Figure 1 Airway devices.

Figure 2 Patient positioned for surgery.

Monitoring requirements for major thoracic procedures

- ECG
- Pulse oximetry
- End-tidal gas analysis — carbon dioxide trace useful during one lung ventilation (OLV)
- Flow volume loop — useful during OLV
- Invasive arterial pressure measurement — arterial blood gas analysis essential during OLV
- Invasive central venous pressure measurement — central venous access useful if vasopressors needed, and monitoring of filling status postoperatively
- Nasopharyngeal temperature — heat loss may be significant
- Urinary catheter — for long procedures, known renal impairment, and may be useful if an epidural in situ

Box 1