Chapter

Segmental Resection in Early-Stage Lung Cancer

Balasubramanian Venkitaraman, Jiang Lei and Suhaildeen Kajamohideen

Abstract

The minimum standard surgical resection required for curative surgical management of carcinoma of lung had been lobectomy, established based on The Lung Cancer Study Group results, published decades earlier. Recent data show similar oncological outcomes for patients undergoing lobar and sublobar resection with proper patient selection. Randomized trials are underway to statistically establish their equivalence. Segmentectomy is a demanding procedure requiring an in-depth understanding of surgical anatomy and its variations and surgical expertise. Many techniques are described, by various specialists, to perform segmental resection, with their own advantages and shortcomings.

Keywords: segmental resection, carcinoma lung, sublobar resection, lobectomy, video-assisted thoracoscopic surgery

1. Introduction

The surgical management of lung cancer has witnessed major advances during the last 1–2 decades; most important would be the minimally invasive surgical techniques and conservatism in parenchymal resection. The lung cancer study group publication by Ginsberg et al. [1] comparing lobectomy and limited resection for early lung cancers concluded the latter to have inferior outcomes. However, this study was part of an old era where the imaging techniques were primitive and pathological understanding and classifications of lung cancer were quite different. Recent updates in the pathological classification of bronchoalveolar carcinoma have given newer terminologies: minimally invasive adenocarcinoma (MIA) and adenocarcinoma in situ (AIS), which after complete surgical resection has shown to have very good survival.

Studies by Altorki et al., Lin et al. also, have shown segmental resection for select early-stage lung cancer patients can provide good outcomes compared to lobectomy [2, 3].

2. Anatomy

The lungs are composed of functional divisions known as bronchopulmonary segments, each having its independent blood supply and air supply. The bronchi of

lobes ramify and divide into divisions for the segments, which are in turn accompanied by the arteries. The venous circulation however is intersegmental and goes through the septae between the segments.

The right side lung is further divided into the right upper, middle, and lower lobes. The right upper lobe further consists of 3 segments namely:

1. S1—Apical segment
2. S2—Posterior segment
3. S3—Anterior segment

S1 is the superior most as its name suggests, posterior and inferior to it is the segment S2 and anterior to it is the segment S3. The latter two are bounded below by the horizontal fissure separating the upper and middle lobes.

The middle lobe of the right lung is divided into two segments: the lateral/costal portion—S4 and the medial/hilar—S5.

The right lower lobe of the lung consists of 5 segments:

1. S6—Superior basal segment
2. S7—Medial basal segment
3. S8—Anterior basal segment
4. S9—Lateral basal segment
5. S10—Posterior basal segment

The left lung has two lobes: the upper and lower lobes. The right upper lobe of the left lung has fewer segmental divisions compared to the right upper lobe, as few of them are merged together.

1. Apico-Posterior segment (S1 + S2)
2. Anterior segment (S3)
3. Superior lingula segment (S4)
4. Inferior lingula segment (S5)

The left lower lobe has 4 segments (one lesser compared to right lower lobe)

1. Superior basal (S6)
2. Anteromedial basal segment (S7 + S8)
3. Lateral basal segment (S9)
4. Posterior basal segment (S10)

3. Indication

Various studies have different selection criteria for patients undergoing segmental resection. Broadly this can be divided into those for primary lung lesions and those for metastatic conditions.

We recommend the following for selection of patients with primary lung cancer for segmental resection:

- Patients with early-stage lung cancer <2 cm, peripherally placed.
- Patients with respiratory compromise are not fit for lobectomy (a clearance of 2 cm is recommended).
- Peripheral nodule ≤2 cm with at least one of the following:
- Pure AIS histology
- Nodule has more than 50% ground glass appearance on CT
- Radiological surveillance confirms a doubling time(≥400 days).

Patients with metastatic tumors—with deposits in the lung—can also be candidates for segmental resection if these are centrally placed and are not ideal candidates for wedge resection.

4. Contraindications

These procedures are contraindicated in patients where surgery cannot be curative, i.e. patients with:

1. Presence of metastatic disease
2. Presence of N2/N3 mediastinal nodal disease

Previous surgeries to the ipsilateral lung are not a contraindication for segmental resection; however, presence of adhesions/fibrosis distorting the anatomy may preclude surgery.

