




## CASE REPORT

# A novel form of precise segmentectomy—Triumphal arch-like anatomical segmentectomy

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## Abstract

The increasingly accurate sublobar anatomical resection is constantly being explored and practiced. Surgeons try to preserve as much viable lung tissue as possible. Sublobar resection of the target tissue is similar with a cone-shaped structure which penetrates deeply into the pulmonary parenchyma and runs through the lobe at both ends. This has not previously been described. The remaining lung tissue resembles the Triumphal Arch in Paris, France. Here, we describe triumphal arch-like sublobectomy in detail, aiming to provide clinicians with an idea to explore this novel sublobectomy under similar conditions.

## KEYWORDS

lung cancer, segmentectomy, surgery

## INTRODUCTION

Although lobectomy is still the standard procedure for early-stage non-small cell lung cancer (NSCLC), anatomical sublobectomy has been widely used as an alternative to lobectomy in terms of intent to cure early-stage NSCLC.<sup>1</sup> Recently, a number of studies have suggested that sublobar resection yielded equivalent oncological outcome in patients with stage I non-small cell lung cancer,<sup>2</sup> which confirms the effectiveness and safety of sublobectomy in the treatment of early lung cancer.

Increasingly accurate anatomical sublobar resection is constantly being explored and practiced. Surgeons try to preserve as much viable lung tissue as possible. Sublobar resection of the target tissue is similar with a cone-shaped structure which penetrates deeply into the pulmonary parenchyma and runs through the lobe at both ends, and has not previously been described. The remaining lung tissue resembles the triumphal arch.

The aim of our study was to describe in detail three cases of triumphal arch-like sublobectomy.

## CASE REPORT

### Case 1

A 49-year-old woman presented to our hospital with a ground-glass pulmonary nodule. Computed tomography (CT) showed the nodule had a maximum diameter of 1 cm and was located in the right S9 segment (Figure 1a).

### Case 2

A 35-year-old man was admitted to a surgery where he was found to have a part solid nodule. CT showed that the maximum diameter of the nodule located in the left ninth segment was 0.9 cm (Figure 1c), which was similar to the one 3 months ago.

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### Case 3

A 37-year-old woman presented to the hospital with a part solid nodule. CT showed that the maximum diameter of the nodule was 0.8 cm in the upper lobe of the right lung (Figure 1e).

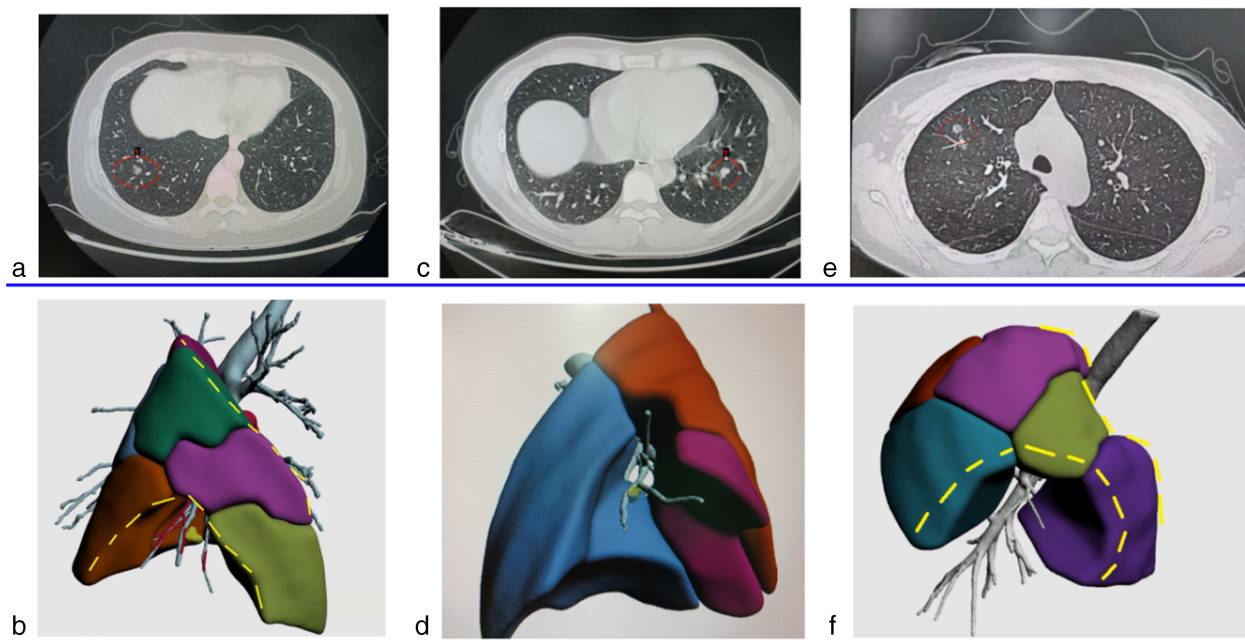
The maximum diameters of all nodules were less than, or equal to 1 cm, and imaging results were not suggestive of metastases. Considering that the nodules in each patient were likely to be malignant tumors, all three patients were admitted for single-port video-assisted thoracoscopic surgery.

