



Right Pneumonectomy

Mercedes de la Torre, Eva M^a Fieira, and Marina Paradela

Abstract

Right pneumonectomy is not a frequent major resection in thoracic surgery, with limited indications. In some cases, it may require complex surgery. For this reason we think uniportal VATS right pneumonectomy should only be performed in centers that are experienced in uniportal resections.

In this chapter the surgical technique is well defined step by step, making feasible the removal of the whole lung and putting special attention to the most critical points such as the dissection of the main pulmonary artery.

We consider that the main key points for this surgery are the adequate patient selection (assessment of respiratory and cardiac function, evaluation of comorbidities) and a good planning of the surgical resection (tumour size and localization, tumour relation with hilar structures).

This procedure maintains the uniportal approach advantages, not only during the surgery (direct view to the hilar vessels and tissue) but the patient recovery as well (less pain, early mobilization and reduced hospital stay).

In our experience, Uniportal VATS right pneumonectomy can be considered a feasible and safe procedure.

The most frequent is the bronchogenic carcinoma with the following characteristics:

- Tumors involving widely the major fissure, compromising the right upper lobe and the right lower lobe.
- Hilar tumors involving the main right bronchus or the intermediate bronchus but unable to perform a sleeve pulmonary resection.
- Hilar tumors involving the main pulmonary artery.

Contraindications

- Tumors that require an extended resection (chest wall, vertebra, superior vena cava, esophagus or carinal resection).
- Huge mass that limited an appropriate surgical view of the hilum and safe manipulation of the lung.
- Surgeon discomfort.
- Preoperative chemotherapy or radiotherapy are not a definite contraindication.

Historical Review

The first video-assisted thoracoscopic pneumonectomy was described by Craig and Walker in 1995 [1]. In 2012, Gonzalez Rivas performed the first single-incision video-assisted thoracoscopic pneumonectomy, in a patient with a right lower lobe adenocarcinoma involving the upper lobe through the fissure [2].

VATS lobectomy is accepted as a valid treatment for patients with early stages of non-small cell lung cancer. The experience with pneumonectomy is quite different and more limited (Table 1), probably due to the fact that the indication of pneumonectomy implies advanced tumors.

Indications

Right pneumonectomy has only selected indications and always after discarding that a lesser resection is feasible, such as a lobectomy or a sleeve-resection.

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-981-13-2604-2_27) contains supplementary material, which is available to authorized users.

M. de la Torre (✉) · E. M. Fieira · M. Paradela
Coruna University Hospital, A Coruña, Spain
e-mail: mtorre@canalejo.org

Table 1 Previous series of video-assisted thoracoscopic pneumonectomy

Author (year)	No. incisions	Total cases	No. pneumonectomies
Craig and Walker (1995) [1]	3	62	6 (2 right)
Yim et al. (1997) [3]	3	78	6
Roviaro et al. (2004) [4]	3	259	6 (3 right)
Mackenna et al. (2006) [5]	3	1100	14
Congregado et al. (2008) [6]	4	237	22 (13 right)
Gonzalez-Rivas et al. (2011) [7]	3/2	200	6 (1 right)
Batto et al. (2014) [8]	3	107	50
Nagai et al. (2014) [9]	3	2480	47 (9 right)
Augustin et al. (2016) [10]	3	390	6
Gonzalez-Rivas et al. (2014) [11]	1	130	7
Aragon et al. (2014) [12]	1	82	1
Ng et al. (2015) [13]	1	150	2 (left)
Zou et al. (2015) [14]	1	168	1 (left)
Xie et al. (2016) [15]	1	1063	2

Apart from that, several studies have reported the safety of thoracoscopic pneumonectomy and equivalent survival rates compared with thoracotomy.

Patient Selection

Patient selection is very important because right pneumonectomy is a really high-risk surgery, apart from the surgical approach.

It must be considered for non-N2 tumors and after assessing distant metastases, making PET-CT scans mandatory.

