Tension Pneumothorax during One-lung Ventilation for Video-assisted Thoracoscopic Surgery (VATS) Using a Single-incision Subxiphoid Approach for Bilateral Lung Tumor Resection

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ABSTRACT

Traditionally, up to six incisions are required for video-assisted thoracoscopic surgery (VATS) for bilateral lung tumor resection. Besides, change posture was required during operation. In this case report, a single-incision subxiphoid approach was used for VATS to shorten operation time and reduce postoperative pain; this approach may also lead to better cosmetic results. However, in the described case, after a right-side tumor was removed, an episode of desaturation due to right-side tension pneumothorax was observed during one-lung ventilation for left lung tumor resection. CO2 insufflation was ceased, and the patient’s condition improved. A literature review and suggestions for future similar surgeries are discussed.

Keywords: Single-incision subxiphoid approach video-assisted thoracoscopic surgery, Desaturation, Tension pneumothorax, Lung tumor resection, One lung ventilation, Anesthesia

INTRODUCTION

Compared with single-incision video-assisted thoracoscopic surgery (VATS) using a subxiphoid approach, traditional VATS for a bilateral thoracic procedure creates more incision wounds and requires a change in position after operating on one side. Reports have indicated that a subxiphoid approach for single-incision VATS has various benefits, including reduced postoperative pain, shorter operation times, and improved cosmetic results. This approach has been adapted for certain thoracic operations, such as mediastinal tumor resection, lobectomy of a lung, and treatments for bilateral pneumothorax. For these operations, the anesthetic technique

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used was general anesthesia with selective one-lung ventilation[1-5]. Our literature search revealed no comprehensive guidelines for anesthetic management for VATS using a single-incision subxiphoid approach. In the described case, a patient underwent this procedure for bilateral lung tumor resection and experienced an episode of severe desaturation due to tension pneumothorax. This occurrence may lead to many uncertainties and potential risks that must be discussed to improve patient outcomes.

**CASE REPORT**

A 62-year-old male had a medical history of dyslipidemia, hypertension, neurosis, and transient ischemic attack. He had experienced pain in the right infra-clavicular area for approximately 3 years. A chest x-ray was performed, and an opaque tumorous shadow was found in the right upper lung field (Figure 1). Thoracic computed tomography was then performed, and lung tumors in the right upper lobe (RUL) and left lower lobe (LLL) were diagnosed (Figure 2). A pulmonary function test indicated normal spirometry. A cardiac echo revealed 1) a dilated aortic root (42 mm) and ascending aorta (41 mm); 2) a dilated left atrium and normal left ventricular contractility, with an ejection fraction of 65%; 3) trivial mitral regurgitation and mild tricuspid regurgitation; and 4) a pressure gradient across the tricuspid valve of 20 mmHg and an estimated right ventricular systolic pressure of approximately 30 mmHg. After discussion with the patient’s surgeon, VATS using a single-incision subxiphoid approach was arranged.

Upon the patient’s arrival in the operating room, an intravenous catheter, ECG monitor, and invasive blood pressure monitor were set. A thoracic epidural catheter was used for intraoperative and postoperative pain control. We gave the patient 10 ml of 1% lidocaine and 75 µg fentanyl epidurally immediately after the epidural catheter was in place. Subsequently, the patient remained in the supine position. For induction, 0.2 mg glycopyrrolate, 50 mg lidocaine, 200 µg fentanyl, 180 mg propofol, and 50 mg rocuronium were administered intravenously. A 35 Fr left double-lumen endotracheal tube (DLT) was then placed, and the position of the DLT was confirmed using a fiberscope. Desflurane was given to maintain anesthesia. Volume control with a tidal volume of 600 ml (FiO₂...
= 100%) was established, with a respiratory rate of 12 times per minute. Ventilator settings were adjusted as appropriate during surgery. Via the subxiphoid incision, the right pleural cavity was entered, and CO₂ insufflation was given (at a pressure of 4-8 cmH₂O). The RUL tumor was identified and excised with an Endo GIA stapling device.

Without delay, the left pleural cavity was approached in the same manner. However, desaturation was noted (in particular, SpO₂ decreased from 100% to 84%). We immediately ceased the operation and switched to two-lung ventilation, but no significant improvement was observed; instead, a drop in blood pressure from 160/68 mmHg to 120/45 mmHg, increased end-tidal CO₂ (from 33 mmHg to 41 mmHg), and elevated airway pressure (from 16 cmH₂O to 35 cmH₂O) were detected. Arterial blood gas examination revealed a pH of 7.348, a PaO₂ of 346.5 mmHg, and a PaCO₂ of 38.5 mmHg. All mechanical or technical problems, including malposition of the DLT, were excluded, leading to our suspicion of tension pneumothorax of the right lung. As CO₂ insufflation ceased, the patient’s oxygen saturation improved (SpO₂ increased to 100%), and airway pressure decreased. Despite the lack of CO₂ insufflation, the operation continued without a change in the surgical plan. It became difficult to perform the operation, but the LLL tumor was resected. Two Jackson-Pratt (J-P) drainage tubes were placed in the right and left pleural cavities. The surgeon checked the patient’s bleeding, closed the incision in layers and covered the incision with gauze. During emergence, residual neuromuscular blockade by rocuronium was reversed by the intravenous administration of 0.6 mg glycopyrrrolate and 3.0 mg neostigmine. The patient regained consciousness, responded to commands, and could move his extremities. The DLT was extubated, but the patient complained of chest tightness and severe chest pain. We gave the patient 10 ml of 1% lidocaine epidurally for chest pain relief. Shallow breathing and decreased breath sounds were noted. Bilateral pneumothorax was suspected, and suction through bilateral J-P drainage was performed. Subsequently, the patient’s shallow breathing was relieved, and his chest tightness and chest pain were somewhat improved. In relatively stable condition, he was sent to the post-operative care unit. A post-operative chest x-ray revealed 1) inadequate inspiration of the thorax and 2) the status after the placement of bilateral chest tubes (Figure 3). Post-operative arterial blood gas examination revealed a pH of 7.354, a PaO₂ of 134.5 mmHg, and a PaCO₂ of 45.8 mmHg. The patient gradually recovered well and was discharged 6 days later with stable vital signs.

