



# Non-intercostal access for video-assisted thoracic surgery—analysis of technical advantages and disadvantages

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**Background:** Video-assisted thoracoscopic surgery (VATS) lobectomy has become an accepted method for the treatment of early-stage non-small-cell lung cancer (NSCLC). The standard VATS approach is an intercostal one which is often followed by postoperative pain due to injury of the intercostal nerve. The non-intercostal techniques of VATS include the subxiphoid, transcervical, transdiaphragmatic and transoral procedures.

**Methods:** The technical difficulty of operative management of the anatomical structures during VATS anatomical resection are compared for the intercostal, subxiphoid and transcervical approaches.

**Results:** Some operative steps have different range of difficulty, which are analyzed in detail.

**Conclusions:** The clearest advantages of the non-intercostal approaches include less postoperative pain and superradial bilateral mediastinal lymphadenectomy in case of the transcervical approach. However, the non-intercostal approaches are more technically demanding procedures, which therapeutic role has to be clarified in the future.

**Keywords:** Non-small-cell lung; intercostal nerves; video-assisted; pain; postoperative

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## Introduction

Video-assisted thoracoscopic surgery (VATS) lobectomy has become an accepted method for the treatment of early-stage non-small-cell lung cancer (NSCLC). The last edition of American College of Chest Physicians (ACCP) guidelines recommended that VATS was preferred over a thoracotomy for patients with clinical stage I NSCLC for anatomic pulmonary resection (1). This recommendation was based on the results of many non-randomized studies and subsequently supported by Bendixen *et al.*, who prospectively compared postoperative pain and quality of life (QOL) in patients randomly assigned to the open

anterolateral thoracotomy or 3-port VATS and discovered a significant advantage for VATS over thoracotomy (2). There are several variants of VATS lobectomy. The most accepted approach is an intercostal one with the use of one to several small incisions and without retraction of the ribs (3-6). In the recent years the uniportal approach described by Gonzales-Rivas has gained a world-wide interest (7). Furthermore, there are at least 3 variants of the intercostal uniportal VATS approach—anterior, posterior and axillary (7-10). Common disadvantage of all intercostal VATS technical variants is a substantial risk of development of a chronic postoperative pain and a decreased quality of life. The incidence of such pain after VATS was estimated for

approximately 11–31.7% (11-14). Up to now, there was only one prospective study comparing uniportal vs multiportal VATS approach for anatomical pulmonary resections in regard to intensity of postoperative pain, which showed no difference between those techniques (15).

Possible advantages of the uniportal approach include avoidance of trocars and better geometry of performance of operations (16). There are possible disadvantages, which include quarreling of instruments, extra demands for thoracoscope-holding assistant and poorer ergonomics. Therefore, the problem of postoperative pain and the quality of life exists and for these reasons the other operative approaches are currently investigated.

Contemporarily, there are three alternative non-intercostal approaches including a subxiphoid, transcervical and transdiaphragmatic one. These techniques share one common feature of avoiding injury of the intercostal nerves and subsequent neuropathic pain.

### ***Subxiphoid approach***

This approach has been used for creation of a pericardial window, pericardiotomy and defibrillator implantation since the late seventies (17-19). More recently, the subxiphoid incision has been used for thymectomy, pulmonary metastasectomy and pulmonary lobectomies and segmentectomies for lung cancer, including simultaneous bilateral resections (20-22). The subxiphoid approach should be evaluated separately for thymectomy and the other procedures of the anterior mediastinum and for pulmonary wedge resections and for anatomical pulmonary resection (lobectomies and segmentectomies).

### ***Thymectomy, mediastinal procedures***

There has been a fast-growing evidence for the virtues of the subxiphoid approach for thymectomy and the other anterior mediastinal procedures. Although no direct comparative studies for the intercostal VATS (unilateral or bilateral) and subxiphoid thymectomies has been ever undertaken, there are some undisputed advantages of the subxiphoid approach, including an access to both sides of the mediastinum with clear visibility of both phrenic nerves, which guarantees the completeness of an operation. The other advantage is a possibility to remove the content of the aorta-pulmonary window area, often containing ectopic thymic foci, which is not feasible in case of the right-sided VATS approach. The last and probably the most important

advantage of the subxiphoid approach for thymectomy is a lack of chronic postoperative pain. There has been no single case of chronic postoperative pain in the group of 611 patients operated on at the Pulmonary Hospital in Zakopane with use of the subxiphoid approach (23). The incidence of the chronic postoperative pain in patients undergoing unilateral or bilateral VATS thymectomy has been never reported, nevertheless such pain is suffered by some patients.

In regard to the pulmonary metastasectomy it is possible to perform bilateral wedge pulmonary resection during one procedure.

