

Triple Sleeve Bronchial Resection with Total Lung Preservation

Adrian Ciuche^{1,2}, Anca-Pati Cucu^{1*}, Claudiu-Eduard Nistor^{1,2}

¹Thoracic Surgery Clinic, "Dr. Carol Davila" Central Military Emergency University Hospital, Bucharest, Romania

²"Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

*Corresponding author:
Anca-Pati Cucu, MD
"Dr. Carol Davila" Central Military
Emergency University Hospital
Thoracic Surgery Clinic, 5th Floor
134, Calea Plevnei Street
1st District, Zip Code 010825
Bucharest, Romania
E-mail: ancutapati@gmail.com

Rezumat

Rezecția bronșică segmentară triplă ("triple sleeve") cu preservare pulmonară totală

Rezecția bronșică segmentară triplă cu bronho-anastomoză (triple sleeve bronchial resection) este un procedeu tehnic complex, mai dificil decât tehnicile de rezecție - bronho-anastomoză standard, indicat la pacienții cu tumori benigne sau cu grad redus de malignitate (tumori carcinoide), situate pe bronșiile mari (primitive și lobare). Este o intervenție chirurgicală sigură și eficientă atunci când este efectuată cu acuratețe de către chirurghii experimentați. Principalul avantaj al acestui tip de intervenție chirurgicală este salvarea în întregime a parenchimului pulmonar în condițiile rezecției radicale a tumorii bronșice. Acest aspect este deosebit de important în ceea ce privește păstrarea funcției pulmonare atât la pacienții tineri (menținerea optimă a capacității de efort) cât și la pacienții vârstnici sau la cei cu funcție alterată cardio-pulmonară (care nu tolerează lobectomia sau pneumonectomia).

Cuvinte cheie: rezecție bronșică segmentară triplă, bronho-anastomoză, tumori carcinoide, preservare pulmonară totală

Abstract

Triple sleeve bronchial resection with bronchial anastomosis is a complex surgical procedure, more difficult than the standard techniques of bronchial resection and anastomosis, commonly used to treat benign or low-grade malignant neoplasms (such as carcinoid tumours) that are located on the central bronchial axis (primary and

Received: 07.04.2022
Accepted: 26.06.2022

lobar bronchi). When performed carefully by a highly trained surgeon, bronchial sleeve resection and reconstruction is a safe and effective surgical procedure. The complete preservation of the lung parenchyma is the main advantage of this surgical technique, along with a radical bronchial tumour resection. Sparing pulmonary function is crucial for both young (to maintain an optimal effort capacity) and elderly patients as well as those with impaired cardiopulmonary function (they may not tolerate lobectomy or pneumonectomy).

Key words: triple sleeve bronchial resection, bronchial anastomosis, carcinoid tumours, total lung preservation

Introduction

As a special type of bronchial sleeve resection, triple sleeve bronchial resection with total sparing of lung parenchyma has the advantage of preserving healthy lung tissue during radical tumor resection (1). Due to this curative effect along with minimal invasiveness (maximal preservation of lung function), this procedure has been used to treat benign bronchial lesions (tumors and stenosis) as well as low grade bronchial malignancies (like bronchial carcinoid tumors) (2,3). Because of its low incidence rate and particular localization on the central bronchial axis, only one triple sleeve surgical procedure has been performed so far. This was the first time this surgical intervention was performed in Romania.

This paper discusses our triple sleeve bronchial resection technique for a carcinoid tumor located in the proximal part of the right bronchial axis, its clinical outcomes, and its application to the distal part of the right bronchial axis.

Bronchial carcinoid tumors are a relatively rare type of pulmonary neoplasms (only 1% to 2% of all lung cancers) (4). These are neuro-endocrine tumors (NETs) derived from Kulchitsky bronchial cells.

Based on their clinical behaviour and histologic features, these tumors are classified as typical or atypical. (typical: < 2 mitoses/ 2 mm^2 , absence of necrosis, Ki-67 index $\leq 5\%$ and atypical: > 2 mitoses/ 2 mm^2 , presence of necrosis, Ki-67 index $> 5\%$) (6,7).

Although both types are considered malignant, the common typical carcinoids rarely

metastasize to regional lymph nodes or distally and have an excellent prognosis with a 10-year survival rate of 82% to 100% (6).

The most of them are centrally bronchial located (75% on the lobar bronchi, 10% on the main-stem bronchi, 15% on the periphery of the lung) (6).

