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Original Article

Video-assisted thoracoscopic lung-sparing tracheobronchial and carinal resections: a single-center experience

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ABSTRACT

Background: In selected patients, lung-sparing airway resections may achieve complete oncological resection while preserving pulmonary parenchyma. With increasing experience in video-assisted thoracoscopic surgery (VATS), these complex procedures can now be performed using minimally invasive techniques. We aimed to present our single-center experience with VATS lung-sparing tracheobronchial and carinal resections, focusing on perioperative outcomes.

Materials and Methods: Data from 7 patients who underwent VATS lung-sparing airway resections in our clinic between February 2022 and December 2024 were retrospectively evaluated in terms of surgical indications, as well as preoperative, intraoperative, and postoperative conditions.

Results: The surgical procedures included isolated carinal resection and reconstruction in two patients, main bronchial bronchotomy with bronchoplastic resection and reconstruction in two patients, segmental sleeve resection of the right main bronchus in one patient, and segmental sleeve resection of the bronchus intermedius in two patients, including one posterior biportal and one anterior uniportal approach. The mean age was 46.4 ± 17.1 years (range: 26-67). Pathological diagnoses included four typical carcinoid tumors, one glomus tumor, one sarcoma, and one squamous cell carcinoma. All resections achieved negative surgical margins. Postoperatively, the mean time to chest drain removal was 1.86 ± 0.38 days, and the mean length of hospital stay was 4.43 ± 1.40 days. No intraoperative mortality occurred, and no major postoperative complications or anastomotic failures were observed.

Conclusions: VATS lung-sparing tracheobronchial and carinal resections are feasible and safe in carefully selected patients. These procedures allow complete oncological resection while preserving lung parenchyma, with favorable perioperative outcomes and short hospital stays. Minimally invasive lung-sparing airway surgery may offers a valuable alternative to more extensive resections in selected tracheobronchial tumors.

Keywords: VATS, tracheobronchial resection, carinal resection, lung-sparing surgery, minimally invasive surgery, bronchoplasty

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Introduction

Sleeve lobectomy resections help avoid pneumonectomy, which is associated with high rates of morbidity and mortality [1-3]. However, in cases of tumors located solely in the carina or low-grade neoplasms such as carcinoid tumors arising in the tracheobronchial tree, curative surgical resection may be achieved without any parenchymal removal. Various terms have been used to describe this surgical strategy in which no lung parenchyma is resected. These include bronchoplastic and sleeve resections of the tracheobronchial tree without parenchymal removal, as well as isolated carina resections. Airway control and effective ventilation are particularly critical in carinal surgery. For this purpose, different techniques such as cross-field ventilation and high-frequency jet ventilation [HFJV] may be employed [4].

Historically, the standard approach to access the carina, right main bronchus, and bronchus intermedius has been via a right posterolateral thoracotomy through the fourth or fifth intercostal space [5]. Recently, with growing experience in VATS, these complex procedures have become feasible in experienced centers [2]. VATS has demonstrated clear advantages over open surgery, including reduced postoperative pain, shorter hospital stays, decreased morbidity, and improved cosmetic outcomes [6].

This study presents technical details of seven cases: two isolated carinal resections with reconstruction due to malignancies localized to the carina; one isolated right main bronchus resection and sleeve anastomosis for a glomus tumor in the right main bronchus; two bronchoplastic resections and reconstructions of the main bronchus for typical carcinoid tumors, one in the right main bronchus and the other in the left main bronchus; and two segmental sleeve resections of the bronchus intermedius for typical carcinoid tumors confined to that region.

Materials and Methods

A retrospective analysis was performed on seven patients who underwent VATS lung-sparing airway resections and reconstruction at our clinic between February 2022 and December 2024, evaluating surgical indications and preoperative, intraoperative, and postoperative outcomes. The study was approved by the Ethics Committee of Dr. Ismail Fehmi Cumalıoglu City Hospital (2024/107).

Preoperative evaluation

A comprehensive preoperative evaluation was performed to assess surgical eligibility and to plan the operative strategy. Contrast-enhanced thoracic computed tomography (CT) was used to define tumor location, size, anatomical relationships, and possible invasion of adjacent structures. Positron emission tomography-computed tomography (PET-CT) was performed to evaluate metabolic activity and to identify regional lymph node involvement and distant metastases. Rigid or fiberoptic bronchoscopy (FOB) was utilized for direct visualization of the lesion, histopathological confirmation via biopsy, and airway patency restoration when required. Pulmonary function was assessed using forced expiratory volume in one second (FEV_1), with diffusing capacity for carbon monoxide (DLCO) measured in selected patients. Only patients deemed suitable from both respiratory and cardiological perspectives were considered candidates for surgical intervention.

