Southern African Journal of Anaesthesia and Analgesia. 2021;27(6 Suppl 1):S191-195
https://doi.org/10.36303/SAJAA.2021.27.6.S1.2692

South Afr J Anaesth Analg
ISSN 2220-1181 EISSN 2220-1173

FCA REFRESHER COURSE

Thoracoscopic surgery

NY Fening

Department of Anaesthesia, Faculty of Health Sciences, School of Clinical Medicine, University of the Witwatersrand, Johannesburg, South Africa
Corresponding author, email: *nfenima@gmail.com*

Thoracoscopic procedures or video-assisted thoracoscopic surgeries (VATS) are thoracic surgeries that are minimally invasive and use the aid of a video camera. The first clinical use of the thoracoscope was in 1916 for intrapleural pneumolysis on patients with tuberculosis (TB). It wasn't until the late 20th century with the development of fibre optic technology that its use for diagnostic and therapeutic procedures became more widespread. Surgeons are now able to look at images projected onto a monitor with the aid of computer chip television cameras. This frees up their hands and allows them to perform a variety of procedures as well as more complex procedures.

The preoperative assessment of patients coming for thoracoscopic surgery must be as robust as that for open thoracotomy procedures. Pulmonary function tests can be used to determine if patients will be suitable for one lung ventilation. There must be ongoing discussions with the surgeons to determine the surgery planned and how feasible it is.

VATS sometimes requires lung isolation techniques. The double-lumen tube (DLT) has long been considered the gold standard in one lung ventilation procedures. The choice of anaesthetic technique when it comes to one lung ventilation will depend on the anaesthetist's experience and skill. The fibre optic scope has now become the gold standard for confirming tube position. To avoid ventilator-induced lung injury, a strategy of lung protective ventilation should be employed.

Patients going for thoracoscopic procedures at a minimum are placed in a high dependency care setting. Adequate analgesia is vital to recovery. Analgesic approach must be multimodal. Regional techniques such as thoracic epidural, paravertebral blocks, intercostal nerve blocks and epidural catheters are widely favoured. Nausea and vomiting prophylaxis should be prescribed.

Anaesthesia for thoracoscopic surgery is an interesting and challenging field. It requires good knowledge of the physiology and thorough preparation.

Keywords: anaesthesia, thoracoscopic surgery, VATS, one lung ventilation, lung isolation

Thoracoscopic surgery

Thoracoscopic procedures or video-assisted thoracoscopic procedures (VATS) are thoracic surgeries that are minimally invasive and use the aid of a video camera.[1] The anaesthetic management for these patients is not different as compared to open thoracotomy as the patients still require one lung ventilation with collapse of the lung with the pathology.[8]

The first clinical use of the thoracoscope was in 1916 for intrapleural pneumolysis on patients with tuberculosis (TB).[2] Improvements in pharmaceutical therapy for TB and clinical outcomes of patients with TB, meant that the need for thoracoscopy reached a ceiling and slowly became redundant.[3] It wasn't until the late 20th century, with the development of fibre optic technology, that its use for diagnostic and therapeutic procedures became more widespread.[2]

The first thoracoscopes were made of a hollow tube with a small light bulb over the tip of the scope. The view through them was limited and only the operator was able to visualise the surgical field. New imaging systems use quartz rods to transmit a light beam along a telescope.[3] Surgeons are now able to look at images projected on o a monitor with the aid of computer chip television cameras. This frees up their hands and allows them to perform a variety of procedures as well as more complex procedures.[3]

Indications

Diagnostic procedures

- Pleural diseases including effusions, biopsies of masses
- Interstitial diseases: parenchymal biopsies done by surgeons
- Pulmonary nodules: surgical excision of nodules yields better results
- Mediastinal masses: parenchymal and subcarinal lymph nodes can be accessed through cervical mediastinoscopy
- Chamberlain procedure (anterior mediastinoscopy) is used to assess aortopulmonary window and the pulmonary hila for masses and lymph nodes.