Before surgery, we used three-dimensional CT bronchography and angiography software IQQA (EDDA Technology) to perform a reconstruction of the structures of the segments, including the bronchus, arteries, and veins. We also reconstructed the drainage area for each segment, including preserved and target segments. According to the reconstructed structures, especially the three-dimensional figures of preserved segments without a target segment, we found that the target segment of all the three cases were similar with a cone-shaped structure, penetrated deeply into the pulmonary parenchyma and ran through the lobe at both ends (Figure 1b,d,f). The operation should be performed from both ends of the lobe. Surgery from only one side may result in incomplete surgery and difficulty in surgical exposure. The remaining lung tissue resembles the triumphal arch. We subsequently named this surgical procedure triumphal arch-like sublobectomy.

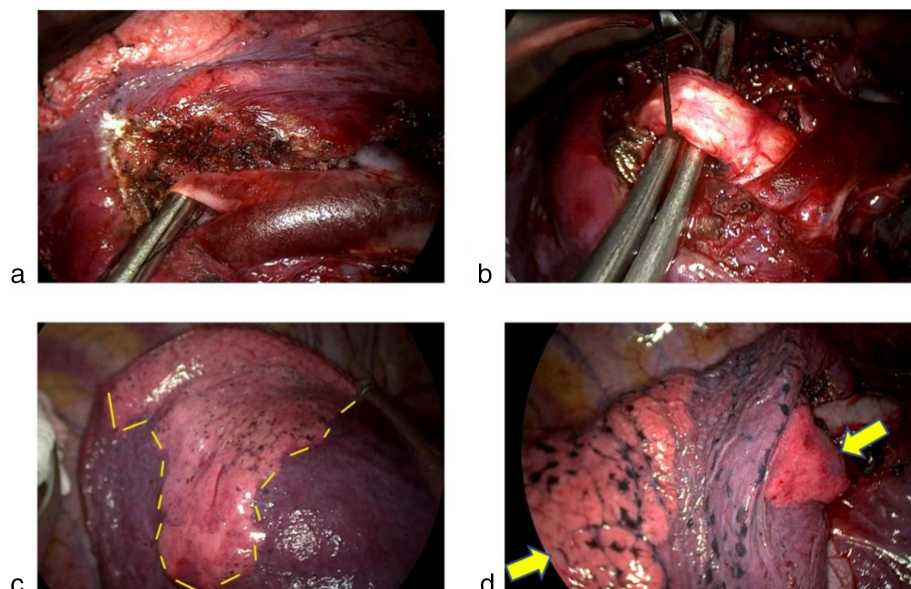
### Surgical technique

Three patients underwent single-port video-assisted thoracoscopic surgery (VATS) anatomic segmentectomy. After endotracheal intubation, the patients were in a state of unilateral differential ventilation. An incision measuring 3.5 cm was performed in the fifth intercostal space for cases 1 and 2, and the fourth intercostal space for case 3, in the middle axillary line. Thoracic instruments were placed for exploration. Multiple pulmonary adhesions were released using electric hooks.

