ABSTRACT

This article reviews the approach-related complications of open versus thoracoscopic anterior exposures of the thoracic spine and suggests possible ways to avoid them.

Key words: complications; spine; surgical procedures, minimally invasive; thoracic surgery, video-assisted; thoracoscopy

INTRODUCTION

Severe rigid scoliosis or kyphosis can be treated by combining anterior releases, discectomies and interbody fusion with posterior instrumented fusion. Surgeons accessing the anterior spine should have a good understanding of the complex anatomy and possible complications.

HISTORY

The anterior approach was first attempted as early as 1895 for Pott’s disease. A few decades later, a retroperitoneal incision to treat tuberculous infection of the spine was described, in which an oblique nephrectomy incision was used for the thoracolumbar junction, and the costotransversectomy approach was used for exposure of the thoracic spine. By the 1930s, the anterior approach to the spine developed into a more reliable technique. Others have also used a transperitoneal approach to the anterior lumbar spine. Subsequently, anterior treatment of the thoracic spine for Pott’s disease was also widely performed in Hong Kong, and its modified versions entailing transthoracic exposure have been practised globally.

With advancement in surgical techniques, minimally invasive approaches such as thoracoscopic surgeries became widely accepted for their better cosmetic results. From its initial use for tuberculosis-
related effusions, thoracoscopy has evolved to include video cameras for high-definition magnified viewing. Coupled with the development of sophisticated surgical instruments and stapling devices, the scope of thoracoscopy has expanded to more complex procedures. Video-assisted thoracoscopic surgery (VATS) has advantages over open thoracotomy, such as less postoperative pain and morbidity, earlier mobilisation leading to shorter hospital stays and lower costs, and smaller scars. It is more commonly performed on relatively healthy individuals as a diagnostic procedure and on high-risk patients to avoid open thoracotomy.

**APPRAOH-RELATED COMPLICATIONS**

**Open thoracotomy**

Disadvantages of open thoracotomy are larger wounds, tissue trauma and hence worse cosmesis. Post-thoracotomy incisional pain may occur following general anterior exposure. An early though transient decrease in upper extremity and pulmonary function may also occur after traditional thoracotomy. In up to 50% of both adult and paediatric patients, atelectasis, pneumothorax, pneumonia, and even death have been reported. Paraparesis or paraplegia secondary to cord ischaemia can occur during correction of thoracic spinal deformities involving bilateral disruption of segmental vascularity, as the cord is supplied by both anterior and posterior spinal arteries, though the incidence was less than 1%. Injury to the anterior artery of Adamkiewicz remains a concern, although its sacrifice has been tolerated without complications. Magnetic resonance imaging is the standard for assessing prevailing anatomy. Chylothorax secondary to disruption of the thoracic duct can manifest after minimally invasive or open operations, with an incidence of about 1%. Infrequent postoperative complications with an approximately 10 to 30% incidence include cardiac, vascular, gastrointestinal, and technical (pneumothorax, wound and urinary tract infection, wound disruption, and haemorrhage) complications. More unusual complications include postoperative visual loss after prolonged prone positioning and latissimus dorsi rupture.

**Thoracoscopic surgery**

Complications associated with thoracoscopic procedures are similar to those of open thoracotomy, with variations in the incidence. In addition, anaesthesia, patient positioning, port placement and access, and instrument manipulation also contribute to an array of complications (Table). Complications related to anaesthesia are mainly related to single lung ventilation. Incorrect placement, inaccurate tubing size, and over- or under-inflation of the bronchial cuff that can lead to complications such as air leaks into the operated lung. Other anaesthesia-related complications involve injury to a vein during positive-pressure insufflation maintenance, which can lead to CO₂ embolism, with neurological and cardiac sequelae that can be fatal. Some patients may also have pulmonary blebs, which spontaneously burst and cause a pneumothorax, resulting in hypercarbia.