Therapeutic procedures

- Thoracostomy and pleurodesis for malignant diseases
- Pleurectomy, mechanical abrasion, use of sclerosing agents
- Empyema: drainage and adhesiolysis

- Trauma; acute phase: diagnosing and treating lesions as well as obtaining haemostasis, subacute: draining of retained haemothoraces
- Bullous lung disease: removal of blebs and bullae and pleurectomy and mechanical abrasion
- Lung resection: wedge resection of tumours lobectomy/ pneumonectomy
- Resection of solitary metastasis
- Diagnosis and treatment of diaphragm injuries
- VATS pericardiectomy to treat recurring pericardial effusions
- Removal of mediastinal masses
- Diagnosing and treating oesophageal cancer and other benign oesophageal lesions
- Autonomic nervous system: truncal vagotomy, thoracic splanchnicectomy[3]

Anaesthetic preparation

The preoperative assessment of patients coming for thoracoscopic surgery must be as robust as that for open thoracotomy procedures.

Patient factors to consider include preoperative comorbidities especially cardiac and pulmonary. A lot of these patients have chronic obstructive pulmonary disease.[4] The American Society of Anesthesiologists' physical status assessment tool has been found to be a strong predictor of morbidity.[4]

Special investigations such as pulmonary function tests, arterial blood gases and imaging, CT scans, are vital. Pulmonary function tests can be used to determine if patients will be suitable for one lung ventilation.[4]

Blood work up; full blood count, urea and electrolytes and any other relevant tests depending on the patient's profile should be assessed and optimised where possible.

Conduct of anaesthesia

There must be ongoing discussions with the surgeons to determine the surgery planned and how feasible it is. Due to the nature and difficulty of anaesthesia for thoracoscopic surgery, it is a good idea to have a team that is experienced in these procedures to provide the necessary assistance in case of an emergency.

At Charlotte Maxeke Johannesburg Academic Hospital, the theatre preparation is rigorous:

- Lines are prepared for insertion of arterial cannula and central venous catheters.
- A line is prepared for large bore intravenous access.
  - This line is usually a blood infusion set connected to a fluid warming device which allows for rapid infusions of warm fluid or blood as is necessary.
- A warming blanket is available if the procedure will be long to keep the patient warm.
- A fibre optic scope is prepared for confirmation of placement of a double-lumen tube (DLT).
- An ultrasound machine is used for insertion of lines.
- The drugs prepared for VATS depend on the nature of the procedure and the duration.
- In general, one or two infusion pumps are made available for running propofol or remifentanil infusions as required.
- Other drugs prepared include emergency boluses of adrenaline and atropine, short-acting opiates such as alfentanil in boluses and intermediate-acting muscle relaxants such as rocuronium, atracurium or cisatracurium.

Aside from the above, a separate trolley is set up for airway intubation. On this trolley would be:

- laryngoscope blades and handles,
- oral airway devices,
- double-lumen tubes (at least two sizes),
- endotracheal tubes, and
- a laryngotracheal anaesthesia device (LTA).

In our setting, most of these procedures begin with bronchoscopy to examine the bronchial tree, to look for masses and to remove mucous plugs or copious secretions or blood. Measurements are also taken, for example, of the distance from the vocal cords to the mouth or the carina to the mouth and if there is a stricture or mass this can also be measured.

The bronchoscopy is usually done under general anaesthesia. Standard monitors are placed, and large bore intravenous access is obtained. The patient is induced with a volatile agent such as sevoflurane and kept breathing spontaneously. Boluses of propofol or a propofol infusion may be used to keep the patient deep. Analgesia in the form of boluses of fentanyl or alfentanil are titrated while keeping the patient breathing spontaneously. Once the patient is exhibiting shallow steady breathing with a low normal blood pressure and a low normal heart rate and is unresponsive to stimulus, direct laryngoscopy is conducted, the vocal cords are visualised and local anaesthetic is administered with the use of an LTA.

Once this is done, the surgeon may introduce the rigid bronchoscope into the airway to examine the bronchopulmonary tree. During this examination, the patient is kept breathing spontaneously and air is insufflated through the bronchoscope into the airway using a special connector. The challenge here is to maintain an adequate depth of anaesthetic to minimise coughing and movement and ensure patient comfort. This is achieved using boluses of short-acting opiates and propofol. This method of ventilation is spontaneous assisted ventilation.

Other methods include:

apnoeic oxygenation,

controlled ventilation (closed system),

- manual jet ventilation, and

- high-frequency jet ventilation.[9]

Once the surgeon is done with the rigid bronchoscope the patient can now be paralysed in preparation for VATS.

