Anaesthesia for thoracic surgery

William Simpson

Abstract

Thoracic anaesthesia is an expanding and evolving sub-speciality. This article will focus primarily on the anaesthetic management of major lung resections, procedures which are generally performed for malignant disease and which can confer significant mortality and morbidity. The equipment needed and ventilatory strategies during one lung anaesthesia will be discussed and the important changes in respiratory physiology that occur will be looked at in detail. Recent advances in pain management necessitate that postoperative analgesic regimens are covered in some depth. There has been an increase in the number of video-assisted thoracoscopic surgery (VATS) cases and the merits and anaesthetic implications of VATS procedures are reviewed.

Keywords Analgesia; equipment; one lung ventilation; video-assisted thoracoscopic surgery

Royal College of Anaesthetists CPD Matrix: 1A01, 2A03, 2E01, 2G01, 3G00

According to the Society for Cardiothoracic Surgery the total number of lung resections performed for malignancy in 2014−15 was 7228, representing a 7.7% rise from the previous year and reflecting the overall trend of increasing thoracic surgical activity (Table 1).[1] Not only has activity increased but the number of high-risk cases has also increased. This generally reflects the ageing population and patients with multiple co-morbidities that in the past may have precluded surgical intervention. Despite this 98.1% of patients undergoing lung resection for lung cancer survive to hospital discharge. Tertiary centres with a high thoracic workload achieve the best outcomes. Suitable perioperative management and diligent patient selection is essential in producing good postoperative outcomes.

Although thoracic work load has increased the number of pneumonectomies being performed is falling. This perhaps reflects efficient cancer pathways, earlier surgical intervention and increased public education surrounding lung cancer. The number of video-assisted thoracoscopic surgery (VATS) procedures performed for malignancy has risen and technological advances are likely to mean that increasingly fewer operations will require open thoracotomy.

Physiology of one-lung ventilation

The changes in respiratory physiology that occur during one-lung ventilation (OLV) are well documented. When considering the intubated patient undergoing single-lung ventilation in the lateral decubitus position (Figure 1) it is important to understand the effect on both ventilation and perfusion of the lungs.

In the lateral position, the bottom, ventilated lung is classically referred to as the dependent lung. Although the dependent lung it is selectively ventilated the weight of mediastinal contents and excursion of abdominal viscera reduces the lung compliance and functional residual capacity. This contributes to ventilation: perfusion (V:Q) mismatch.

With regards to perfusion the situation is more complicated. In the lateral position the dependent lung receives around 60% of pulmonary blood flow; this is due to gravity. On initiating OLV the non-dependent lung is collapsed but still receives a blood supply, thus producing further V:Q mismatch and shunt. However, the result of hypoxic pulmonary vasoconstriction and surgical manipulation is to restrict flow of blood to the non-dependent lung. Consequently, as diseased lung tissue may already have a diminished blood supply this will reduce shunting such that only around 20% of pulmonary blood flow reaches the non-dependent lung.

The drugs administered and the ventilatory strategies employed have an impact on the degree of V:Q mismatch, a number of which are highlighted in Table 2.

Anaesthetic assessment

Patients undergoing lung resection surgery often have chronic obstructive pulmonary disease and so a thorough assessment of respiratory function is required. Traditionally a forced expiratory volume in 1 second (FEV_1) of less than 0.8 litres would contraindicate lung resection while an FEV_1 of greater than 1.5 litres would be deemed adequate. However this rule does not apply to patients undergoing lung volume reduction surgery. In cases of ambiguity predicting postoperative FEV_1 and diffusing capacity (DLCO) can be useful. Patients with a predicted postoperative FEV_1 below 40% and predicted postoperative DLCO less than 40% have a much higher rate of intra- and postoperative cardiopulmonary complications and as such are deemed high risk for surgery.

Other preoperative investigations such as resting blood gas analysis, exercise tolerance testing and formal cardiopulmonary exercise testing can be used to stratify operative risk. These tests can help guide clinicians as to the best level of postoperative care for high-risk patients and in some cases may suggest that surgery is inappropriate.

As well as investigations one must evaluate the patient's physiological state as a whole. A significant decline in activity, loss of appetite and weight loss with a falling body mass index indicate late stages of disease and are associated with increased morbidity and mortality. In an ageing population and patients with multiple co-morbidities an increasing number of high-risk patients are referred for surgery. Cardiovascular problems such as ischaemic heart disease, previous myocardial infarction and heart failure are common. The physiological reserve of these patients should be quantified and cooperation with a cardiologist is often required.

