



# Uncommon segmentectomies: upper lobe apical (S1) and posterior (S2) segmentectomy

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**Abstract:** A combined resection of the apicoposterior segments (S1+S2) of the upper lobes is regarded to be an uncommon segmental resection. The benefits of saving the anterior segment (S3) seem small, while augmenting the technical difficulty of the resection in comparison to a classic S1+S2+S3 resection, being a right upper lobectomy or left lingula sparing lobectomy. However, a spared S3 is usually surprisingly large and nicely supports the remaining middle lobe on the right and the lingula on the left.

In this paper, we discuss the anatomy, procedure and pitfalls concerning VATS anatomical S1+S2 resections.

**Keywords:** Segmentectomy; upper lobe; lung cancer; metastasis; apical (S1); posterior (S2)

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## Introduction

Anatomical VATS segmentectomies can be indicated in patients with oligo-metastatic lung disease or primary lung cancer. In case of primary lung cancer, two groups of patients can be identified: patients with poor lung function—where a lobectomy should be avoided— and patients with small lesions—where a lobectomy is oncologically not strictly indicated and lesser anatomical resection can be defended. The latter situation is still under investigation; the results of large randomized trials are awaited (1).

Several papers have demonstrated a smaller loss of lung function with segmentectomy compared to lobectomy (2). Concerning the combined resection of the apical (S1) and posterior (S2), one could argue that the gain is small as only the anterior segment (S3) is spared; on the right side the alternative is a right upper lobectomy and on the left an upper trisegmentectomy, also known as a lingula sparing left upper lobectomy. In both procedures segments 1, 2 and 3 are resected. Furthermore, one can argue in favour of a S1–S2–S3 resection as an apicoposterior resection is thought to be more technically demanding (especially compared to a right upper lobectomy).

Surgeons recommending a combined S1–S2 resection argue that the remaining S3 segment is quite large, and thus worthwhile to spare and seems to support the middle lobe on the right and lingula on the left when left in place, possibly preserving its volume and lowering the chance of hilar torsion or bronchial angulation.

## Patient selection and workup

At this moment, we only perform segmentectomies in patients:

- (I) with suspicion of central located lung metastasis;
- (II) with suspicion of NSCLC smaller than 2 cm with impaired lung function making them poor candidates for lobectomies (with exception of small lesions in the upper lobe with heterogeneous emphysema);
- (III) with pure ground glass opacity lesions or adenocarcinomas *in situ* or with minimal invasion (in accordance to ESMO guidelines) (1).

## Pre-operative preparation

A thorough knowledge of the pulmonary bronchovascular

anatomy and possible variations is mandatory. The 2012 textbook of Nomori and Okada, and the recent update of the Atlas of Endoscopic Major Pulmonary Resections by Gossot are highly recommended literature (3,4). A 3D-CT reconstruction can provide a better understanding of the unique anatomy of your patient (5).

### ***Right upper lobe***

The right upper lobe consists of three segments: S1 apical, S2 posterior and S3 anterior. The right upper lobe bronchus divides into these three segments, but often two of the three have a common orifice.

The first branch of the artery is the truncus anterior. It always provides one or two branches to the apex (A1), A3 can originate from this truncus anterior, but can also depart more distal on the pulmonary artery (PA). The posterior ascendens artery (or ascending A2) towards the posterior segment usually originates from the lower part of the PA separately, but can also have a common orifice with the apical artery of the lower lobe (A6) (6). A2 and A6 can originate as a smaller branch of each other, A2 can be very small or absent.

The segmental venous anatomy is highly variable; a detailed overview was provided by Shimizu *et al.* describing the location of the several venous variations in relation to the bronchi (7). Most often four drainage routes can be found when looking from an anterior hilar view on the superior vein. The most apical V1, anterior V3, a central vein, and V4–5 from the middle lobe. The central vein runs in the virtual fissure between middle lobe and upper lobe, just cranial to the middle lobe artery and drains V2 (posterior segmental vein) and an intersegmental vein between S2 and S3 draining partially S2 and the posterior part of S3. Rarely, V2 drains posterior into the lower vein together with a V6 (apex lower lobe).

### ***Left upper lobe***

The left upper lobe bronchus divides into a lingular bronchus (B4–5), an anterior bronchus B3 and a apicoposterior bronchus (B1–2). Left S1–S2 is often considered to be one segment as opposed to the right S1 and S2.

There is high variability in arterial anatomy of the left PA, i.e., the number, size and location of the different branches (8,9). Typically, there is an anterior trunk with branches for S1 and S3. Posterior and opposite to A6, one

can find one or more A2 branches. Cranially of the branches of the basal segment of the lower lobe, one or more lingular arteries are to be found. A common variation with high importance during segmentectomy of the left upper lobe is a mediastinal lingular branch anterior from the bronchus, or an additional A2 running between the segmental bronchi, both originating from the anterior aspect of the PA (6,9). As on the right, the venous anatomy can be highly variable. Typically, there are tree branches: the apicoposterior vein (V1–2), a middle vein coming from the anterior segment (V3) and the lingular vein (V4–5). Various intersegmental veins often drain in V3. Often, a radiating pattern is seen and it is unclear how to designate all veins (4).