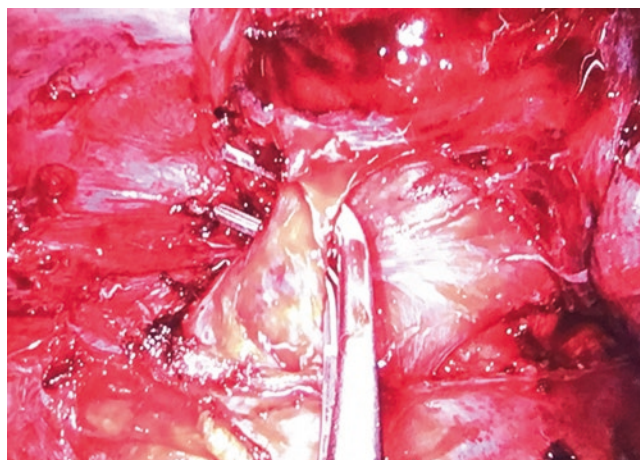
Assessment with bronchoscopy of the tumor limits can be performed at the beginning of the surgery in case of endobronchial affection.

Complete pulmonary function tests, including lung diffusion capacity and a ventilation-perfusion scan, are necessary to define the patient's ability to tolerate a pneumonectomy. Studies of cardiac function to assess ventricular function and to discard pulmonary hypertension are also indicated. Finally, a strict evaluation of patient's comorbidities and performance status is essential.

Sometimes, right pneumonectomy can be an unplanned resection. The intraoperative decision must also be based on this strict patient evaluation.

Surgical Technique

Uniportal VATS pneumonectomy is technically easier to perform than a lobectomy because the fissure does not need to be managed. However, extra care must be taken during dissection and division of the main artery and the main bronchus.

**Fig. 1** Dissection of the middle lobe vein

Patients are intubated with a double lumen tube and positioned in left lateral decubitus.

The incision is done in the fifth intercostal space in the antero-lateral position, with a length of 4–5 cm.

The first step must be the evaluation of the pleural cavity and the lung, to assess the tumor's resectability and to confirm the need for a pneumonectomy.

For the correct instrumentation, the thoracoscope (10 mm, 30° and high-definition) is placed in the posterior part of the incision while the instruments and the staplers are positioned in the anterior part.

There are two important key points:

- Optimal exposure of the lung to perform the dissection of the structures easier. The lung is retracted with a short or long ring-forceps managed by the assistant.
- Bimanual instrumentation: the surgeon exposes the target tissue with the suction or other ring forceps doing the dissection at the same time.

The lower lobe is retracted cranially to divide the pulmonary ligament and dissect the inferior vein. The lung is then retracted posteriorly, the anterior mediastinal pleural is opened, the middle lobe vein (Fig. 1) and the superior vein (Fig. 2) are dissected and encircled, separately or together. If either one or more veins are invaded by the tumor, the pericardium can be entered and an additional 1–2 cm of vein can be exposed.

To expose the artery, the upper lobe is retracted caudally and posteriorly, the upper mediastinal pleura is open, separating the azygos vein and exposing the superior aspect of the main bronchus. The anterior arterial trunk is dissected (Fig. 3), the anterior aspect of the intermediate trunk is exposed retracting the superior vein and opening the space between the artery and the superior cava vein. It is recommended to remove station 10 lymph nodes to make the main