### ***Anatomical pulmonary resections***

A subxiphoid approach has been used for anatomic pulmonary resection since 2014 (24).

Song *et al.* found the average pain scores significantly lower than those in the control group (standard intercostal uniportal VATS) (25). Disadvantages of the subxiphoid access include more difficulty in controlling bleeding with necessity to perform an additional VATS or open approach in case of major bleeding, less convenient access to the posterior aspect of the chest cavity and more difficult mediastinal lymphadenectomy. A specific, although rare complication of the subxiphoid approach is a postoperative abdominal wall hernia which occurred in 3/611 of our subxiphoid thymectomy group (23).

### ***Transcervical approach***

Historically, this approach was for the first time used by Sauerbruch, who performed thymectomy for myasthenia gravis in 1911 (26). Afterwards, transcervical thymectomy was reintroduced by Crile and later by Cooper *et al.* (27,28). Our team used this approach for transcervical extended mediastinal lymphadenectomy and, subsequently for the right upper lobectomy and left upper lobectomy (29,30). In 2016 we refined the technique of transcervical lobectomy and extended the operative indications to all pulmonary lobes with use of uniportal transcervical method (31). Tezel *et al.* has also described mediastinoscopic right upper lobectomy (32).

### ***Transdiaphragmatic approach***

Transdiaphragmatic approach which was described by Andrade *et al.* involves introduction of 4 laparoscopic ports including 2 intrathoracic ports inserted through diaphragmatic

**Table 1** The ease or difficulty of management of individual structures of the right pulmonary hilum by the intercostal VATS, subxiphoid and transcervical techniques

Operative step	Comparison of the intercostal VATS, subxiphoid and transcervical techniques
1. Upper trunk of the right pulmonary artery	Probably the range of difficulty is similar for all techniques
2. Right segment 2 artery	The transcervical approach is the most convenient with an excellent view from above ( <i>Figure 1</i> ); the subxiphoid is probably the most difficult
3. Right superior pulmonary vein	Probably the range of difficulty is similar for all techniques
4. Right upper lobe vein	Probably the range of difficulty is similar for all techniques
5. Middle lobe vein	Probably the range of difficulty is similar for all techniques
6. Pulmonary ligament	The transcervical approach is the most difficult the subxiphoid and intercostal are alike
7. Right inferior pulmonary vein	The transcervical approach is the most difficult the subxiphoid and intercostal are alike
8. Middle lobe artery	The transcervical approach is the most difficult the subxiphoid and intercostal are alike
9. Right segment 6 artery	The transcervical approach is the most convenient with an excellent view from above ( <i>Figure 2</i> ); the subxiphoid is probably the most difficult
10. Right upper lobe bronchus	The transcervical approach is the most convenient with an excellent view from above ( <i>Figure 3</i> ); the subxiphoid is probably the most difficult
11. Middle lobe bronchus	The intercostal approach is the least difficult and the transcervical is the most difficult
12. Right lower lobe bronchus	Probably the range of difficulty is similar for all techniques, although the technique of transcervical approach, which is a posterior one is quite different from the anterior approach to the bronchus used for the intercostal and the subxiphoid approaches
13. Right Oblique fissure	The transcervical approach is the most convenient with an excellent view from above; the subxiphoid is probably the most difficult
14. Horizontal fissure	The transcervical approach is the most convenient with an excellent view from above ( <i>Figure 4</i> ); the subxiphoid is probably the most difficult

openings (33). An intrathoracic resection was performed in a standard VATS technique, a specimen was retrieved through the abdomen and the diaphragmatic openings which were finally closed. The main advantages of this technique was an elimination of the intercostal pain. The possible disadvantages included technical difficulties due to the long distance from the ports to the upper mediastinum, possible seeding of the abdominal cavity with cancer cells, possible intraabdominal formation of adhesions with a risk of subsequent ileus.

The aim of this article is to compare the basic technique of the intercostal VATS with two new non-intercostal approaches—the subxiphoid and the transcervical ones. At our institution we practice all these techniques, therefore we are going to try to present our own subjective opinion, which is only based on our clinical experience.

## Methods

To compare the advantages and disadvantages of the intercostal,

subxiphoid and transcervical approaches for anatomic pulmonary resection we decided to consider a pulmonary resection as a series of separate actions aimed to manage the pulmonary vessels, the bronchus and the parenchyma.

## Results

The ease or difficulty of management of individual structures of the right and left pulmonary hilum and the mediastinal nodal stations by the intercostal VATS, subxiphoid and transcervical techniques are described in *Tables 1-3*.