Complete surgical excision is the preferred therapeutic option for these rare tumors (6,7). When planning such surgical intervention, it is critical to keep in mind that all possible lung parenchyma should be preserved in centrally placed bronchial carcinoid tumors (8).

A 49-year-old woman with a history of upper respiratory infections and chronic fatigue was admitted with wheezing but without clinical or biological evidence of carcinoid syndrome (normal 5 HIAA urine result). Chest computed tomography (*Fig. 1*) and bronchoscopy exami-

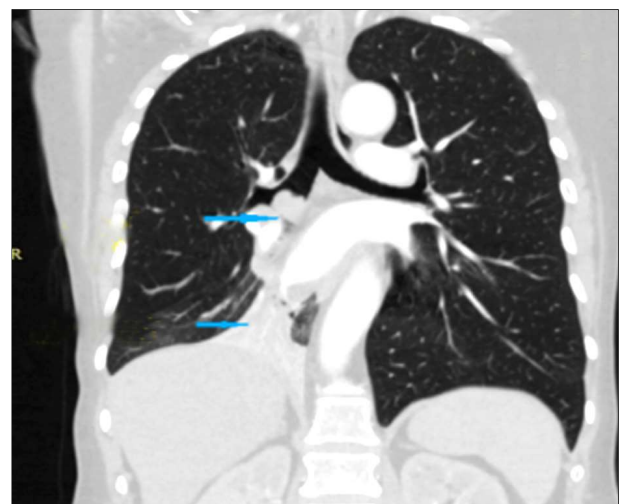


Figure 1. Preoperative coronal reconstruction thoracic CT scan examination

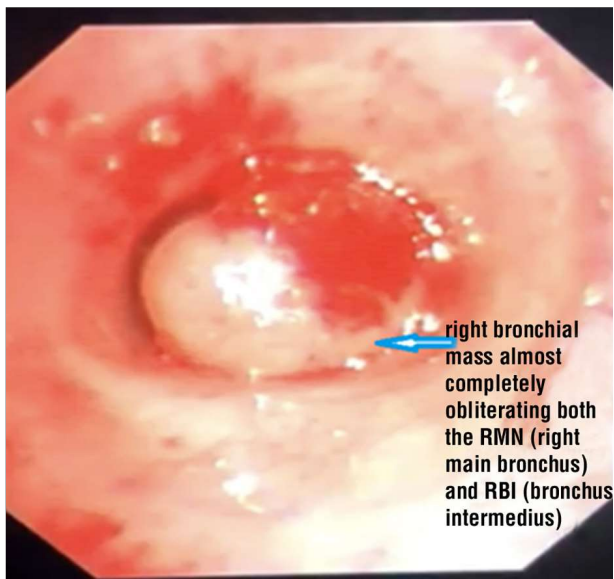


Figure 2. Preoperative bronchoscopy examination

nation (*Fig. 2*) revealed a right bronchial tumor that nearly completely obliterated both the RMB (right main bronchus) and BI (bronchus intermedius). Biopsy through bronchoscopy revealed a grade I neuroendocrine tumor (NET) (Kultchitsky I cells) - typical carcinoid.

Surgical Technique

Following a double lumen endotracheal tube intubation with selective single left lung ventilation, a right antero-lateral thoracotomy incision was made in the fourth intercostal.

Anteromedial retraction of the lung and azygos vein resection allowed visualization of the posterior aspect of the right main bronchial axis. Along the airway's posterior wall, we identified a bronchial tumor involving the distal part of the right main bronchus (RMB), bronchus intermedius (BI) and the proximal part of the right upper lobe bronchus (RULB) (*Fig. 3*).

A thoracic lymphadenectomy with harvesting lymph nodes from station 3a, 4, 7, 10 and 11 was performed in the beginning, followed by circumferential dissection of the right main bronchus (RMB), right upper lobe bronchus (RULB) and bronchus intermedius (BI) as well