<table>
<thead>
<tr>
<th>Complications</th>
<th>Newton et al., 2005</th>
<th>Al-Sayyad et al., 2004</th>
<th>Anand et al., 2002</th>
<th>Huang et al., 1999</th>
<th>McAfee et al., 1995</th>
</tr>
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<tbody>
<tr>
<td>Intercostal neuralgia</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>4.4</td>
<td>6</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>25</td>
<td>1.4</td>
<td>5</td>
<td>2.2</td>
<td>-</td>
</tr>
<tr>
<td>Pulmonary embolus</td>
<td>-</td>
<td>1.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pulmonary oedema</td>
<td>28.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Pleural effusion</td>
<td>60</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Lung atelectasis</td>
<td>84</td>
<td>1.4</td>
<td>6</td>
<td>2.2</td>
<td>5</td>
</tr>
<tr>
<td>Blood loss of ≥ 2000 ml</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>5.5</td>
<td>2</td>
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<tr>
<td>Chylothorax</td>
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<td>0</td>
<td>-</td>
<td>1.1</td>
<td>-</td>
</tr>
<tr>
<td>Implant failure</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.1</td>
<td>-</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>2.7</td>
<td>1.4</td>
<td>2</td>
<td>1.1</td>
<td>-</td>
</tr>
<tr>
<td>Ileus</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Conversion to open thoracotomy</td>
<td>2.7</td>
<td>0</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

Table: Complication rates of video-assisted thoracoscopic surgery reported in various studies
haemodynamic instability, and even venous gas embolism. Ventilation-perfusion mismatch resulting in arterial desaturation may occur secondary to both lungs being perfused while one lung is ventilated.\textsuperscript{21} Prolonged non-ventilation of one lung may lead to accumulation of excessive secretions in the airways, resulting in atelectasis and pneumonia.\textsuperscript{12,21,22}

Lateral decubitus positioning may affect the brachial plexus either by pressure on the side the patient is lying on, or by over-abducting the arm on the operated side. Peroneal nerve palsy can occur if the nerve is compressed over the fibular head.\textsuperscript{21}

Regarding complications related to endoscope placement, injury to the lung parenchyma and other vessels may occur,\textsuperscript{1,21} as the initial port is placed blindly. Lung adhesions may be the cause of lung injury during port placement and postoperative air leaks. When one lung is collapsed, diaphragmatic migration up to the eighth intercostal space may damage structures, including the diaphragm itself.\textsuperscript{21,22} Incomplete dislodgement of trocars is liable to cause subcutaneous or mediastinal emphysema.\textsuperscript{22}

Injury to large intrathoracic vessels may also occur with instrumentation. Endoscopic instruments and retractors placed in the chest cavity can cause injury to the lung parenchyma and to large vessels in the chest cavity, leading to air leaks postoperatively and excessive blood loss intra-operatively.\textsuperscript{12,21–23} Likely bleeding sources include epidural veins, tumour feeding vessels, and sometimes intercostal vessels (especially when corpectomy is involved).

Breakage of endoscopic instruments inside the chest cavity with forceful use is not uncommon. Early recognition enables prompt retrieval.\textsuperscript{21,22} Burns from the tips of the endoscopes may occur when they get extremely hot, especially when they are not placed upwards outside the thoracic cavity. There is a small possibility of an explosion when unipolar cautery is used inside a closed space with an oxygen leak, especially in patients on high concentrations of oxygen.\textsuperscript{21,22,24} Postoperative intercostal neuralgia may occur as a result of pressure on the intercostals nerves by rigid thoracoscopic ports, or during trocar placement.\textsuperscript{21,22,24}

Patients undergoing VATS may be at risk of pharyngeal pain because they require double-lumen intubation, although such pain is not procedure related.\textsuperscript{22} Infection may occur in both thoracoscopic and open surgery. In thoracoscopic procedures, it may be caused by contamination from the head of the camera and light source. The placement and removal of instruments may cause excessive incisional wound trauma and a higher incidence of skin contusion and possible infection.\textsuperscript{21,24}

**METHODS TO AVOID COMPLICATIONS**

Patients with known lung disease should have preoperative lung function tests and arterial blood gas evaluation. Cessation of smoking is encouraged. In children, a bronchial blocker, Fogarty catheter balloon, or a single lumen tube in the appropriate bronchus can be used instead of a double lumen tube, which maybe too large for a child’s trachea. Caution is needed for those with spinal deformities; surgery should be performed on the convex side, leaving the concave side for ventilation.\textsuperscript{21}