VATS sometimes requires lung isolation techniques. There are four methods of lung isolation, using:

- DLTs,
- bronchial blockers,
- endobronchial tubes (difficult to find), or
- positioning of single-lumen tube into mainstem bronchus.[6,10]

In our setting, the most used device is a DLT. The DLT has long been considered the gold standard in one lung ventilation procedures.[5] However, a study by Narayanaswamy et al. suggests that in 100 patients who had left-sided surgery, when assessing the quality of surgical exposure, there was no difference between bronchial blocker and DLT.[9] The choice of anaesthetic technique when it comes to one lung ventilation will depend on the anaesthetist's experience and skill.[5]

The DLT is designed for lung isolation, it allows ventilation of each lung as a separate unit. They can be left- or right-sided. Right-sided tubes are difficult to place so most procedures are done with left-sided tubes.[6] Direct laryngoscopy is used to place the tip of the DLT through the vocal cords. The introducer is then removed, and the DLT is turned 90 degrees to the left while being directed distally. The tube should be pushed as far as it will go with the thick y-connection of the tube at the level of the patient's incisors.[12]

Once the tube has been placed, the position needs to be confirmed. This is done clinically by inflating both the tracheal and bronchial cuffs, connecting the patient to the circuit, and ventilating both lungs. On auscultation breath sounds will be heard in both lung fields. The tracheal lumen of the tube can then be clamped and opened to air resulting in breath sounds only on the left. The tracheal lumen is unclamped, and reconnected, and bronchial lumen clamped and opened to air resulting in breath sounds only on the right side.

The position of the tube is further checked using a fibre optic scope. This has now become the gold standard.[6] If the fibre optic scope is introduced into the tracheal lumen, you should be able to visualise the carina and the blue bronchial cuff just beyond the carina on the left side. The fibre optic scope is then inserted into the bronchial lumen to make sure the bronchial tube is not too deep.[6]

Once the correct position has been confirmed and the tube secured, any invasive lines not placed before induction can now be added.

The patient is now ready for positioning in the lateral decubitus position. Again, this requires a team effort. The bronchial cuff of the DLT is deflated and the patient given adequate analgesia for turning. The patient is turned such that the lung to be operated on is on top (nondependent lung) for easy surgical access. Once the patient has been turned, lung isolation can begin. The relevant lumen is clamped, and one lung ventilation commenced.

To avoid ventilator-induced lung injury, a strategy of lung protective ventilation should be employed.[3,5] Protective strategies include:

- Using low tidal volumes (4–6 ml/kg).
- Judicious use of PEEP, 5–10 cmH_2O if tidal volumes are low and less than 5 cmH_2O if dealing with patients with COPD.
- Keeping airway pressure to less than 30 cmH_2O.
- Using the minimum inspired fraction of oxygen required to maintain saturation above 90%.
- Adjusting respiratory rate to maintain end tidal CO_2 and arterial carbon dioxide tension at patient's baseline.[7]

Garutti at al. failed to show a significant difference in arterial oxygenation during one lung ventilation in patients ventilated with pressure control versus volume control if tidal volumes were kept at 8 ml/kg.[5]

During one lung ventilation, there may be a drop in saturation and hypoxaemia may develop. There are many factors that influence the rate at which this happens and how big the drop is including the patient's premorbid state, the condition of the ventilated lung and the decrease in tidal volumes required in one lung ventilation. We tend to accept saturation of no less than 90% for our patients. If the saturation drops below this level, we must look at ways to improve the patient's condition.

The steps to deal with hypoxaemia include:

- Increasing the inspired oxygen concentration to 100%.
- Using the fibre optic scope to check that the tube has not moved.
- Suctioning down the tube as there may be mucous, secretions or blood occluding the airway.
- Checking that the patient has an adequate cardiac output.[7]

If these steps do not work, then one can consider:

- Recruitment manoeuvers.
- Adding PEEP to the dependent lung.
- Providing CPAP to the nondependent lung (note: obscures surgical field).
- The nondependent lung may have to be ventilated at intervals to improve oxygenation.
- A bronchial blocker may be used to collapse just the lobe to be operated on.[3]

If all else fails, the procedure may have to be abandoned.

The haemodynamic effects experienced on surgical incision and introduction of the scope largely depend on the patient's premorbid state. In patients with cardiopulmonary compromise, one may find that the cardiac output drops with a drop in blood pressure and boluses of inotropes or vasopressors are necessary. This is useful to prepare in advance as stated above.