Note: The visceral pleural invasion (VPI) noted on histology is a high-risk entity and segmental resections are not recommended in such patients.

5. Workup

All patients should be evaluated with pulmonary function tests and other routine investigations prior to surgery. A metastatic workup with whole-body FDG PET CT with an MRI brain should be performed to rule out a metastasis. Patients are admitted a day prior to the surgery. All cases are to be discussed in a multi-disciplinary tumor board prior to surgery. (As we do not have level 1 evidence for sublobar resection.)

6. Operative technique

We describe the technique of uniportal VATS segmental resection here.

Patient is intubated with an endotracheal double lumen tube to achieve lung isolation.

Patient is positioned on the table in the lateral decubitus position with the involved side exposed in its entirety, with a bridge underneath the chest, to spread out the ribs. Surgeon stands in front of the patient with assistant standing behind and the camera placed at the cranial end (**Figure 1**).

Depending on the lesion location, the uniportal utilitarian incision is placed on the 4th/5th intercostal space along the anterior axillary line (**Figure 1**). The incision is deepened and extended into the thoracic cavity, along the upper border of the rib. A wound protector/sleeve is used to cover the incision. Camera is placed in the anterior aspect of the incision and the thoracic cavity is inspected for any pleural deposits/effusion.

In lesions that are difficult to localize and deep within the parenchyma, preoperative localization techniques are helpful.

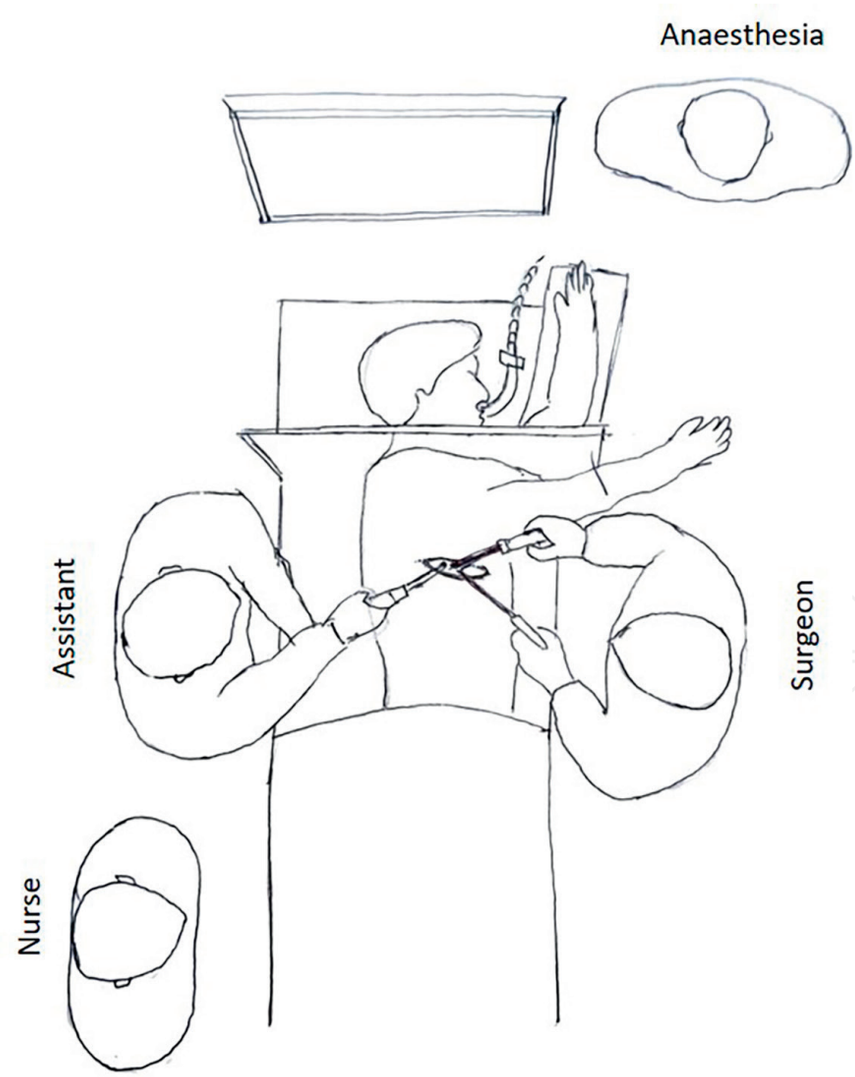

Figure 1.
Schematic representation of the operation theater set up for uniportal thoracoscopic surgery. Uniportal incision on the lateral aspect of the ipsilateral chest wall. Surgeon standing anteriorly, assistant standing behind the patient, monitor placed on the head end aspect.