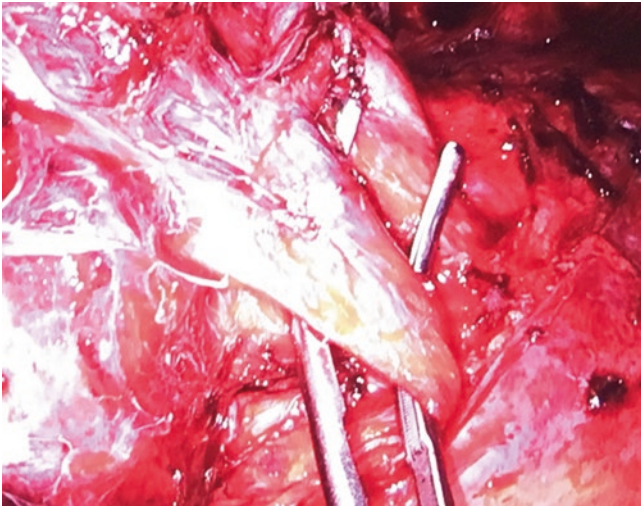


Fig. 2 Dissection of the upper lobe vein

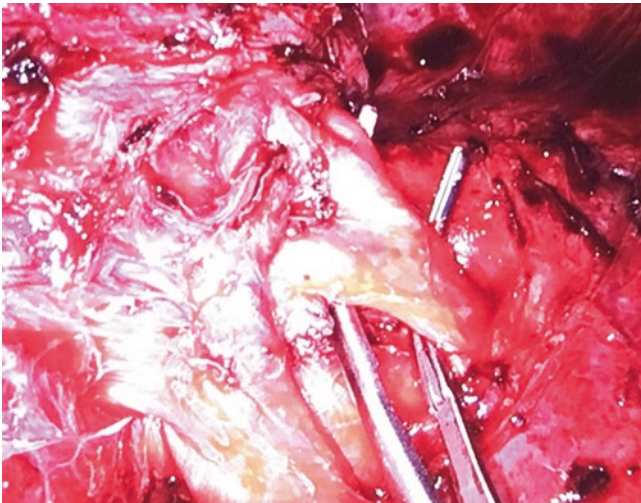


Fig. 3 Dissection of the anterior arterial trunk

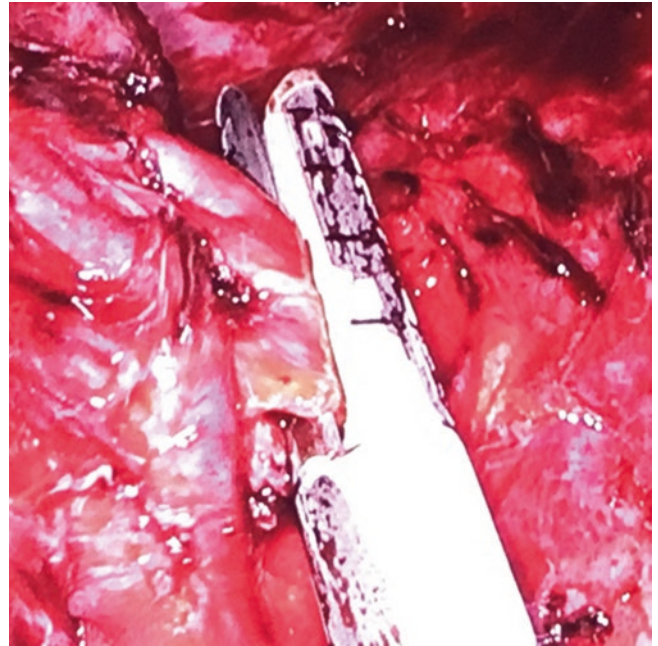


Fig. 4 Division of the anterior arterial trunk

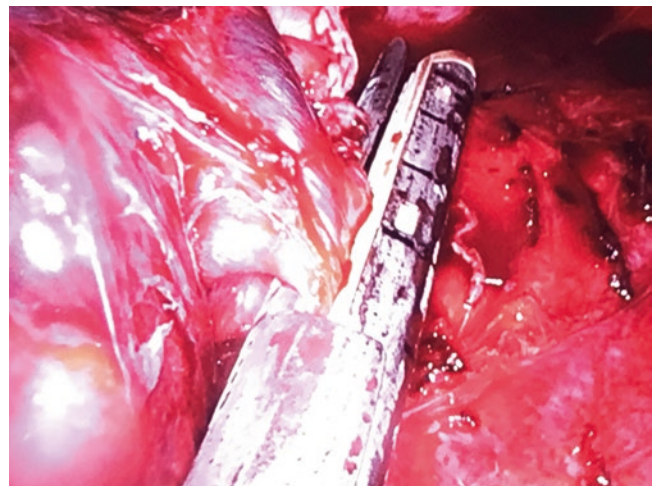


Fig. 5 Division of the upper lobe vein

artery dissection easier. Uniportal approach provides a direct view for these steps.

Then, the surgical table is rotated towards the surgeon and the lung is retracted anteriorly (a sponge stick is helpful) to open the posterior mediastinal pleura exposing the pericardium and the posterior aspect of the main bronchus.