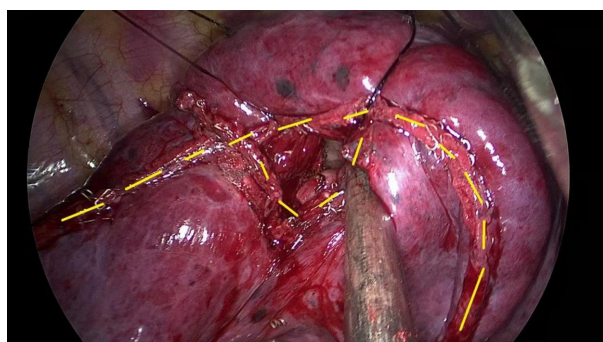
Here we provide a detailed introduction to this procedure performed in case 1. From the oblique fissure position, the targeted arteries A9 and targeted bronchi B9 were exposed and then divided by ligation or stapler (Figure 2a, b). Then, we used a modified inflation-deflation method<sup>3</sup> to create a demarcation line between the inflated targeted tissue and deflated adjacent tissue, showing preserved tissue straddling the target tissue, like an arch (Figure 2c,d). Using the bronchial stump at the proximal end of the target tissue for traction, we used combined dimensional reduction (CDR) method<sup>3</sup> to perform the separation. From the proximal end, we separated the target tissue along the intersegmental plane according to the intersegmental demarcation, towards the distal end with the ultrasonic scalpel. We also used the ultrasonic scalpel to separate the intersegmental plane from the distal end, trying to achieve the purpose of penetration of both sides. Once we achieved penetration of



**FIGURE 1** (a) Chest computed tomography (CT) of case 1 showed a ground-glass pulmonary nodule in the inferior lobe of the right lung. (b) Reconstructive software indicated the lesion of case 1 was located in the RS9 and showed the preserved segments. Yellow lines indicate the intended surgical field at both ends of the lobe. (c) Chest CT of case 2 showed a solid pulmonary nodule in the inferior lobe of the left lung. (d) Reconstructive software indicated the lesion of case 2 located in LS9 and showed the preserved segments. The target segment runs through the lobe. (e) Chest CT of case 3 showed that a part solid pulmonary nodule was in the upper lobe of the right lung. (f) Reconstructive software indicated the lesion of case 3 was located in the RS3a and showed the preserved segments. Yellow lines showed the intended surgical field at both ends of the lobe



**FIGURE 2** (a) The segmental artery RA9 and (b) segmental bronchi RB9 were exposed and dissected. (c) After the modified inflation-deflation method, obvious demarcation showed the S9 intersegmental plane on the diaphragm surface of the right lower lobe. (d) After the modified inflation-deflation method, the targeted segment was seen at both ends of the lobe (indicated by the yellow arrow)



**FIGURE 3** The operation port showing the preserved segments which resemble the triumphal arch. The two ends of the lobe were perforated

both sides, and there was enough space for us to do the exposure, we used the stapler to trim the boundary between the target segment and the surrounding lung tissue along the demarcation line to obtain a larger operating space and a better field of view. Next, we progressed to separating the target tissue inward from the boundary line to connect two separating planes by ultrasonic scalpel, forming an operation port. The proximal end of the target segment was pulled from the operation port to the distal end for better exposure. Using the combined dimensional reduction method, we adjusted the route to tailor the peripheral residual border. Finally, we completely removed the target tissue, and the remaining lung tissue resembled the triumphal arch (Figure 3). At the end of the operation, after checking that there was no air leakage from the lungs, placing the drainage tube in the chest cavity, we closed the chest layer by layer to complete the procedure.

We performed similar procedures for cases 2 and 3, and the triumphal arch-like sublobectomies were all accomplished satisfactorily.

## RESULTS

The operation was successfully completed in three patients. The intraoperative frozen pathological results indicated minimally invasive adenocarcinoma in cases 1 and 3, and a benign nodule in case 2. The margins of all three cases were adequate and were consistent with the postoperative pathological results. The operation time of the three patients was 150, 123, and 147 min respectively. The mean blood loss was 30 ml. The mean duration of thoracic closed drainage was 1.7 days. The mean postoperative hospital stay was 3.7 days, and the drainage tubes were all removed before discharge. There were no postoperative complications related to surgery, such as air leakage, hemoptysis, chylothorax, or pulmonary infection.