Perioperative evaluation andsurgical technique

All patients were positioned in lateral decubitus. Selective intubation was utilized in cases requiring main bronchus or bronchus intermedius resection, while in patients undergoing isolated carinal resection, single-lumen intubation in combination with either an endobronchial blocker or high-frequency jet ventilation (HFJV) was employed. In one segmental sleeve resection of the bronchus intermedius, a uniportal technique was used, whereas a biportal approach was adopted in all other cases. A 30º thoracoscope was used for visualization, and a soft tissue retractor such as Alexis® (Applied Medical Resources Corporation, Rancho Santa Margarita, CA, USA) was placed in the utility incision to facilitate retraction. Following intubation, all patients underwent fiberoptic bronchoscopy (FOB) to reassess the tumor localization and the planned surgical intervention. In long-segment resections of the tracheobronchial tree, release maneuvers are recommended to reduce anastomotic tension [7]. In a total of 5 cases involving isolated carinal sleeve resections, segmental sleeve resections of the intermediate bronchus, and main bronchus sleeve resections, the inferior pulmonary ligament was released as a releasing maneuver. In the first case of isolated carinal resection and reconstruction, additional distal tracheal mobilization was performed. To further reduce tension at the anastomotic site and prevent in-

voluntary neck extension, the chin was sutured to the manubrium of the sternum in both cases of isolated carinal resection/reconstruction. This technique reduced anastomotic tension and mitigated the risk of sudden neck hyperextension. These sutures were removed after approximately one week. To achieve optimal exposure and facilitate anastomosis in procedures involving the carina and right main bronchus, the azygos vein was divided, and both ends were anchored to the chest wall and mediastinal pleura.

In bronchoplastic resections, the tumor-containing airway segment was removed via bronchotomy, and the bronchial defect was repaired with primary sutures. In sleeve resections, anastomosis was started at the membranocartilaginous junction of the proximal airway using an inside-to-outside suturing technique along the cartilaginous wall. To avoid suture entanglement during thoracoscopic anastomosis, the first proximal stitch was passed through the parietal pleura, brought out through the utility incision, and temporarily secured under tension. After completion of two-thirds of the cartilaginous portion, the suture was retrieved, and the membranous portion was completed in the opposite direction. The anastomosis was finalized using an endoscopic knot pusher. For isolated carinal resections, the trachea was first partially anastomosed end-to-end with the left main bronchus. The right main bronchus was subsequently anastomosed end-to-side to the remaining tracheobronchial opening.

Intraoperative frozen section analysis was performed in all patients to confirm negative bronchial margins. As no positive margins were identified on frozen section examination in any case, additional bronchial resection prior to anastomosis or bronchoplasty was not required. Additionally, to adhere to oncological principles and ease the anastomotic procedure, the right lower paratracheal and subcarinal lymph nodes were excised at this stage. To enhance anastomotic healing and prevent minor leaks, viable tissue flaps such as omentum, parietal pleura, or pericardial fat may be used. The application of fibrin sealants (e.g., Tisseel) over the anastomotic site is another option to prevent minor air leaks and reduce the risk of dehiscence. In our series, a parietal pleural flap was used in one case, and fibrin sealant (Tisseel) was applied in four cases.

Postoperative evaluation

Patients were extubated and monitored in the intensive care unit ICU for one day before transfer to the thoracic surgery ward. Chest drains were removed when daily drainage was <100 mL, no air leak was present, and complete lung expansion was confirmed on posteroanterior chest radiographs. Carinal resection patients were monitored until chin sutures were removed. Outpatient follow-up was scheduled 10 days post-discharge. No FOB was required postoperatively in any case.

Results

Between February 2022 and December 2024, a total of 858 VATS anatomical lung resections were performed at our institution. Among these procedures, 40 cases (4.6%) consisted of bronchoplastic or sleeve resections. Video-assisted thoracoscopic lung-sparing tracheobronchial and carinal resections were performed in 7 patients, representing 0.8% of all VATS anatomical lung resections and 17.5% of the bronchoplastic/sleeve resections.

The cohort consisted of seven patients with a mean age of 46.4 ± 17.1 years (range: 26-67). Pathological diagnoses included four typical carcinoid tumors, one glomus tumor, one sarcoma, and one squamous cell carcinoma. All resections achieved negative surgical margins.

Postoperatively, the mean time to chest drain removal was 2.00 ± 0.58 days, and the mean length of hospital stay was 4.43 ± 1.81 days. No intraoperative mortality occurred. No major or minor complications or anastomosis failures occurred in the postoperative period. The mean follow-up duration was 22 months, during which no local or distant recurrence was observed, and all patients were alive at the last follow-up.

Case 1. Right VATS bronchotomy and bronchoplastic resection and reconstruction of the right main bronchus

A patient evaluated due to a typical carcinoid tumor localized in the proximal right main bronchus underwent FOB, which revealed a 1×1 cm lesion on the posterior wall of the distal right main bronchus extending toward the carina. The lesion was located in the right main bronchus on thorax CT (Figure 1). Selective intubation was performed, and with the patient in the left lateral decubitus position, thoracic access was achieved through a 3 cm utility incision at the 4th intercostal space in the anterior-mid axillary line. The camera port was inserted through the 7th intercostal space along the posterior axillary line. The surgical assistant retracted the lung inferiorly using a lung retractor inserted through the camera port to expose the paratracheal area. For ex-

posure, the azygos vein was divided, and its posterior stump was sutured to the chest wall. The hilar (10R) lymph node was excised. The right main bronchus was circumferentially dissected and suspended with a vessel loop. Macroscopically, a bulging lesion over the membranous portion at the carinal level was observed. The distal trachea was mobilized close to the carinal plane, with careful preservation of the vagus nerve. Using a scalpel and endoscopic scissors, a bronchotomy was performed from the distal right main bronchus toward the carina, ensuring negative surgical margins, and the lesion was excised over a 1 cm^2 area. The resulting defect was closed with a continuous suture using 3-0 polypropylene with a round needle. The anastomotic line was reinforced with a parietal pleural flap, and fibrin sealant (Tisseel) was applied to support the repair site (Figure 2). The operation lasted 125 minutes with an estimated blood loss of 100 mL. The chest drain was removed on postoperative day 2, and the patient was discharged on postoperative day 3.