The surgeons typically use 2–4 incisions (5–10 mm in size) depending on the type of surgery. There is no standardised technique or approach. Usually, there is a camera port and utility incision, these are placed in the mid or anterior axillary line in the intercostal space most relevant to the procedure. More incisions are made depending on the need. A background infusion of remifentanil may be useful to attenuate the pain of the incisions and the surgery. This is not necessary if regional techniques have been employed. Other intraoperative analgesics include fentanyl, ketamine, and paracetamol. Morphine and nonsteroidal anti-inflammatory drugs (NSAIDs) are better left for postoperative analgesia.

At the end of the procedure, the nondependent lung will need to be reinflated. This is usually done under vision. The surgeon watches to see that the lung is expanding appropriately before closing the incision site. Reinflation of the lung is done by providing positive airway pressure between 20–30 cm H_2O for 10–15 seconds.[7] Reinflation of the lung also allows the surgeon to look for air leaks.[3] Once the surgeon is satisfied with the quality of reinflation, the incision site is closed. A chest drain is sited. The isolation can now be reversed with care taken to continue using protective lung strategies.[5,11] Patients are turned supine, reversed and extubated if conditions allow. Any intravenous postoperative analgesia is given.

Postoperative care

Patients going for thoracoscopic procedures at a minimum are placed in a high dependency care setting. This allows for adequate monitoring, providing sufficient analgesia and encouraging early mobilisation (with physiotherapy) of the patients.

Adequate analgesia is vital to recovery.[7] Analgesic approach must be multimodal. Regional techniques such as thoracic epidurals, paravertebral blocks, intercostal nerve blocks and epidural catheters are widely favoured.[7] Most of these regional procedures are done at the beginning of the case before the patient is put to sleep. The surgeon can also directly infiltrate local anaesthesia in and around the incision site. Opiates in the form of morphine titrations and patient-controlled analgesia (PCA) pumps containing morphine can also be used. Paracetamol given intravenously for the first 24 hours, then orally, can also act as a powerful adjunct to other analgesics. For resistant pain one can also add ketamine, gabapentin or pregabalin.[7]

Nausea and vomiting prophylaxis should be prescribed.

Postoperative complications to watch out for include:

- Postoperative bleeding
- Arrhythmias (atrial fibrillation: most common[13])
- Ischaemia
- Cardiac herniation
- Right to left shunt in patients with patent foramen ovale
- Heart failure
- Pulmonary oedema,
- Post pneumonectomy syndrome
- Lobar torsion and gangrene
- Cardiac tamponade
- Chylothorax
- Prolonged air leak
- Injury to surrounding structures like phrenic nerve and laryngeal nerve
- Infections
- DVTs[14]

Unconventional thoracoscopic procedures

Non-intubated video-assisted thoracoscopic surgery (NIVATS)

This involves performing thoracic surgery in patients that are awake and not intubated. VATS done in this way usually involves using a single port for pleural effusions, empyema, retained haemothoraces and pneumothoraces, as well as for performing biopsies. Patients done under NIVATS usually have severe comorbidities which exclude them from safely having a general anaesthetic.[1]

This procedure is not advisable patients that have haemodynamic instability, extensive adhesions, difficult airway, patients who are uncooperative or who have contraindications to performing regional techniques.[1]

Robotic-assisted thoracoscopic surgery (RATS)

As the name suggests, robotics to perform VATS provides a more precise way of conducting thoracic procedures successfully.

It is critical that during RATS, the patient does not move causing injury to his/herself or damage to the robotic arms, and therefore, neuromuscular blockade must be carefully monitored with a peripheral nerve stimulator.[1]

It may be difficult to see and respond quickly to emergency situations as, apart from what is seen on camera, it is difficult to perceive the patient's condition. The team performing RATS must be well trained and ready to handle emergencies as they arise. The need to convert to an open procedure in an emergency must always be kept in mind.[1]

Enhanced recovery after thoracoscopic surgery

The aim of enhanced recovery after surgery (ERAS) for thoracoscopic surgery is to avoid postoperative pulmonary complications. The main goals are:

In the perioperative period

- Risk assessment to plan the optimal anaesthetic.
- Home therapy optimisation to reduce perioperative complications.
- Avoiding premedication to prevent postoperative cognitive dysfunction.[1]