- Three-dimensional reconstruction and spatial orientation [4]
- CT guided wire placement/needloscopic [5, 6]
- Intraoperative imaging—radiograph/ultrasound
- Finger palpation

Once the segment to be removed is localized, further dissection takes place along the bronchus/artery and the branch leading to the segment is dissected out. Different techniques can be used for identification of the intersegmental plane during the procedure. These include the conventional deflation-inflation technique, where the bronchial division is divided and the rest of the lung is inflated. The deflated parenchymal markings provide us with the intersegmental plane or the plane for parenchymal division. However, there could be other communications that may cross-inflate the segment to be divided, giving a wrong plane of resection.

Another way is the inflation-deflation technique, where the lung is inflated and the bronchus to segment is divided and the lung is deflated [7]. Here since the bronchus is stapled, the segment remains inflated and forms the margins, helping in identifying a plane of resection. Disadvantages of this are the inflated lung many times obscures the vision and makes it difficult to apply staplers. Indocyanine green fluorescence has also been used in identification of the intersegmental plane. After the segmental artery was divided, an intravenous systemic injection of indocyanine green was given and with infrared assistance, margins were made out [8].

We use a SAFE technique for identification of the intersegmental plane, published earlier [9]. After identification and division of the segmental artery, the bronchus is identified. A small incision is made in the bronchial division of the

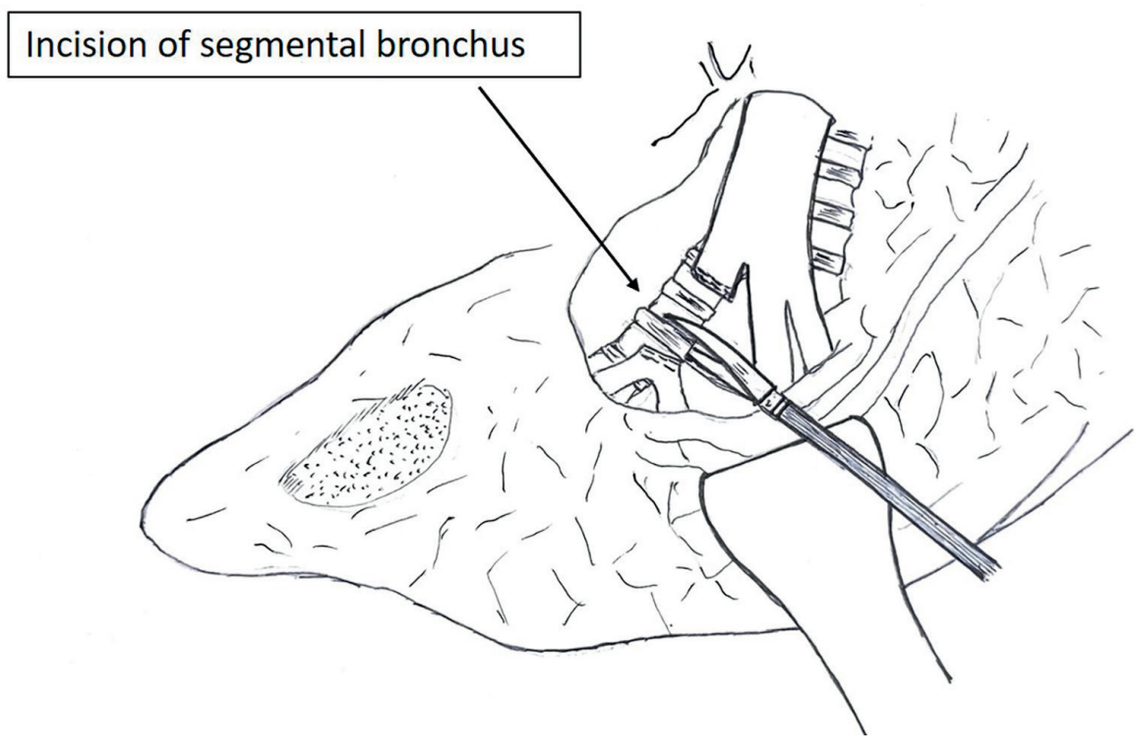

Figure 2.
Segmental bronchus being identified and an incision made with sharp scissors.