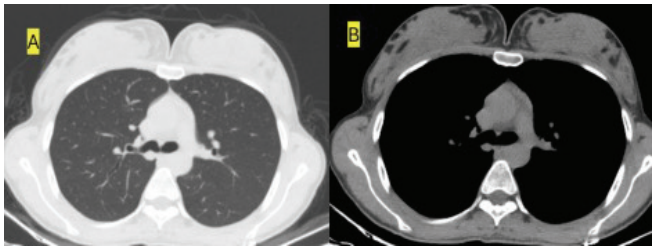

Figure 1. CT image of the lesion localized in the right main bronchus. **A:** Thoracic computed tomography parenchymal section image of the lesion in the right main bronchus localization, **B:** Mediastinal section image.

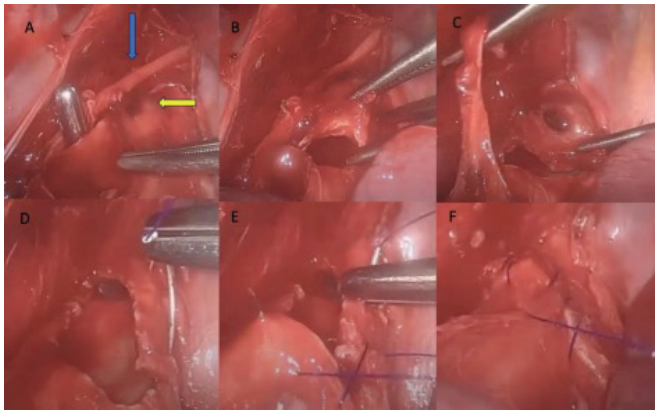

Figure 2. Right VATS Bronchotomy and Bronchoplastic Resection and Reconstruction of the Right Main Bronchus. **A:** Right main bronchus. Blue arrow: Vagus nerve, yellow arrow: Lesion**, B:** Bronchotomy proximal to the lesion, **C:** Bronchotomy distal to the lesion. **D, E, F:** Continuous suture of the right tracheobronchial defect.

Case 2. Left VATS left main bronchus bronchotomy and bronchoplastic resection and reconstruction

Due to a 1 cm typical carcinoid tumor located in the distal left main bronchus, surgery was performed in the right lateral decubitus position under selective intubation. Thoracic access was achieved through a 3 cm utility incision at the 4th intercostal space in the midaxillary line. The camera port was inserted at the 7th intercostal space along the posterior axillary line. The lung was retracted anteriorly to expose and dissect the left main bronchus, which was circumferentially mobilized and suspended using a vessel loop. To localize the lesion intraoperatively, an angiocatheter was inserted intraluminally through the distal left main bronchus. The catheter was visualized via FOB, confirming the lesion's position. A bronchotomy was performed on the membranous portion of the left main bronchus using a scalpel, and the lesion was resected with negative surgical margins. The defect was closed with a continuous suture using 3-0 polypropylene with a double round needle. Lymph nodes from the aortopulmonary window and subcarinal region were excised. No air leak was observed during the leak test. A single 28 Fr chest drain was placed through the camera port, and the procedure was concluded. The operation lasted 90 minutes with an estimated blood loss of 150 mL. The chest drain was removed on postoperative day 3, and the patient was discharged on day 4 (Figure 3).

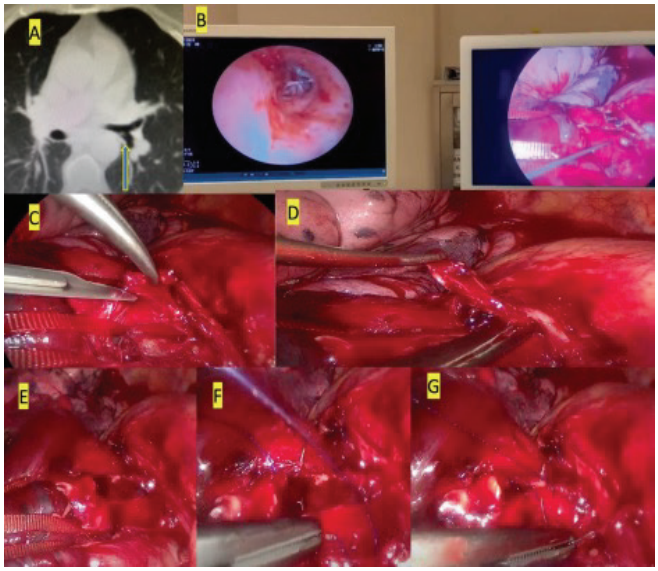

Figure 3. Left Vats Left Main Bronchus Bronchotomy and Bronchoplastic Resection and Reconstruction **A:** CT image of the lesion in the distal main bronchus, **B:** Screenshot of angiocut application to the bronchus during the operation (FOB and VATS visual), **C, D:** Excision of the lesion with scissors, **E:** Defect area in the main bronchus, **F, G:** Continuous suturing of the defect area