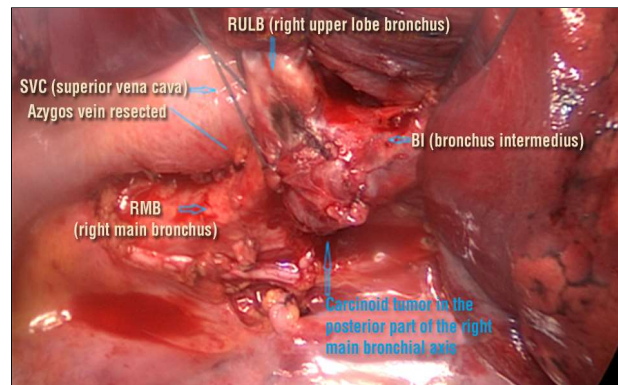


Figure 3. Intraoperative aspect (carcinoid tumor in the posterior part of the right main bronchial axis)

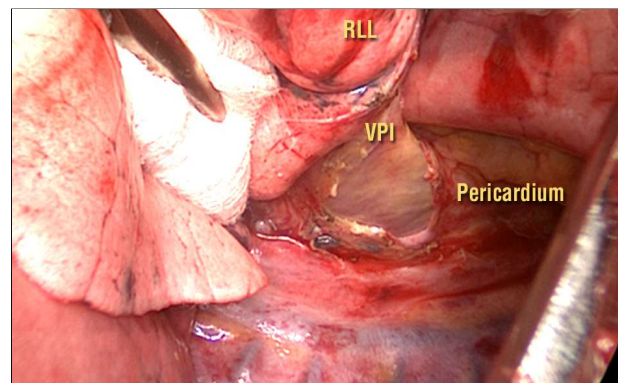


Figure 4. Pulmonary hilar release using C-shaped incision in the pericardium at the bottom of the inferior pulmonary vein (VPI)

as dissection of the hilar vessels. The inferior pulmonary ligament was divided, the intra-pericardial vascular system was released (the right inferior pulmonary vein- VPI), and a C-shaped incision was made in the pericardium at the bottom of the inferior pulmonary vein (*Fig. 4*) to reduce tension during the future bronchial anastomosis.

Due to a greater bronchial defect after the initial excision of the posterior part of the right main bronchial axis (*Fig. 5*), the right main bronchus (RMB), right upper lobe bronchus (RULB) and bronchus intermedius (BI) were transected and all tissues attached to the tumor were excised en bloc with the mass (*Fig. 6*). Frozen sections of the bronchial margins were clear of tumor.

Next, we proceeded to the bronchial axis reconstruction by creating a bronchial medial anastomosis between right upper lobar bronchus (RULB) and bronchus intermedius

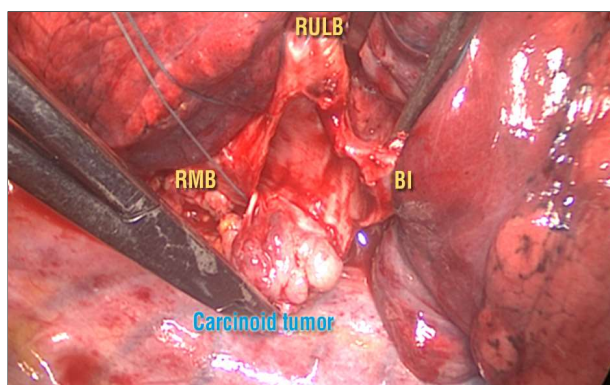


Figure 5. The greater bronchial defect after initially excision of the posterior part of the right main bronchial axis

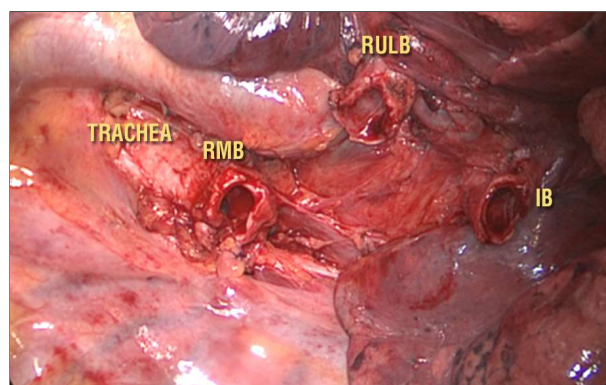


Figure 6. A triple sleeve bronchial resection of the right main bronchial axis (RMB, RULB, BI) for complete sparing of lung parenchyma

(BI), using interrupted 4-0 monofilament absorbable (polydioxanone) suture (*Fig. 7*).