segment (**Figure 2**) and a deep vein catheter is placed into the incision directed distally into the segment to be removed (**Figure 3**). Incision on the bronchus is just enough to admit the catheter. Clamp is applied on the bronchus as shown in **Figure 4** and air is insufflated through a syringe, and the parenchyma gets inflated, defining the segmental boundary.

Once this is defined, the catheter is removed and the segmental bronchus divided using endostaplers and the distal cut end is lifted up. Parenchymal dissection is done further to aid in the placement of the staplers for division of the parenchyma. Once parenchymal division takes place, we check for air leak.

Nodal dissection needs to be performed in patients with invasive lung cancer according to the AJCC /IASLC station map, removing the level 1 and level 2 nodes – as per the location of the tumor.

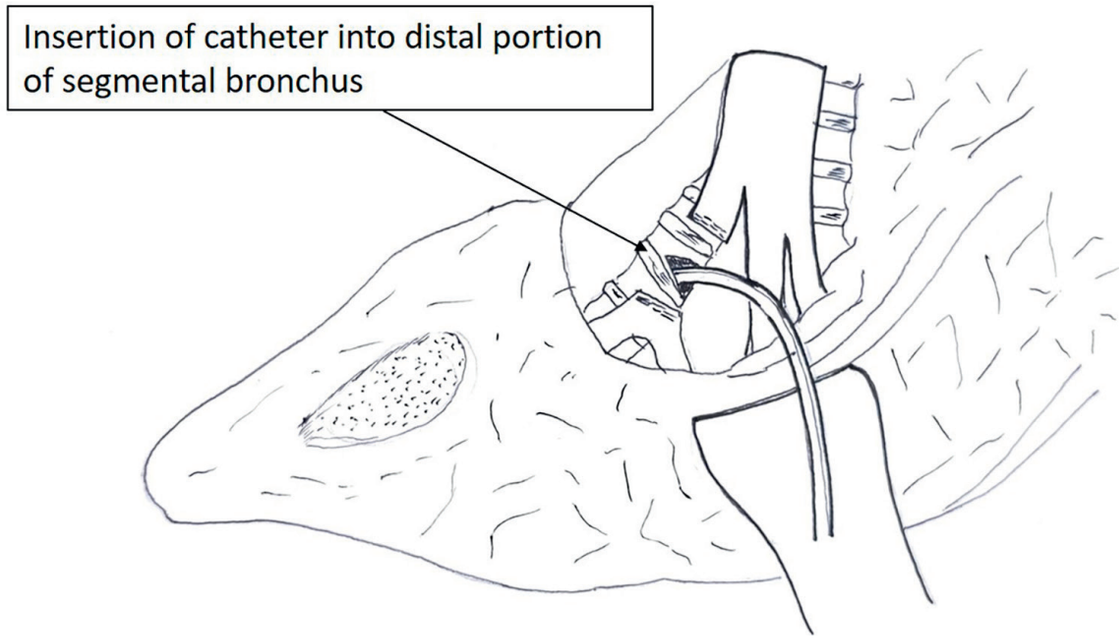

Figure 3.
Deep vein catheter placed through the incision, directed distally into the segmental bronchus.