Case 3. Right VATS segmental sleeve resection of the right main bronchus

Due to a glomus tumor localized on the lateral wall of the distal right main bronchus, surgery was performed under selective intubation with the patient in the left lateral decubitus position. Thoracic access was achieved via a 3 cm utility incision at the 4th intercostal space. A camera port was inserted at the 7th intercostal space along the posterior axillary line. The azygos vein was divided using an endoscopic stapler, and its ends were anchored to the chest wall and mediastinal pleura to provide adequate exposure. With careful preservation of the vagus nerve, the trachea and right main bronchus were dissected circumferentially and suspended using a vessel loop. A bronchotomy was performed with a scalpel on the right main bronchus, allowing direct visualization of the tumor. The affected segment of the right main bronchus, including the lesion, was partially resected, ensuring negative microscopic margins at both proximal and distal ends. An end-to-end anastomosis was then performed using a continuous suture technique with 3-0 polypropylene and a double round needle. After confirming the absence of an air leak, the divided ends of the azygos vein were reapproximated and sutured over the anastomotic line to provide additional support. A single 28 Fr chest drain was placed in the thoracic cavity. The operation lasted 130 minutes with an estimated blood loss of 250 mL. The chest drain was removed on postoperative day 2, and the patient was discharged on day 3 (Figure 4).

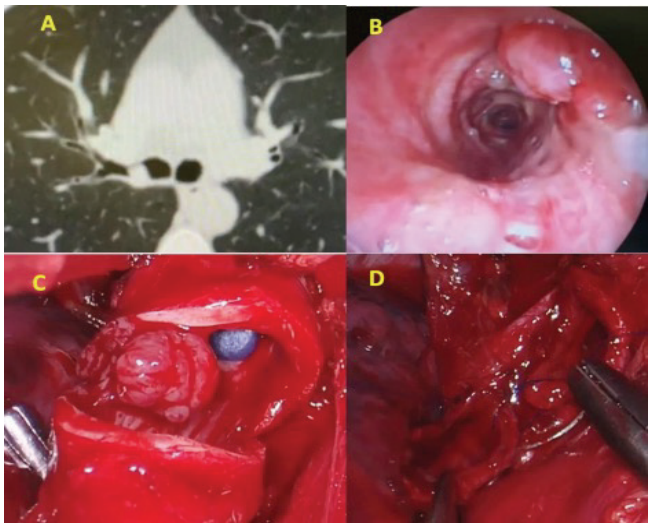

Figure 4. Right VATS Segmental Sleeve Resection of the Right Main Bronchus. **A:** Thoracic CT of endobronchial tumor localized in the right main bronchus, **B:** Fiberoptic bronchoscopy images of endobronchial tumor localized in the right main bronchus, **C:** Glomus tumor in the right main bronchus, **D:** Sleeve anastomosis of the right main bronchus.

Case 4. Right VATS isolated carina resection and reconstruction

Rigid bronchoscopy was performed by the interventional pulmonology team due to a follicular dendritic cell sarcoma localized at the carina. The lesion was causing near-total obstruction of the right main bronchus and approximately 70% obliteration of the left main bronchus (Figure 5). Airway patency was partially restored via argon plasma coagulation (APC), and definitive surgical resection was planned and performed 10 days later. Under general anesthesia, the patient was placed in the left lateral decubitus position. Endotracheal intubation was performed with an 8.0-mm tube, and an endobronchial blocker was positioned in the right main bronchus. A 3 cm utility incision was made through the 4th intercostal space, and the camera port was placed at the 7th intercostal space along the posterior axillary line. The azygos vein was divided using an endovascular stapler to facilitate exposure. The trachea was circumferentially mobilized and suspended with a vessel loop. The main pulmonary artery and the superior pulmonary vein were dissected, looped, and retracted inferiorly to expose the right main bronchus and carina. The right main bronchus was then dissected and suspended with a vessel loop. Macroscopically, the tumor was protruding approximately 2 cm outward from the membranous portion at the posterior aspect of the carinal level. The right main bronchus was first transected at its most proximal margin using a scalpel. The left main bronchus was then visualized and dissected distally, circumferentially mobilized, and suspended with a vessel loop. For traction, a 2-0 polyglactin was placed on the cartilaginous wall of the left main bronchus. The distal trachea was transected at the level corresponding to the proximal carina using a scalpel. Before this step, the patient's oxygen saturation was optimized, and the endobronchial blocker was withdrawn. Finally, using the traction suture placed on the left main bronchus, the left main bronchus was transected with a scalpel, and the specimen was removed en bloc. At this stage, the patient's ventilation was maintained via a high-frequency jet ventilation (HFJV) cannula inserted from the trachea into the left main bronchus. The inferior pulmonary ligament was released, and the head was placed in flexion. End-to-end anastomosis between the left main bronchus and the trachea was initiated using 3- 0 polypropylene with a double round needle in a continuous suture technique. The suture was advanced over approximately 1 cm, af-