End-tidal carbon dioxide monitoring is important, and if insufflation is used to collapse the isolated lung, insufflation pressures should be kept below 10 to 15 mmHg, so as to avoid mediastinal compression and subsequent cardiac tamponade and possible circulatory collapse, particularly in hypovolaemic patients.\textsuperscript{21}

Intra-operative positive end-expiratory pressure on the ventilated lung, with continuous positive airway pressure on the non-ventilated lung can prevent atelectasis or respiratory deterioration, as can postoperative respiratory care for both open and thoracoscopic surgery.\textsuperscript{8,13,21,24}

Failure to collapse the lung on the operated side usually results from improper placement of the double lumen tube. The position of the tube needs to be rechecked with a bronchoscope after the patient is in the lateral decubitus position and prior to trocar incisions.\textsuperscript{21,22} If arterial saturation drops below 90% during single-lung ventilation, the position of the tube should be rechecked.\textsuperscript{21}

Adequate padding by placing rolls over the pressure points can prevent palsies of the brachial plexus and common peroneal nerves. When opening the intercostal space in the presence of severe spinal stenosis, excessive flexion of the operating table should be avoided to prevent spinal cord injury.\textsuperscript{21}

The first thoracoscopic portal is made without thoracoscopic visualisation, and this can result in injury to the lung parenchyma and other vascular structures in the chest. To prevent lung injury during port placement and postoperative leaks in the presence of lung adhesions, endoshears can be used instead of the cautery is used inside a closed space with an oxygen leak, especially in patients on high concentrations of oxygen.\textsuperscript{21,22,24} Postoperative intercostal neuralgia may occur as a result of pressure on the intercostals nerves by rigid thoracoscopic ports, or during trocar placement.\textsuperscript{21,22,24}

Proper techniques, such as entering the chest very gently, avoiding the neurovascular bundle, placing all ports other than the initial port under endoscopic monitoring, and visualising instruments from entry to exit, can avoid injury to the diaphragm and large...
intrathoracic vessels.

A rigid trocar of larger than 12 mm should not be used because of the narrowness of the intercostal space. The use of a flexible thoracoport (20 mm in diameter) is suggested as it not only helps to protect incisional wounds during manipulation but also prevents possible contact of the incisional wounds with tumours or infected tissue. Avoidance of monopolar cautery, during skeletonisation of the head of the rib before removal, may prevent electrocautery injury to the intercostal nerve.

Movements of instruments in the chest must be monitored to avoid injury to intrathoracic structures and neural elements. In particular, visualisation of fan retractors is needed when they are opened and closed.

A refined VATS technique was reported to reduce blood loss. The so-called less invasive surgical technique with a 2-portal strategy requires a small incision (2 cm) for introducing the thoracoscope and a larger incision (5–6 cm) for the performance of complex spinal procedures. In addition, an intraoperative hypotensive anaesthetic technique was used for patients receiving one-lung ventilation. Bleeding from port sites can be controlled through the endoscope, with bipolar coagulation or ligation with metal clips. If bleeding at the port site is severe, a Foley catheter can be inserted and the balloon inflated to tamponade the bleeding. If the bleeding cannot be stopped, conversion to an open procedure may be needed. A thoracotomy tray must always be ready in case of massive bleeding.

To minimise cord infarction during open thoracotomy, segmental arteries should be divided close to their origins to enable collateral circulation through the internal mammary and intercostal arteries. Collateral circulation from T4 through T9 is not as abundant as that from the cervical and thoracolumbar branches. Unilateral division of segmental arteries at their origins rarely results in cord injury. The more the levels of ligation, the higher is the risk of spinal cord damage, and bilateral ligation is at a higher risk than it is unilateral.

Varied orientation of the disc spaces is one difficulty when treating spinal deformities via the anterior approach. The instruments need to be parallel to the end plates for a complete and safe removal of the disc. Thus, depending on the severity of the scoliosis and hence the amount of obliquity, a new portal may be required to approach each disc. To deal with high curves in which the upper disc spaces point towards the axilla and interfere with the instruments, a high anterior portal is suggested during introduction of a 45° thoracoscope through a more caudal portal in the anterior axillary line. In this set up, surgeons should work tangentially from the spinal canal in order to minimise accidental penetration of the dura.

REFERENCES