## DISCUSSION

Anatomical sublobectomy has been shown to be an effective and safe alternative to lobectomy for treating early-stage NSCLC and is therefore widely performed. However, sublobectomies that create several intricate intersegmental planes are considered complex; examples include resection of the right third, left ninth, right first and third, and left ninth and tenth segments.<sup>1</sup> The complex boundaries between the target and nontarget tissue makes precise anatomical sublobectomy challenging.

In the above three cases, the target tissue was similar with a cone-shaped structure, which penetrated deeply into the pulmonary parenchyma and ran through the lobe at both ends. The resultant peculiar shape of the target tissue makes it difficult to start separating out the boundaries, particularly given that limited information about dealing with this situation has previously been published. Using previously reported methods makes damage to, or

even removal of, the nontarget arch-like tissue highly probable.

To the best of our knowledge, this is the first report to introduce triumphal arch-like anatomical sublobectomy. For a complex curved border, with typically lateral basal segments or some combined subsegments, tailoring with the stapler alone will cause severe crush and curling of the cutting edge and subsequent atelectasis or venous pleonemia of the retained segments.<sup>4</sup> This technique is based on the combined dimensional reduction method. We finished nearly three-fourths of the proximal parenchyma division with an ultrasonic scalpel to make the remaining peripheral parenchyma thin enough, and then tailored the remaining parenchyma using the stapler.<sup>3</sup> It decreases the risk of extension of the resection to the adjacent segment. It achieves a more anatomical and physiological separation plane. In the study,<sup>3</sup> the use of ultrasonic scalpel and staplers for management of the intersegmental plane was associated with a shorter operating time and postoperative stay, with no significant differences in the period of tube drainage, as well as the incidence of postoperative complication than the conventional non-CDR method. The “tunnel-line” dissection technology is used to free the target tissue embedded in nontarget tissue. This technique minimizes interference by other tissue structures, retains the arch-like nontarget tissue, and provides an operating plane that facilitates tailoring of the subsequent residual border. It minimizes unnecessary loss of nontarget lung tissue during resection, which means greater lung function preservation. As far as the resection of the ninth segment is concerned, the communication bridge formed by the sixth and eighth segments across the target segment cannot be completely preserved by the previous surgical method. The new surgical method preserves the continuity of the residual lung as much as possible. To a certain extent, the possibility of postoperative residual pulmonary torsion is reduced. Additionally, this technique has the advantages of being less costly.<sup>3,5</sup> Of course, the “tunnel-line” dissection prolongs the operation time, and has higher requirements for the operator in terms of visual field exposure and tissue separation. For example, the strength of lifting the bronchial stump during the operation is very important. Accidental slippage should be avoided, which may reduce postoperative air leakage due to accidental damage. When air leakage is found after re-expanding the remnant lung, the relevant measures must be taken, such as the use of biological glue, absorbable fibrin sealant patch,<sup>6</sup> pleural suture method and so on.

The results in the three patients presented here indicate that the surgical procedure is safe and feasible. This technique is suitable for deep pulmonary nodules that are in line

with segmentectomy and the target segment is similar with a cone-shaped structure, which penetrates deeply into the pulmonary parenchyma and runs through the lobe at both ends. In addition, when planning the extent of resection and after target segment resection, it is vital to ensure that the incision margin is adequate (e.g., greater than 2 cm). However, not many patients need to undergo triumphal arch-like sublobectomy. Based on our experience, this technique may be used in the following types of segmentectomy, such as the left S9, right S9, S3a of upper right Lung, S3a + S2b of the upper right lung. This technique provides a new option for similar patients, which may bring greater benefits to patients in the future. Considering the small number of cases and short duration using this technique, its long-term efficacy still needs to be further explored.

#### CONFLICT OF INTEREST

The authors report no conflict of interest.

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