ter which both ends were temporarily secured by tying them to newly placed anchoring sutures, intentionally leaving a gap at the medial aspect of the anastomosis. Subsequently, a parabolic (crescent-shaped) cartilage segment was excised from the tracheal edge at the remaining gap to create an adequate opening for the end-to-side anastomosis of the right main bronchus. The right main bronchus was then anastomosed to this site using continuous sutures with 3-0 polypropylene and a double round needle. No air leak was observed. For reinforcement, fibrin sealant (Tisseel) was applied to the anastomotic site. A single 28 Fr chest drain was placed in the thoracic cavity. To reduce tension on the anastomosis postoperatively, the patient's chin was sutured to the sternum using a No. 1 silk suture. The total operative time was 4 hours, with an estimated blood loss of 350 mL. The chest drain was removed on postoperative day 2. On day 7, the chin suture was removed, and the patient was discharged.

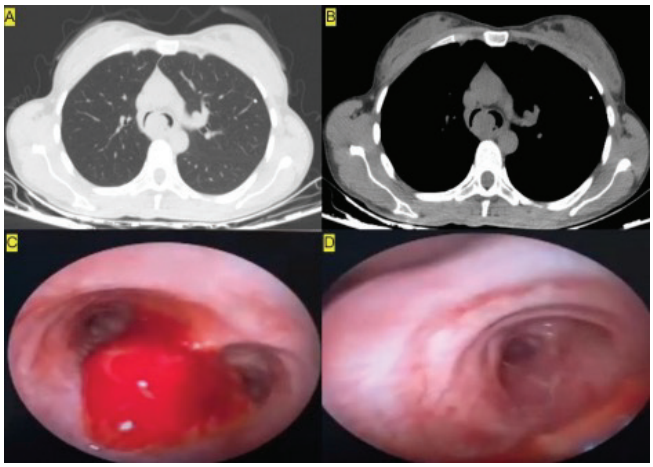

Figure 5. CT bronchoscopy and images of the lesion localized in the carina. **A:** Parenchymal section CT image of the lesion in the carina localization, **B:** Mediastinal section, **C:** FOB image of the lesion, **D:** Open image of the left main bronchus after the carina.

Case 5. Right VATS isolated carina resection and reconstruction

A patient diagnosed with squamous cell carcinoma localized at the carina underwent surgery in the left lateral decubitus position. The lesion was seen at the carina level in the thorax CT and FOB examination (Figure 6). The patient was intubated with an 8.5 mm endotracheal tube. Using FOB through the tube, an endobronchial blocker was placed into the right main bronchus. A working incision was made at the 4th intercostal space along the mid-axillary line. The camera port was inserted through the 8th intercostal space at the posterior axillary line. Through the camera port, the surgical assistant used a lung retractor to displace the lung inferiorly, exposing the paratracheal region. The azygos vein was dissected, suspended, and divided using an endovascular stapler. The distal trachea was circumferentially mobilized and suspended with a vessel loop. Subsequently, the right main bronchus was also dissected and suspended. With the aid of FOB, the proximal resection margin on the right main bronchus was identified. At this point, the endobronchial blocker was withdrawn, and bilateral ventilation was achieved using low tidal volumes. The right main bronchus was transected with negative surgical margins. The left main bronchus was dissected distally, and a 2-0 polyglactin traction suture was placed to facilitate exposure and manipulation. The left main bronchus was transected near the carina with negative surgical margins. Ventilation was maintained via cross-field ventilation, using a sterile 5.5 mm spiral endotracheal tube introduced directly into the left main bronchus through the operative field. The carina was then resected from the distal trachea using a scalpel, ensuring negative surgical margins. The excised specimen was sent for frozen section analysis, which confirmed margin negativity. To reduce tension at the anastomotic site, the inferior pulmonary ligament was released, and the patient's head was placed in neck flexion. Reconstruction began with an end-to-end anastomosis of the left main bronchus to the trachea. The first stitch was placed using 3-0 polypropylene with a double round needle, starting from the junction between the cartilaginous and membranous portions of the trachea (inside-out), and continuing at the corresponding site on the left main bronchus (outside-in), near the junction of the cartilage and membranous wall. The end-to-end anastomosis was completed, leaving a 1 cm gap on the medial aspect. The free suture ends were tied to newly placed sutures and then cut. To create a suitable opening for the right main bronchus, a crescent-shaped piece of cartilage was excised from the tracheal side. The right main bronchus was then anastomosed end-to-side to this newly formed opening. Near completion of the anastomosis, a caliber mismatch was noted, prompting the excision of an additional small cartilage segment from the tracheal edge to ensure proper alignment. After confirming the absence of air leaks, fibrin sealant (Tisseel) was applied to the anastomotic site for reinforcement, and the ends of the divided azygos vein were reapproximated and sutured together. To prevent inadvertent neck hyperextension,

the chin was sutured to the manubrium of the sternum using No. 1 silk suture. A single 28 Fr chest drain was placed. The total operative time was 180 minutes, and the estimated blood loss was 350 mL. The chest drain was removed on postoperative day 2, and the chin sutures were taken down on day 7, at which point the patient was discharged (Figure 7).