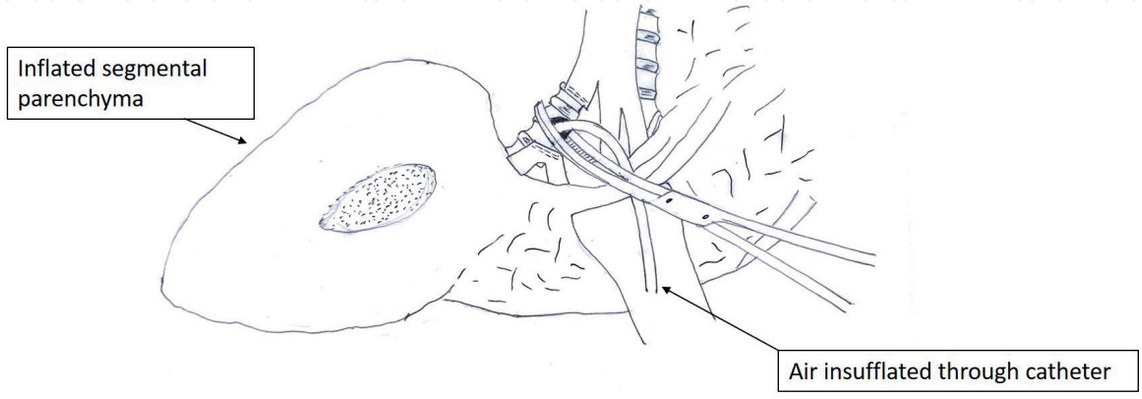

Figure 4.
Air insufflated through the catheter, showing inflation of the segmental parenchyma. This helps in parenchymal demarcation, helping to identify the intersegmental plane for division.

7. Commonly performed segmental resections: technique

7.1 Left side: lingulectomy (S4-S5)

After approaching the hilum thoracoscopically, from anteriorly, the left superior pulmonary vein is identified and traced to identify the lingula branch. This is divided with staplers to reveal the bronchial anatomy. The upper lobe bronchial division and the lingular divisions are identified, the latter is divided with staplers, after defining the intersegmental plane. The lingualar artery is acceptable is approached as the visaulised, better posteriorly, and divided, followed by parenchymal division.

7.2 Left upper lobectomy: lingula sparing (S1-S3)

The left hemithorax is approached thoracoscopically and in an anterior approach, the hilar structures are identified. The left superior pulmonary vein is identified and dissected out to identify the branches to the upper lobe. Branches are divided with staplers and then the bronchial tree is visualized. The same is dissected out to identify the S1, S2, and S3 branches which are then divided with staplers.

The left upper lobe receives short segmental arterial branches from the left main pulmonary artery as it winds around the hilum, going posteriorly. These are dissected and taken individually if needed and then the parenchymal transection is made.

7.3 Superior segmentectomy: lower lobe (S6): both sides

On either side, the inferior pulmonary ligament is dissected out and the inferior pulmonary vein is identified. From a posterior approach, the superior segmental vein S6 is identified in the fissure and is divided, preserving the basilar branches. The S6 arterial branch can be identified posteriorly and divided. The lower lobe bronchus can be traced and the S6 origin identified, cut, and catheter placement is done. S6 is inflated and parenchymal margins are marked out. S6 is then divided with staplers and parenchymal transection is completed.

7.4 Basilar segmentectomy: S7-S10

Similar to the superior segmentectomy approach, the inferior pulmonary vein is first identified and then dissected out to identify the S6 branch. The vein distal to this is divided. Inferior pulmonary artery distal to the S6 branch is divided, better in the posterior approach. The lower lobe bronchus is traced and the division distal to the S6 branch is canulated and the parenchyma is inflated. The bronchus is divided and then parenchymal division is done.

8. Node dissection

Systematic nodal dissection and systematic nodal sampling both have been proved to have similar outcomes, especially in patients with N0 on imaging [10]. Nodal dissection should be based on the lesion location.

A minimum of 3—N2 level nodes should be sampled with a total of at least 6 nodes.

For left upper—left levels 4, 5, 6, and subcarinal should be removed along with hilar node dissection.

For left lower lobe lesions—left levels 7, 8, 9, and 10 should be removed along with hilar node dissection.

For right upper lobe lesions—right level 2.4.7 with hilar nodes need to be removed.

For right lower lobe lesions—right levels 7, 8, 9, and 10 with hilar nodes need to be removed.

9. Conclusion

Segmental resection is a sound alternative to lobar resection in select patients with early-stage lung cancer. Proper selection of patients becomes an important component to ensure good outcomes. A nodal dissection needs to be accompanied by segmental resection in patients with preoperative diagnosis of invasive primary lung cancer. In patients with uncertain pathologies, an intraoperative frozen section is recommended to help in completing nodal dissection for malignant conditions. Larger trials are underway and their results can confirm or refute the oncological safety of segmentectomy in early-stage lung cancer [11].

Conflict of interest

The authors declare no conflict of interest.

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