We do not have any experience with pneumonectomy by the subxiphoid and transcervical approaches, therefore we cannot compare difficulty in management of the main bronchi and the main trunks of the pulmonary arteries

## Conclusions

Introduction of the uniportal approach is probably a final

**Table 2** The ease or difficulty of management of individual structures of the left pulmonary hilum by the intercostal VATS, subxiphoid and transcervical techniques

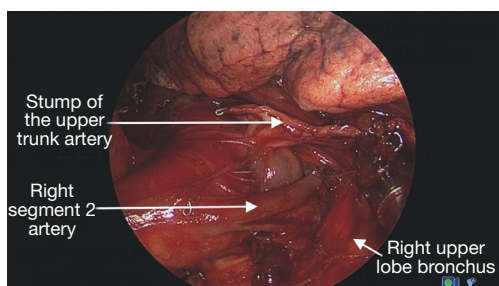
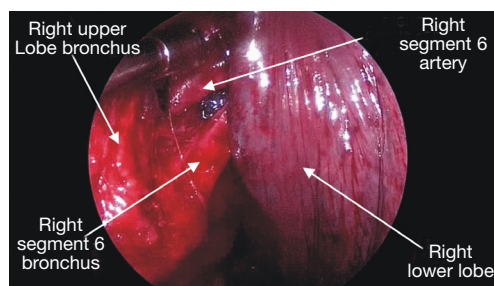
Operative step	Comparison of the intercostal VATS, subxiphoid and transcervical techniques
1. Left segment 1+3 artery	Probably the range of difficulty is similar for all techniques, although the technique of transcervical approach, which is a superior one is quite different from the anterior-inferior approach used for the intercostal and the subxiphoid approaches
2. Left segment 2 artery	Probably the range of difficulty is similar for all techniques, although the technique of transcervical approach, which is a superior one is quite different from the anterior-inferior approach used for the intercostal and the subxiphoid approaches
3. Lingular artery	The transcervical approach is the most difficult the subxiphoid and intercostal are alike
4. Left segment 6 artery	The transcervical approach is the most convenient with an excellent view from above; the subxiphoid is probably the most difficult
5. Left superior vein	Probably the range of difficulty is similar for all techniques, although the technique of transcervical approach, which is a superior one is quite different from the anterior-inferior approach used for the intercostal and the subxiphoid approaches
6. Left lower vein	The transcervical approach is the most difficult the subxiphoid and intercostal are alike
7. Left upper lobe bronchus	Probably the range of difficulty is similar for all techniques, although the technique of transcervical approach, which is a superior one is quite different from the anterior-inferior approach used for the intercostal and the subxiphoid approaches
8. Left lower lobe bronchus	The transcervical approach is the most difficult the subxiphoid and intercostal are alike
9. Left pulmonary ligament	The transcervical approach is the most difficult the subxiphoid and intercostal are alike
10. Left oblique fissure	The transcervical approach is the most convenient with an excellent view from above, the subxiphoid is probably the most difficult

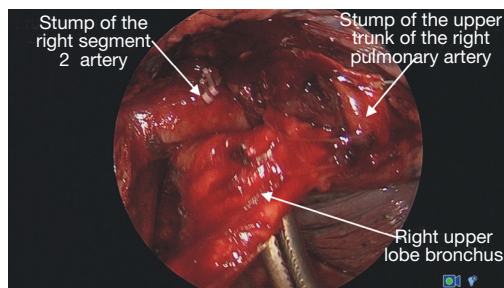
step in development of minimizing of the VATS approach with limitation to only one incision of 3–4 cm. However, there is a disadvantage of uniportal approach which is an intercostal incision, with possible risk of postoperative pain originating from injury of the intercostal nerve. To eliminate this risk the alternative uniportal approaches are currently studied, including subxiphoid and transcervical approaches, both of them avoiding the risk of chronic postoperative pain. Our experience in transcervical and subxiphoid operations assured us that a chronic postoperative pain never occurred in case of these approaches. Regarding the management of postoperative pain in patients undergoing transcervical lobectomies, no epidural or paravertebral analgesia is necessary due to the omission of any intercostal incisions. Our postoperative pain protocol includes treatment with nonsteroid anti-inflammatory drugs occasionally supplemented with narcotic drug injections, if necessary. In patients undergoing standard VATS lobectomy at our institution, we use epidural or paravertebral catheters. Additional advantages of subxiphoid and transcervical approaches is a creation of an opportunity to reach both pleural spaces and resect bilateral lesions during