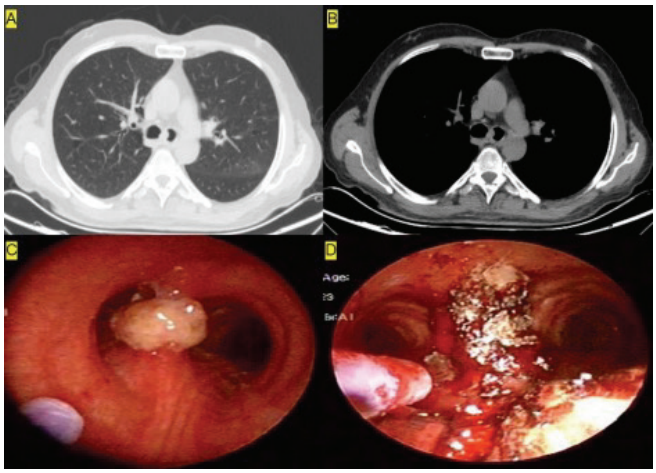

Figure 6. CT bronchoscopy and images of a tumor localized in the carina. **A:** Parenchymal section CT image of the tumor in the carina localization, **B:** Mediastinal section, **C:** FOB image of the tumor **D:** FOB image after endobronchial treatment.

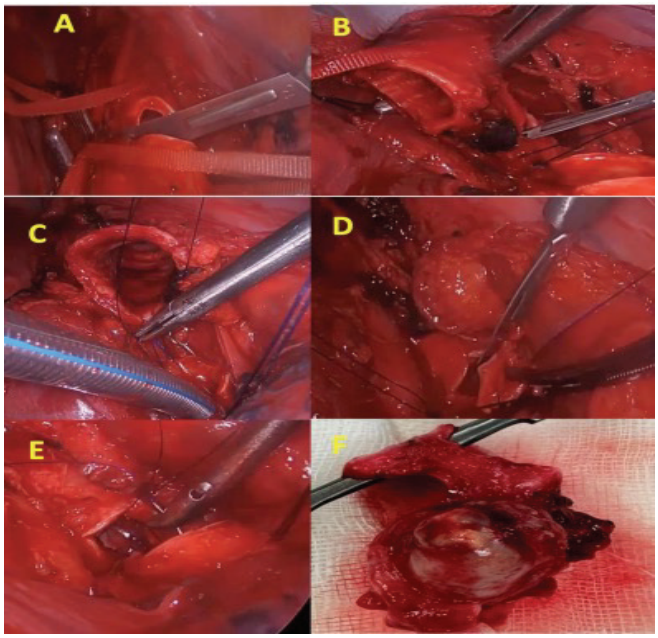

Figure 7. The surgical technique of VATS isolated carina resections and reconstructions **A:** Division of the right main bronchus, **B:** Division of the left main bronchus, **C:** Continuous end to end anastomosis of trachea to left main bronchus, **D:** After the trachea is anastomosed to the left main bronchus, leaving 3/4 of the area open, partial cartilage resection is performed to provide sufficient clearance for the anastomosis of the right main bronchus over the trachea, **E:** End-to-side continuous anastomosis of the right main bronchus to the trachea and left main bronchus anastomosis line, **F:** Carinal tumor. The right main bronchus is marked.

Case 6. Right VATS segmental sleeve resection of the bronchus intermedius: posterior approach

A patient diagnosed with a carcinoid tumor localized in the right bronchus intermedius underwent surgery in the left lateral decubitus position under selective intubation. The lesion was seen in the intermediate bronchus in the thorax CT and FOB examination (Figure 8). A 3 cm utility incision was made through the 4th intercostal space along the posterior axillary line. The camera port was placed at the 7th intercostal space, also along the posterior axillary line. The mediastinal pleura was incised posteriorly, and dissection was performed down to the distal right main bronchus and the right lower lobe bronchus to fully expose the bronchial anatomy. Care was taken to avoid injury to the pulmonary artery during dissection. The right upper lobe bronchus and the middle lobe bronchus were mobilized proximally, and the bronchus intermedius was circumferentially dissected and suspended using a vessel loop. Intraoperative FOB evaluation revealed that the lesion extended from the posterior wall of the bronchus intermedius at the level of the upper lobe bronchus distally. Therefore, to preserve the upper lobe and ensure negative margins, a curved (tangential) incision rather than a linear one was made proximally on the bronchus intermedius. The upper limit of the incision extended up to the posterior wall of the upper lobe bronchus. A similar curved incision was then made at the proximal portion of the middle lobe bronchus, and the bronchus intermedius was resected en bloc. Frozen section analysis confirmed tumor-free surgical margins. To reduce tension on the anastomosis, the inferior pulmonary ligament was released. The bronchial reconstruction was performed with a continuous end-to-end anastomosis using 3-0 polypropylene with a double round needle (Figure 9). The procedure lasted 130 minutes, and the estimated blood loss was 200 mL. The chest drain was removed on postoperative day 1, and the patient was discharged on day 3.