The surgical table is returned to the initial position. The upper lobe is retracted caudally and the anterior arterial trunk is divided with a vascular stapler (Fig. 4). This maneuver makes the division of the superior vein easier, also using a vascular endostapler (Fig. 5). This step represents the main difference with the left pneumonectomy, where the whole pulmonary artery is stapled.

The lower lobe is once again retracted cranially to divide the inferior vein following with the middle vein, when it is independent. After that, the hilar tissue is dissected and divided, exposing the inferior aspect of the intermediate arterial trunk. The dissection of this trunk is carefully completed using a right angle clamp or a thoracoscopic dissector and after to encircle it (Fig. 6). We recommend to divide it from the superior aspect to the inferior with a vascular endostapler, retracting the lung backwards (Fig. 7).

The last step is the dissection and transection of the main bronchus (Fig. 8). It is helpful to remove the subcarinal lymph nodes to expose correctly the bronchus and to divide it as close to the carina as possible. For the bronchus division, the

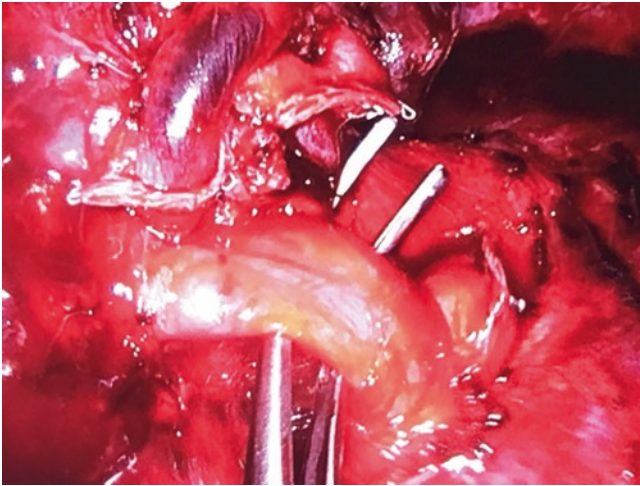


Fig. 6 Dissection of the intermediate arterial trunk

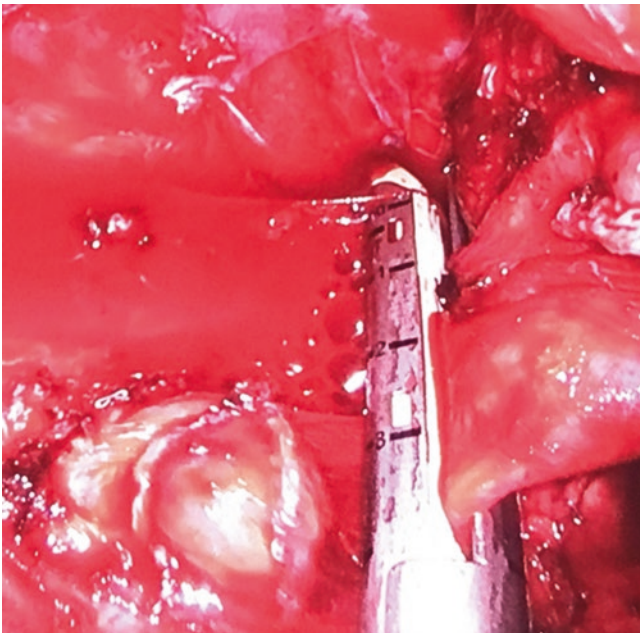


Fig. 7 Division of the intermediate arterial trunk

lung is retracted caudally, respecting the anatomic position of the bronchus and to avoid rotations during its transection. A bronchial endostapler is used.

The whole lung is removed in a protective bag.

In our experience, we don't use bronchial stump coverage. It is known that right pneumonectomy has more risk for bronchopleural fistulae than left pneumonectomy and for this reason many others surgeons recommend to cover bronchial stumps with vascularized tissue, mainly in patients that received neoadjuvant chemotherapy and specially radiotherapy. The intercostal muscle flap and pericardial fat are preferably used.

The pleural cavity should be filled with warm saline to check for bronchial stump air leak.