one procedure. An unique advantage of the transcervical approach is the possibility of performance of super-extended bilateral mediastinal lymphadenectomy by TEMLA preceding a pulmonary resection, with obtaining the results of the study of nodes intraoperatively (34). In case of the presence of the metastatic nodes it is possible to discontinue the procedure to avoid a resection in case of positive N2. Technical complexity and long duration of the procedures are disadvantages of the transcervical uniportal lobectomies. However, our experience with this kind of operations is still very limited, so with further progress and standardization of the details of surgical technique it is possible that the transcervical and subxiphoid approaches become easier and faster. Transcervical lobectomy is probably a more difficult technique than a uniportal lobectomy. Therefore, the other possible alternative to combine TEMLA and VATS lobectomy is to perform TEMLA and a typical uniportal VATS lobectomy independently during one anesthesia. It does not seem possible to perform transcervical lobectomy in non-intubated patients as has been proposed recently for the uniportal VATS and the subxiphoid VATS approaches (35,36). Probably, more complex procedures

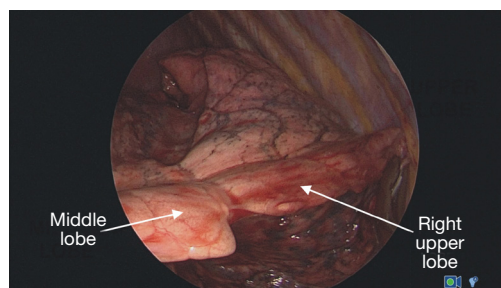
**Table 3** The ease or difficulty of management of the mediastinal nodal stations

Mediastinal nodal station	Comparison of the intercostal VATS, subxiphoid and transcervical techniques
1. Station 1 mediastinal nodes	Are not accessible for the intercostal and the subxiphoid approaches, easily accessible for the transcervical approach
2. Station 2R mediastinal nodes	Easily accessible for the transcervical approach, difficult for the intercostal and most difficult for the subxiphoid approach
3. Station 3A mediastinal nodes	Probably the range of difficulty is similar for all techniques, although the technique of transcervical approach, which is a superior one is quite different from the anterior-inferior approach used for the intercostal and the subxiphoid approaches
4. Station 3P mediastinal nodes	Rarely removed and difficult but the transcervical approach is the most convenient the subxiphoid and intercostal are alike
5. Station 4R mediastinal nodes	Most easily accessible for the transcervical approach and most difficult for the subxiphoid approach
6. Station 7 mediastinal nodes approached from the right side	The transcervical approach is the most convenient with an excellent view from above, the subxiphoid is probably the most difficult
7. Station 8 right mediastinal nodes	Probably the range of difficulty is similar for all techniques, although the technique of transcervical approach, which is a superior one is quite different from the anterior-inferior approach used for the intercostal and the subxiphoid approaches
8. Station 9 right mediastinal nodes	The transcervical approach is the most difficult the subxiphoid and intercostal are alike
9. Station 5 mediastinal nodes	Probably the range of difficulty is similar for all techniques, although the technique of transcervical approach, which is a superior one is quite different from the anterior-inferior approach used for the intercostal and the subxiphoid approaches
10. Station 6 mediastinal nodes	Probably the range of difficulty is similar for all techniques, although the technique of transcervical approach, which is a superior one is quite different from the anterior-inferior approach used for the intercostal and the subxiphoid approaches
11. Station 7 mediastinal nodes approached from the left side	The transcervical approach is the most convenient with an excellent view from above; the subxiphoid is probably the most difficult
12. Station 8 left mediastinal nodes	The transcervical approach is the most difficult, the subxiphoid and intercostal are alike
13. Station 9 left mediastinal nodes	The transcervical approach is the most difficult, the subxiphoid and intercostal are alike
14. Station 10 right nodes	The transcervical approach is the most convenient the subxiphoid and intercostal are alike
15. Station 10 left nodes	The transcervical approach is the most convenient the subxiphoid and intercostal are alike

**Figure 1** Right segment 2 artery—the view from the transcervical incision.**Figure 2** Right segment 6 artery—the view from the transcervical incision.



**Figure 3** Right upper lobe bronchus—the view from the transcervical incision.



**Figure 4** The horizontal fissure—the view from the transcervical incision.

as pneumonectomy, sleeve lobectomy, bronchovascular resections, carinal resection and the chest wall resection will not be possible with use of the transcervical approach, contrary to the intercostal uniportal approach (37). Currently, the transcervical approach is suitable only for relatively easy cases. However, it must be stressed that it was possible to perform lobectomy also in patients with total obliteration of the pleura space by adhesions.

Concluding, the clearest advantages of the non-intercostal approaches include less postoperative pain and superradial bilateral mediastinal lymphadenectomy in case of the transcervical approach. However, the non-intercostal approaches are more technically demanding procedures, which therapeutic role has to be clarified in the future.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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