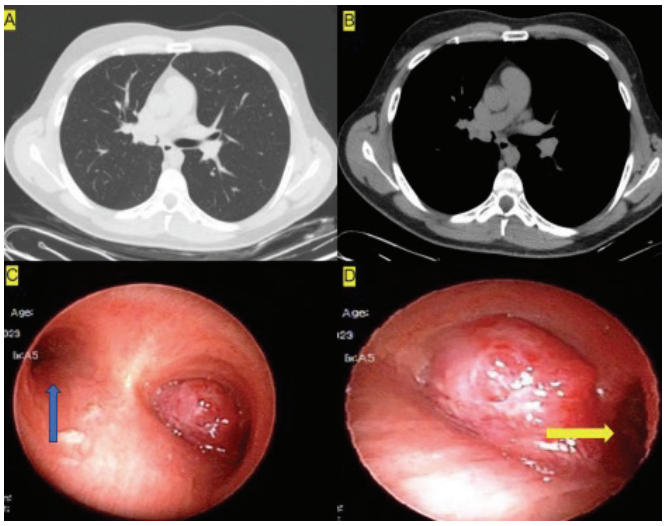

Figure 8. CT bronchoscopy and images of a tumor localized in the intermediate bronchus **A:** CT parenchymal section image of the lesion in the intermediate bronchus localization. **B:** Mediastinum section, **C:** FOB image, blue arrow, upper lobe entrance, lesion at the intermediate bronchus entrance, **D:** FOB image, yellow arrow, middle lobe.

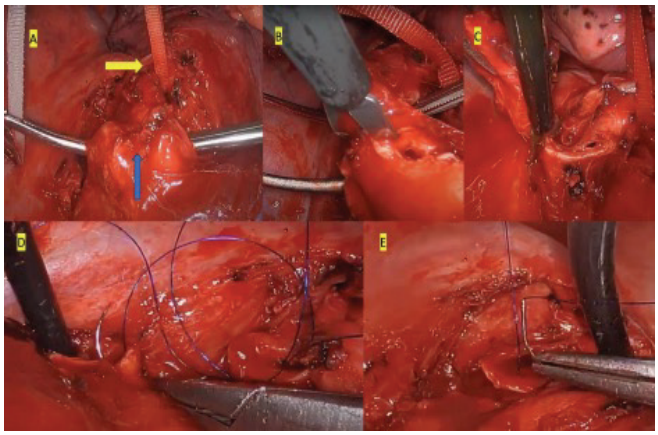

Figure 9. Right VATS Segmental Sleeve Resection of the Bronchus Intermedius – Posterior Approach **A:** Bronchial structures are suspended with tape. Blue arrow: intermediate bronchus, yellow arrow: upper lobe bronchus, **B:** Tangential section of the intermediate bronchus, **C:** Tangential section of the upper lobe bronchus, **D:** Sleeve anastomosis of the bronchial ends with continuous suture.

Case 7. Right VATS segmental sleeve resection of the bronchus intermedius: anterior uniportal approach

A patient diagnosed with a typical carcinoid tumor localized in the bronchus intermedius underwent surgery in the left lateral decubitus position under selective intubation. The tumor was seen in the intermediate bronchus in the thorax CT and FOB examination (Figure 10). Thoracic access was achieved through a 3 cm uniportal utility incision made at the 5th intercostal space along the mid-axillary line. The procedure began with the opening of an incomplete fissure to access the basal pulmonary artery. The lung was then retracted anteriorly, and the posterior mediastinal pleura was incised to expose and excise a paraesophageal lymph node. Using a tunneling technique posterior to the bronchus intermedius, the dissection proceeded through the posterior mediastinal pleura to reach the oblique fissure, which was divided using an endoscopic stapler. Through the fissure, the basal segmental pulmonary artery was looped with a vessel tape and retracted anteriorly, allowing exposure of the bronchus intermedius. The bronchus intermedius was carefully dissected and encircled using a dissector. It was transected just distal to the upper lobe take-off. To ensure complete resection of the tumor, an additional proximal ring of the bronchus intermedius was excised. Macroscopically, the tumor showed protrusion through the membranous wall toward the extrabronchial space; this extension was dissected bluntly and sharply. After proximal resection of the bronchus intermedius, subcarinal and paraesophageal lymph nodes were removed. The distal bronchus intermedius, including the proximal portion of the middle lobe bronchus, was also resected. Frozen section analysis confirmed negative margins at both proximal and distal ends. Bronchial reconstruction was performed with a continuous anastomosis using 3-0 polypropylene with a double round needle. During the leak test, a small air leak was observed at the junction of the cartilaginous and membranous portions on the posterior side of the anastomosis. This defect was repaired with an additional 3-0 polypropylene suture, and no further air leak was detected upon retesting (Figure 11). The operation lasted 180 minutes, with an estimated blood loss of 270 mL. The chest drain was removed on postoperative day 2, and the patient was discharged on day 4.