### **Equipment preference card**

- (I) Standard material for video-assisted anatomic resections. Invest in instruments with smaller tips for the segmental and subsegmental structures;
- (II) Think of alternative (non-stapler) techniques for bronchovascular ligation of these (sub) segmental structures with sutures, clips and vessel sealers;
- (III) Combination of fibrin glue and a sheet of Neoveil® (Gunze Limited, Tokyo, Japan) to treat parenchymal air leaks;
- (IV) Preoperative bronchoscopy to identify correct segmental bronchi;
- (V) Real-time fluorescent imaging, using indocyanine green (ICG) in combination with a near-infrared (NIR) camera.

### **Procedure**

#### ***Right S1+S2 resection (Figure 1)***

After inspection of the thoracic cage, the pleural reflexion is opened at the level of the anterior hilum. After identification of the lower, middle and upper lobe vein, the fat between the upper lobe vein, caval vein and azygos vein is removed, exposing the PA. With an angulated instrument we dissect the upper lobe vein. Next, we will open the posterior pleural reflexion, remove the subcarinal lymph nodes, and free the posterior bronchus exposing the upper lobe bronchus, secondary carina and intermediate bronchus. The node at the secondary carina is then removed, exposing the posterior ascendens artery. In many patients the fissure between the apex of the lower lobe (S6) and the posterior segment of the upper lobe (S2) is well developed. We would





**Figure 2** Left S1–S2 resections (12).

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originating from the truncus or from near the anterior trunk. When in doubt, it is better to only transect the most apical artery and wait until after the transection of the bronchi to see whether other anterior arterial branches are directed toward S1–S2.

We standardly open the posterior pleural reflexion after inspection of the anterior anatomy, and remove the subcarinal nodes. We then free the posterior aspect of the PA, exposing the origin of A2 and A6.

To achieve a complete lymph node dissection, including the position 11 nodes at the secondary carina, we like to open at least the posterior part of the fissure. However, in patients with an absent fissure, we will open the fissure completely with a tunnel technique and staplers, as previously described (11). An open fissure presents the anatomy of the lingular arteries (A4–5), the basal segmental arteries (A7–10), the apex of the lower lobe (A6) and the posterior segmental artery (A2). The A2 is often the first branch we like to transect. Next we follow the artery posteriorly to identify extra A2 or A1 branches.

It is only after transection of the A1 and A2 arteries that a view can be achieved on the posterior aspect of the segmental bronchus of S1–S2 (B1–2), its transection often being the most difficult part of a left S1–S2 segmentectomy. B3 and B4–5 should be identified prior to transection of B1–2. When there was doubt concerning possible A3 or A4–5 arteries, traction on the distal stump of B1–2 will reveal whether they are running towards S1–S2 and need to be transected. The parenchyma can be transected with staplers. One should try to keep the central part of the intersegmental veins and especially the bronchus out of the stapler on the parenchyma.

For lung cancer, the typical mediastinal lymphadenectomy should be performed, together with removal of hilar (position 10), subcarinal (position 11) and tertiary carina (position 12) lymph nodes. When malignant at frozen section, most experts advocate completion lobectomy.

### Role of team members

It is very useful to have a team member available with knowledge of the segmental anatomy to perform a preoperative bronchoscopy helping you to identify the correct segmental bronchi while clamping in the field.

### Post-operative management

Standard VATS anatomical resection postoperative management with early drain removal and mobilization of the patient.

### Tips, tricks and pitfalls

The most important pitfall is failure to recognize the correct anatomy, transect a structure of another segment (especially segment 3, and to lower degree S4–S5 and S6) without proceeding to a completion lobectomy or upper trisegmentectomy.

On the right side, A3 is often single and part of the truncus anterior. B3 should also be properly identified before transecting B1 and B2.

On the left, the most central arterial branches are highly variable and concealed by the veins. A mediastinal lingular branch is common. Furthermore, it can be difficult to differentiate between A1–2 and A3 arteries. In these cases, only the most apical artery should be transected at the start of the operation. Encircling the B1–2 is more difficult on the left than on the right, as the left PA turns around the upper lobe bronchus. So, the posterior arteries (A1–2) should be transected first. Even then, it can be difficult to identify B1–2, B3 and B4–5. We therefore like to open the fissure (partially) between lingula and lower lobe to reveal the complete fissural bronchovascular anatomy which also helps to remove the lymph nodes at the secondary and tertiary carina.

### Conclusions

In this brief report, we present an overview of the anatomy, procedure and pitfalls during combined apicoposterior



(S1+S2) segmentectomy of the upper lobes.

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