Conduct of anaesthesia

A wide-bore intravenous cannula and arterial line should be sited along with standard monitoring. If a thoracic epidural is to be

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Society for Cardiothoracic Surgery Thoracic Registry data, 2014–2015[1]

	Numbers	Deaths (%)
Open lung resections – primary malignant		
Pneumonectomy	350	22 (6.2)
Lobectomy/bilobectomy	3177	68 (2.1)
Wedge resection/segmentectomy	519	8 (1.5)
Open lung resections – other	1445	19 (1.3)
Open pleural procedures		
Decortication	494	15 (3)
Other procedures, including closure of air leak	465	10 (2.2)
VATS lung resections – primary malignant		
Pneumonectomy	13	0
Lobectomy	2131	24 (1.1)
Wedge resection	609	2 (0.3)
VATS lung resections – other	2569	9 (0.4)
VATS pleural procedures	5677	73 (1.3)

Data taken from 36 thoracic centres in the UK and Ireland.

Table 1

inserted then this is done prior to induction of anaesthesia. The need for central venous access should be determined by the scale of the operation, requirement for vasopressors (if an epidural is used) and the patient's clinical condition. Intravenous induction of anaesthesia is generally with an opiate, propofol and neuromuscular blockade achieved with a muscle relaxant of choice. The advent of suggamadex may however favour use of rocuronium or vecuronium. Intubation is either with a double-lumen tube (DLT) or a standard endotracheal tube and placement of a bronchial blocker. Anaesthesia can be maintained using volatile agents or total intravenous anaesthesia (TIVA). If rigid bronchoscopy is planned then intermittent boluses of IV agents can be used but a more suitable method is TIVA with depth of anaesthesia monitoring.

The patient is then placed in the lateral decubitus position. This requires particular attention to protecting pressure areas, ensuring the neck remains in a neutral position, pilot cuffs and wires are clear of the face and that the eyes are covered and protected. A vacuum bean bag that can be suctioned and maintain its shape is often used. This negates the need to 'break' the table to such extremes as were previously seen (Figure 1).

The patient should be actively warmed with constant temperature monitoring. Intravenous fluid administration needs careful consideration and urinary catheterisation is often required for longer cases. The volume of intravenous fluid given should aim to replace physiological and surgical losses only. Administering large volumes of fluid during a major lung resection can lead to the development of an acute lung injury. Consequently, maintenance of arterial blood pressure is best achieved with vasopressors rather than excessive fluid administration. Anti-embolism stockings or calf compression devices are used to reduce the risk of deep vein thrombosis.

At the end of surgery the patient should be warm, well-perfused, have optimal analgesia, acceptable arterial blood gases and anti-emetics administered prophylaxis. Prior to extubation oropharyngeal and endotracheal suctioning is performed, absence of residual neuromuscular blockade is confirmed and the patient is sat up and extubated awake. Sugammadex reverses the effects of rocuronium and vecuronium at various stages of paralysis and is useful in shorter procedures. This is especially so in high-risk patients to enable rapid recovery and greater throughput in busy operating lists. In certain circumstances where excessive coughing may be deleterious then the DLT may be exchanged for a laryngeal mask to facilitate smoother emergence. A minority of high-risk cases may also necessitate tracheostomy following lung resection. These and other complex cases are taken to intensive care sedated and ventilated for a period of observation prior to extubation. In such cases the DLT is exchanged for a single-lumen tube at the end of the procedure.

Strategies for one-lung ventilation

Immediately after induction and insertion of a DLT the lungs are ventilated in a standard fashion, preferably using pressure-controlled ventilation with application of positive end-expiratory pressure (PEEP). A high fractional concentration of inspired oxygen allows rapid de-nitrogenation and optimal utilisation of functional residual capacity prior to OLV.

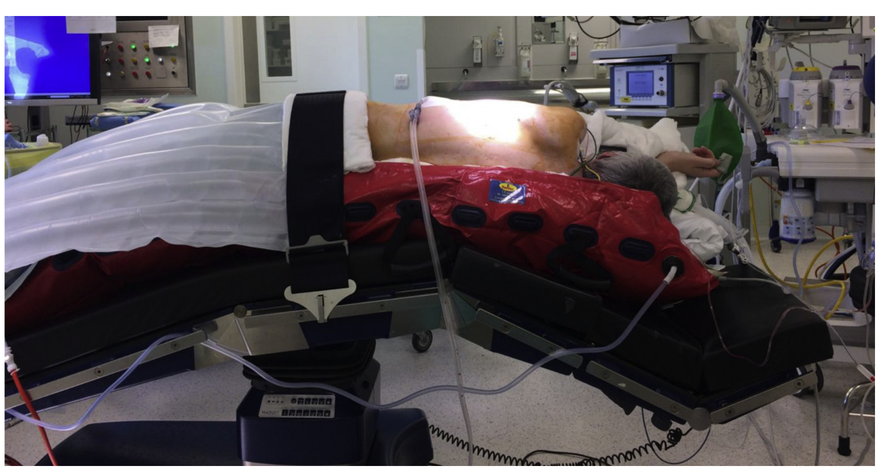

Figure 1 The lateral decubitus position.

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