Then, the upper and intermedius bronchi, previously medially sutured, were anastomosed to the right main bronchus. End-to-end bronchial anastomosis was performed using interrupted 4-0 monofilament absorbable (polydioxanone) suture with all knots tied externally (*Fig. 8*). The bronchial anastomosis was tested for air leakage under saline (while inflating the right lung by a positive ventilation at 40 cm H₂O), then we harvested a vascularized mediastinal fat pad and wrapped around the anastomosis and tacked it to the airway in several places with mattress sutures (*Fig. 9*). Two 28-French chest tubes were placed for drainage. At the end of the intervention the double tracheal tube was exchanged by the anaesthesiologist for a single-lumen one for bronchoscopy, a paramount investigation in

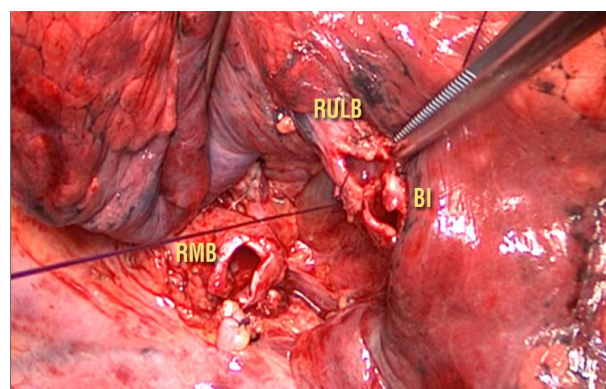


Figure 7. First step of the bronchial axis reconstruction: creating a medial bronchial anastomosis between right upper lobar bronchus (RULB) and bronchus intermedius (BI)

confirming the patency of the bronchial anastomosis. This exchange was necessary for using an wellfitted bronchoscope with a suction channel for immediate postoperative toilet bronchoscopy, thus preventing atelectasis.

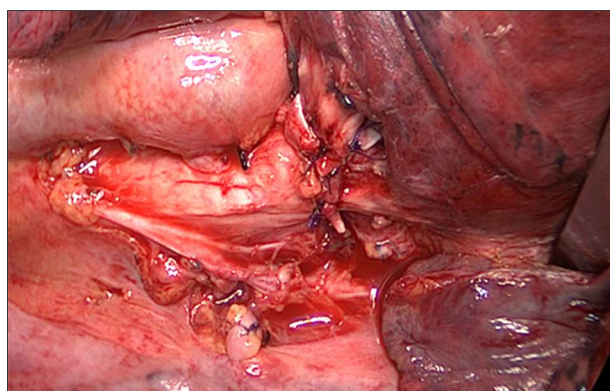


Figure 8. The final aspect of the triple bronchial anastomosis

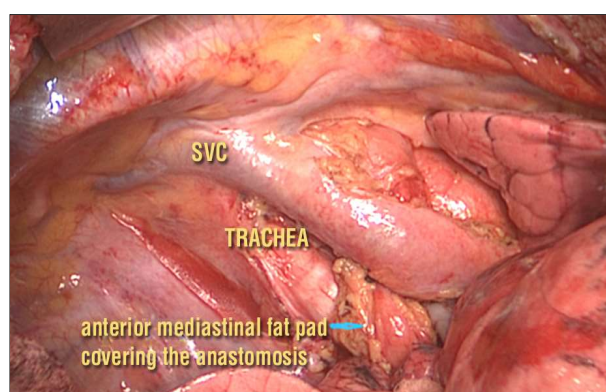


Figure 9. Anterior mediastinal fat pad covering the bronchial anastomosis

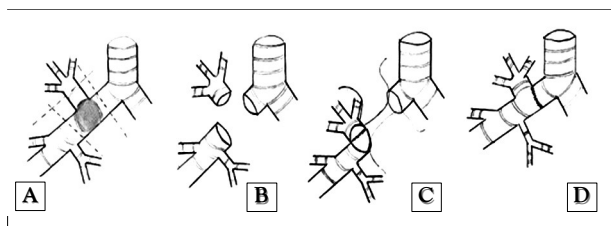


Figure 10. (A-D) Operative procedure steps of “triple sleeve bronchial resection” and reconstruction of the right main bronchial axis

Results

The patient was extubated immediately after surgical intervention. Bronchoscopy examination indicated no kinking or stenosis.

The patient underwent surgery uneventfully with complete expansion of the pulmonary parenchyma and lack of air leaks and atelectasis. On the third postoperative day, an emergency appendectomy under general anaesthesia with endotracheal intubation, for acute appendicitis, was performed.