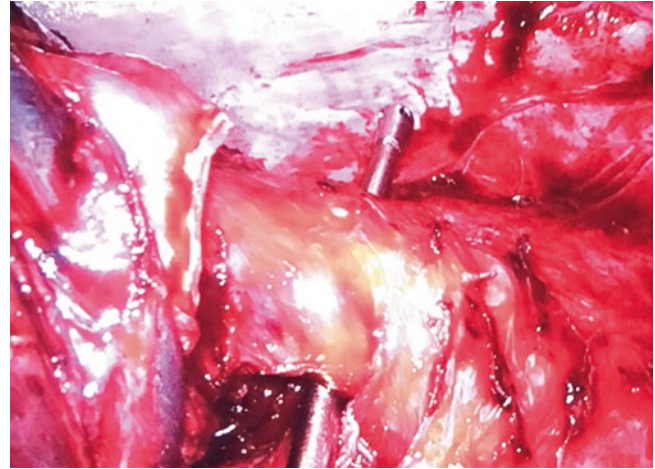


Fig. 8 Dissection of the main right bronchus

Finally, the systematic lymph node dissection is completed.

A single chest tube is placed in the posterior part of the incision or in an independent incision in the seventh intercostal space, depending on the surgeon's choice.

The incision is closed as in a usual uniportal VATS approach.

Special Situations

In case of hilar tumors that adhere to or invade either the boyden trunk or the main artery, the division of the main artery will be necessary. Then, the pneumonectomy can start by dividing the inferior vein, then the middle lobe vein and after that, the superior vein. The anterior pericardium can be opened if it is necessary to divide the superior vein to provide an extra 1–2 cm of length. If the hilum is very fixed, it is very helpful to open the space between the superior cava vein and the main artery, also the pericardium and even to transect the azygos vein and to remove the paratracheal lymph nodes. If the tissue is fibrotic, extra care must be taken. All these maneuvers make the transection of the main right pulmonary artery viable. The last option can be the use of a linear stapler.

In case of big tumors, it might be necessary to enlarge the incision or even to dilate the intercostal space with a rib retractor, removing finally the whole lung. In this situation, we recommend to place the chest tube in another incision and close the intercostal space with a suture.

Discussion

In the last decade, thoracoscopic procedures have expanded in application and popularity to perform more complex operations, such as segmentectomy, bronchoplasty and pneumonectomy.

Video-assisted thoracoscopic surgery pneumonectomy is an uncommon procedure because appropriate candidates are

limited and it is difficult to establish the safety of the procedure.

However, both technical and instrumental advances in thoracoscopic surgery, joined to the roll of induction chemotherapy shrinking large tumors more reliable, have enabled to adopt VATS pneumonectomy as a common indication in experienced VATS centers.

Several studies have demonstrated the safety of VATS pneumonectomy [16], reduction in conversion rate with experience, good morbidity and mortality rates and an equivalent impact for local control of advanced lung cancer diseases [8, 9]. One single institutional publication reported equivalent survival for VATS approach compared with thoracotomy [17].

Two points remains the most debated, the maximum tumor size and the vascular involvement. Battoo et al. found that for tumor diameter >7 cm, there was a higher conversion rate. This group emphasized the importance of controlled conversions performed prudently, because delayed conversions were associated with worse outcomes.

The technique of uniportal VATS right pneumonectomy was first described by Gonzalez-Rivas et al. in 2013 [18]. We think the main advantage of uniportal VATS pneumonectomy is the direct view to the hilar structures, especially over the main pulmonary artery. In fact, the main difference compared with two or three-ports VATS right pneumonectomy is the possibility to divide this artery in two trunks, making safer its division. Uniportal VATS provides also a good vision for the dissection and division of the main bronchus. The surgical steps are well defined and we consider previous experience in uniportal VATS lobectomy is mandatory and specific instruments, long and with proximal and distal articulation, are very helpful.

It is important to remember that this approach preserves the principles advantages of minimally invasive surgery for the patients, mainly less postoperative pain, reduced hospital stay and better compliance for adjuvant chemotherapy.

In conclusion, attempting uniportal VATS right pneumonectomy at experienced centers appears safe and must be offered to selected candidates.