![Figure 3](image-url)
DISCUSSION

Compared with traditional VATS, VATS using a subxiphoid approach has several advantages, including fewer incision wounds, shorter operation time, and better cosmetic results. However, a limited approach to posterior anatomy was reported during VATS using a subxiphoid approach[4]. Potential risks of this surgery exist, but our literature review found no reports of anesthesia-related complications of this operation. In terms of complications, hypoxia was noted in our case. There are suggested protocols for the management of hypoxia[6, 7]. In our case, decreased SpO2 was noted under controlled mechanical ventilation with 100% FiO2. Because severe and precipitous desaturation was observed, we shifted to two-lung ventilation[7] with hand ventilation and a larger tidal volume[6]. The patient’s airway, breathing, and circulation were also checked[6]. With respect to airway, we assessed the position of the DLT using a fiberscope and determined that this tube was adequately positioned. With respect to breathing, hand ventilation was performed during the desaturation episode; elevated end-tidal CO2 was noted at that time. Due to concern regarding the ongoing aseptic operation on the chest, we did not perform chest auscultation. With respect to circulation, the patient was subjected to real-time arterial pressure monitoring, and a reduction in blood pressure was observed. An ECG revealed normal sinus rhythm. Blood loss was minimal at that time. Intravenous fluid administration was adequate, and volume depletion was unlikely. The oxygen supply, concentrator, cylinder, and breathing circuit were checked, and no problems were found.

CO2 insufflation related to venous return compromise had to be excluded. During the right lung portion of the operation, CO2 insufflation of the right thoracic cavity resulted in no significant compromise of venous return (insufflation pressure: 5 mmHg), and no desaturation was noted. Desaturation occurred when the left thoracic cavity was opened; CO2 insufflation of the left thoracic cavity may have compromised venous return, resulting in desaturation and a decrease in blood pressure. Moreover, bilateral pleural cavities were opened, and CO2 insufflation was established at the xiphoid incision wound. It was reasonable to infer that CO2 was insufflated into both sides of the thoracic cavity, leading to drastic tension pneumothorax, which impeded the expansion of both lungs and therefore resulted in severe compression of both lungs, with significantly elevated airway resistance, and a reduction in venous return, with significantly decreased blood pressure. Signs of pneumothorax under endotracheal tube intubation include difficulty in ventilation (e.g., increased airway pressure), hypotension, unilateral chest expansion, distension of the abdomen, engorgement of neck veins, elevated central venous pressure, deviated trachea, changes in heart rate, and desaturation[8]. However, only a subset of these signs were present in our case; the lack of the remaining indicators could have delayed our differential diagnosis regarding the possibility of tension pneumothorax and rendered it more difficult to determine the relationship between pneumothorax and VATS with a subxiphoid approach.

Single-lumen endotracheal tubes with two-lung ventilation can be used for operations that utilize single-excision VATS with a subxiphoid approach, such as resection of mediastinal or pleural
tumors. However, to provide adequate ventilation, the ventilator must overcome the CO₂ insufflation pressure. In our case, one-lung ventilation was necessary, and maintaining adequate tidal volume would increase the risk of lung injury secondary to high airway pressure. Although minimally invasive surgery has become a trend due to its aforementioned advantages, the use of VATS with a subxiphoid incision for bilateral lung tumor resection may increase the risk of tension pneumothorax in the initially operated lung. This phenomenon may be caused by leakage of CO₂ from the first pleural defect (created by the surgeon) into the pleural cavity during CO₂ insufflation for operating on the other pleural cavity. In our case, desaturation quickly resolved after CO₂ insufflation was discontinued. We propose the insertion of a chest tube into the initially operated side and the use of wet gauze to plug the pleural defect before continuing to the opposite side. Other types of alternative ventilation management could be considered, such as apneic oxygenation or high-frequency positive-pressure ventilation.

In conclusion, VATS using a single-incision subxiphoid approach is beneficial for bilateral lung tumor resection because it results in fewer wounds, shorter operation time, and better cosmetic results than traditional VATS. However, the potential risk of tension pneumothorax should always be considered and must be managed accordingly.

REFERENCES

經劍突下單孔胸腔鏡雙側肺腫瘤切除手術
於單肺通氣時併發張力性氣胸

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中文摘要

傳統上，使用胸腔鏡做雙側肺腫瘤切除手術，需要切開六個傷口，並於術中換位，而我們這位病人，經由劍突下切開一個傷口而完成手術，不僅不需換位，也可縮短手術時間，術後疼痛較少，在傷口的美觀上也比較理想。然而，在手術當中，外科醫師切下右肺腫瘤後，於單肺通氣下進行左邊肺腫瘤切除時，病人發生右側張力性氣胸，血氧下降，在停止灌二氧化碳到胸腔以後情況改善。我們回顧相關文獻，並且探討未來進行類似的手術時的處置流程與注意事項。

關鍵詞: 經劍突下單孔胸腔鏡手術，缺氧，張力性氣胸，肺腫瘤切除，單肺通氣，麻醉

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