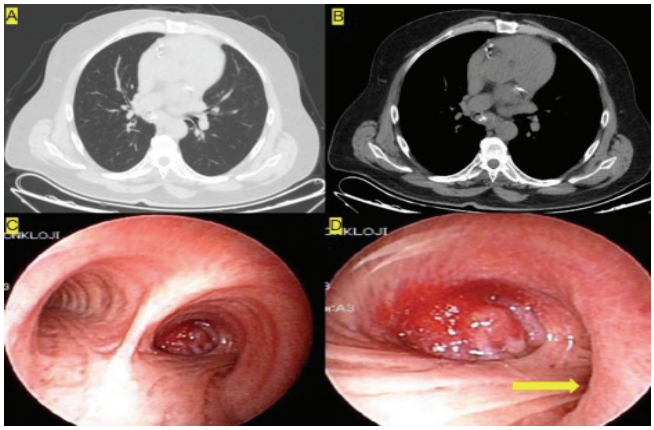

Figure 10. CT bronchoscopy and images of a lesion localized in the intermediate bronchus **A:** CT parenchymal section image of the lesion in the intermediate bronchus localization. **B:** Mediastinum section, **C:** FOB view of main bronchi, **D:** FOB image, yellow arrow, upper lobe entrance.

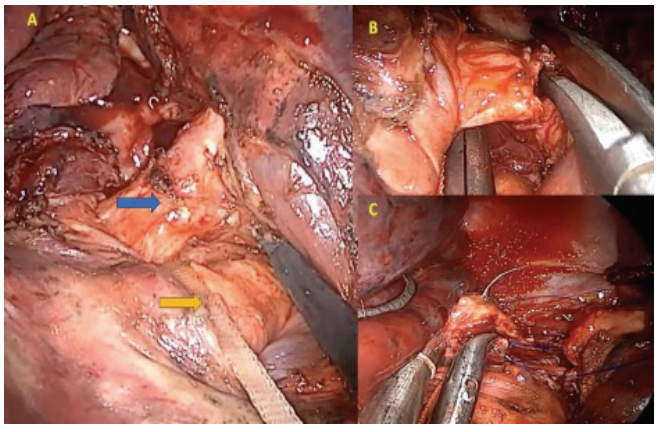

Figure 11. Right VATS Segmental Sleeve Resection of the Bronchus Intermedius – Anterior Uniport Approach **A:** Blue arrow intermediate bronchus, yellow arrow basal artery retracted anteriorly with tape, **B:** Division of the intermediate bronchus **C:** Anastomosis of proximal and distal edges after segmental resection of intermediate bronchus.

Discussion

Sleeve resections have long been performed using both open and minimally invasive approaches, yet curative resection of only the bronchial tree without parenchymal removal remains rare [7]. These procedures require high technical expertise but have become feasible via minimally invasive techniques in skilled centers [2]. Indications include tumors isolated to the carina, low-grade tumors such as carcinoids in the main or intermediate bronchus, and selected benign pathologies [8]. In cases where there is no systemic spread and R0 resection is performed, surgically isolated airway resection and reconstruction significantly increase survival [9]. For airway-limited tumors without parenchymal invasion, lung-sparing resections are preferred. Historical reports of bronchoplastic resections date to the 1980s and 1990s [8,10]. Complex tracheobronchial resections with full parenchymal preservation have recently been achieved with minimally invasive techniques [2]. Diego et al. [2], in their 2020 review, described the technique using a uniportal approach. Although the preferred technique in our clinic for such complex minimally invasive procedures is often the biportal approach, uniportal access is also utilized in selected cases. Airway continuity during these procedures requires coordination between surgery and anesthesia teams, employing cross-field ventilation or HFJV [4]. Tubeless spontaneous ventilation techniques have also been reported [11]. In our series, cross-field ventilation was primarily used, with HFJV in one case. Current literature suggests that, due to the lack of a safe and functional interposition graft for tracheal segments, there are anatomical limits to the length of the trachea that can be surgically resected [14]. Mortality for carinal resections ranges 7.2–29% [12], but adequate patient selection, surgical technique, and postoperative management have lowered rates. Lung-sparing approaches reduce mortality, mainly due to fewer anastomotic complications compared to carinal pneumonectomies [13]. Reinforcement flaps are optional, with mixed evidence [14,15]. Fibrin sealants (Tisseel) were used in some cases to prevent minor leaks [16]. Continuous and interrupted suture techniques yield similar outcomes; success relies on suture quality and tension-free anastomosis [17,18]. In parenchyma-sparing sleeve resections, complete oncologic resection is achieved without lung tissue loss. This case series highlights surgical nuances and technical considerations in minimally invasive VATS lung-sparing airway procedures.

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Ethics approval

The study was approved by the Ethics Committee of Dr. Ismail Fehmi Cumalıoglu City Hospital (2024/107).

Authors' contribution

MEF: contributed to the definition of intellectual content, VE: was involved in the manuscript preparation and design, MÜ: contributed to the statistical analysis, design, and editing, ACK: was involved in the clinical studies, EK: contributed to the data acquisition, MSOM: contributed to the editing, NY: contributed to the definition of intellectual content, AÇ: was involved in the literature search, MM: contributed to the review of the manuscript, all authors have read and approved the final version of the manuscript

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