In the intraoperative period

- Using short-acting agents for quick recovery.
- Neuromuscular blockade monitoring for optimal blockade and reversal.
- Protective strategies for one lung ventilation to guard against acute lung injury.
- Optimum fluid therapy to decrease acute lung injury and promote better tissue perfusion.
- Precise regional anaesthesia to reduce the use of opiates and reduce the stress response.
- Avoiding hypothermia to improve recovery and reduce complications.
- Postoperative nausea and vomiting prophylaxis.[1]

Conclusion

Anaesthesia for thoracoscopic surgery is an interesting and challenging field. It requires good knowledge of the physiology and thorough preparation. Meticulous attention to detail both preoperatively and intraoperatively can be key to avoiding morbidity and mortality. The idea that the anaesthesia and thoracoscopic surgery is any less impactful on the patient than open surgery is a grave misconception.[13]

Conflict of interest

The author has no conflict of interest to declare.

Funding source

None.

Ethical approval

Not required.

ORCID

NY Fening https://orchid.org/0000-0001-5465-3240

References

1. Elsayed HH, Moharram AA. Tailored anaesthesia for thoracoscopic surgery promoting enhanced recovery: The state of the art. Anaesth Crit Care Pain Med. 2021;40(2):100846. https://doi.org/10.1016/j.accpm.2021.100846.
2. Stoica SC, Walker WS. Video assisted thoracoscopic surgery. Postgrad Med J. 2000;76(899):547-50. https://doi.org/10.1136/pmj.76.899.547.
3. Conacher ID. Anaesthesia for thoracoscopic surgery. Best Pract Res Clin Anaesthesiol. 2002;16(1):53-62. https://doi.org/10.1053/bean.2001.0207.
4. Begum S, Hansen HJ, Papagiannopoulos K. VATS anatomic lung resections-the European experience. J Thorac Dis. 2014;6(Suppl 2):S203-10. https://doi.org/10.3978/j.issn.2072-1439.2014.05.04.
5. Hartigan P. Anesthesia for video-assisted thoracoscopic surgery (VATS) for pulmonary resection - UpToDate (Internet). Available from: https://www.uptodate.com/contents/anesthesia-for-video-assisted-thoracoscopic-surgery-vats-for-pulmonary-resection?search=anesthesia%20ffor%20thoracospic%20surgerey&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1. Accessed 10 Sept 2021.
6. Pathak V, Welsby I, Mahmood K, et al. Ventilation and anesthetic approaches for rigid bronchoscopy. Ann Am Thorac Soc. 2014;11(4):628-34. https://doi.org/10.1513/AnnalsATS.201309-302FR.
7. Martin M, Slinger PD. Lung isolation techniques. UpToDate (Internet). Available from: https://www.uptodate.com/contents/lung-isolation-techniques. Accessed 10 Sept 2021.
8. Fischer GW, Cohen E. An update on anesthesia for thoracoscopic surgery. Curr Opin Anesthesiol. 2010;23(1):7-11. https://doi.org/10.1097/ACO.0b013e3283346c6d.
9. Narayanaswamy M, McRae K, Slinger P, et al. Choosing a lung isolation device for thoracic surgery: a randomized trial of three bronchial blockers versus double-lumen tubes. Anesth Analg. 2009;108(4):1097-101. https://doi.org/10.1213/ane.0b013e3181999339.
10. Lee KG. Airway apparatus for thoracic surgery. Anaesth Intensive Care Med. 2017;18(12):620-5. https://doi.org/10.1016/j.mpaic.2017.09.007.
11. Martin M, Slinger PD. One lung ventilation: General principles - UpToDate (Internet). Available from: https://www.uptodate.com/contents/one-lung-ventilation-general-principles?topicRef=14944&source=see_link. Accessed 10 Sept 2021.
12. Simpson W. Anaesthesia for thoracic surgery. Anaesth Intensive Care Med. 2017;18(12):593-7. https://doi.org/10.1016/j.mpaic.2017.09.010.
13. Shaw JP, Dembitzer FR, Wisnivesky JP, t al. Video-assisted thoracoscopic lobectomy: state of the art and future directions. Ann Thorac Surg. 2008;85(2):S705-9. https://doi.org/10.1016/j.athoracsur.2007.11.048.
14. Iyer A, Yadav S. Postoperative care and complications after thoracic surgery. In: Firstenberg M, editor. Principles and practice of cardiothoracic surgery (Internet). InTech; 2013. https://doi.org/10.5772/55351.