References

1. Craig SR, Walker WS. Initial experience of video assisted thoracoscopic pneumonectomy. *Thorax*. 1995;50:392–5.

2. Gonzalez-Rivas D, De la Torre M, Fernandez R, Garcia J. Single-incision video-assisted thoracoscopic right pneumonectomy. *Surg Endosc*. 2012;26:2078–9.
3. Yim AP, Liu HP. Thoracoscopic major lung resection-indications, technique, and early results: experience from two centers in Asia. *Surg Laparosc Endosc*. 1997;7(3):241–4.
4. Roviario G, Varoli F, Vergani C, Maciocco M, Nucca O, Pagano C. Video-assisted thoracoscopic major pulmonary resections. Technical aspects, personal series of 259 patients, and review of the literature. *Surg Endosc*. 2004;18:1552–8.
5. Mackenna RJ, Houck W, Fuller CB. Video-assisted thoracic surgery lobectomy: experience with 1100 cases. *Ann Thorac Surg*. 2006;81:421–6.
6. Congregado M, Jimenez-Merchan R, Gallardo G, Ayarra J, Loscertales J. Video-assisted thoracic surgery (VATS) lobectomy: 13 years experience. *Surg Endosc*. 2008;22:1852–7.
7. Gonzalez D, De la Torre M, Paradela M, Fernandez R, Delgado M, Garcia J, et al. Video-assisted thoracic surgery lobectomy: 3-years initial experience with 200 cases. *Eur J Cardiothorac Surg*. 2011;40:21–8.
8. Battoo A, Jahan A, Yang Z, Nwogu CE, Yendumari SS, Dexter EU, et al. Thoracoscopic pneumonectomy: an 11-year experience. *Chest*. 2014;146(5):1300–9.
9. Nagai S, Imanishi N, Matsuoka T, Matsuoka K, Ueda M, Miyamoto Y. Video-assisted thoracoscopic pneumonectomy: retrospective outcome analysis of 47 consecutive patients. *Ann Thorac Surg*. 2014;97:1908–13.
10. Augustin F, Maier H, Lucciarini P, Bodner J, Klotzner S, Schmid T. Extended minimally invasive lung resections: VATS bilobectomy, bronchoplasty, and pneumonectomy. *Langenbeck's Arch Surg*. 2016;401:341–8.
11. Gonzalez-Rivas D, Fieira E, Delgado M, Mendez L, Fernandez R, De la Torre M. Is uniportal thoracoscopic surgery a feasible approach for advanced stages of non-small cell lung cancer? *J Thorac Dis*. 2014;6(6):641–8.
12. Aragon J, Perez I. From open surgery to uniportal VATS: Asturias experience. *J Thorac Dis*. 2014;6(S6):644–9.
13. Ng CSH, Kim HK, Wong RHL, Yim APC, Mok TSK, Choi YH. Single-port video-assisted thoracoscopic major lung resections: experience with 150 consecutive cases. *Thorac Cardiovasc Surg*. 2016;64(4):348–53.
14. Zhu Y, Xu G, Zheng B, Liang M, Wu W, Zheng W, Chen CH. Single-port video-assisted thoracoscopic surgery lung resection: experiences in Fujian Medical University Union Hospital. *J Thorac Dis*. 2015;7(7):1241–51.
15. Xie D, Wang H, Fei K, Chen CH, Zhao D, Zhou X, et al. Single-port video-assisted thoracic surgery in 1063 cases: a single-institution experience. *Eur J Cardiothorac Surg*. 2016;49:31–6.
16. Sahai RK, Nwogu CE, Yendumari S, Tan W, Wilding CE, Demmy TL. Is thoracoscopic pneumonectomy safe? *Ann Thorac Surg*. 2009;88:1086–92.
17. Nwogu CE, Yendumari S, Demmy T. Does thoracoscopic pneumonectomy for lung cancer affect survival? *Ann Thorac Surg*. 2010;89:S2012–6.
18. Gonzalez-Rivas D, Delgado M, Fieira E, Mendez L, Fernandez R, De la Torre M. Uniportal video-assisted thoracoscopic pneumonectomy. *J Thorac Dis*. 2013;5(S3):S246–52.