Pathology examination of the bronchial specimen revealed a 3-cm grade I carcinoid neuroendocrine tumor—typical carcinoid—of the bronchial wall. All lymph nodes and bronchial margins were negative for the tumor. Histopathologic findings of the appendectomy specimen were conclusive for an acute appendicitis without carcinoid tumor localization. No additional therapy was given.

Two years later, the patient is disease free and asymptomatic.

Discussion

Bronchial low-grade malignant tumors are very rare. Their treatment options include endoscopic resection (laser Nd:YAG or electrocautery) or surgical resection (9). Surgical resection is the choice treatment for broad-based endoluminal masses (10).

Surgeons have always tried to salvage as much lung parenchyma as possible in the centrally localized bronchial typical carcinoids. This has led to a more frequent use of bronchoplastic resections (resection and reconstruction of a lobar bronchial orifice) and sleeve



Figure 11. Coronal reconstruction CT scan of the chest (3 months after surgery)

bronchial resections (resection of a circumferential segment of a bronchus) with reconstruction by primary circumferential anastomosis (4,8). In our patient's case, we were able to preserve the entire lung parenchyma due to the fact that the tumor was located in the bronchus intermedius (BI) near the ending of the right main bronchus (RMB) and the origin of the right upper lobe bronchus. Several studies have demonstrated the value of bronchial sleeve resection with pulmonary sparing in the treat-



Figure 12. Bronchoscopy examination (3 months after surgery) (view from the right main bronchus)

ment of benign or low-grade malignant bronchial tumors (9,11).

Several technical aspects are crucial for success. At first, we must create a double-barrel bronchus (right upper lobe bronchus and bronchus intermedius sutured together) with an opening that matches to the right main bronchus's proximal single lumen (12). When the size discrepancy between the distal and proximal bronchi is greater, the smaller distal lumen can be telescoped into the larger proximal one (1). To avoid stenosis, air leaks, or kinking at the anastomosis level, we use moderately tight stitches to preserve the anastomosis's blood supply (leaving the posterior wall last and attempting to tailor the bronchial ends by placing larger spaces between sutures on the membranous portion of the larger lumen) and avoid extensive peribronchial tissue dissection to preserve the bronchial vascular system (12). It is paramount to transect the bronchus perpendicular to its axis and to avoid wedge bronchial resection, which might result in anastomosis kinking (1,13). A variety of suture materials have been used for bronchial anastomosis. We prefer to use 4-0 polydioxanone suture (PDS, Ethicon Inc., Somerville, NJ). The next step was to wrap the suture line with a surrounding tissue flap to protect the anastomosis. Division of the inferior pulmonary ligament, intrapericardial vascular released and a C-shaped incision in the pericardium at the bottom of the inferior pulmonary vein helped to avoid the tension of the future bronchial anastomosis (14). Finally, bronchial frozen sections are mandatory to ensure all resection margins are tumor free (12). At the end of the surgery, flexible bronchoscopy examination has an important value both for removing secretions and for ruling out any bronchial stenosis, with an eventually reintervention decision (5).

Tracheal intubation for a general anaesthesia appendicectomy (done on postoperative day 3) was a true test for the recent bronchial anastomosis. According to the histological investigation of the excised appendix, acute appendicitis was a separate pathology unrelated to the carcinoid tumor.

Intraoperative frozen section R0 bronchial resection margins enabled us to do bronchial sleeve resection and reconstruction, which was the best surgical option for this patient. If the frozen-section pathology report hadn't confirmed the radicality of the resection, a surgical parenchymal lung resection procedure would have been used.

Conclusion

This intervention called "triple sleeve bronchial resection" is a complex technique performed in the right main bronchial axis and may carry a higher risk of complications than a standard sleeve resection, but it is an effective and safe technique for selected patients with benign or low-grade malignant bronchial tumors.

The main benefit of this surgical intervention is that it allows for complete preservation of the healthy lung parenchyma, avoiding additional pulmonary resection procedures such as right upper lobe sleeve resection, right lower sleeve bilobectomy, or even pneumonectomy.

Conflict of Interest

All authors have no conflict of interest to declare.

References

- Schirren J, Muley T, Vogt-Moykopf I. Sleeve lobectomy. In: Shields TW, LoCicero J, Ponn, RB editors. *General Thoracic Surgery*. 5th edition. Philadelphia: Lippincot Williams & Wilkins; 2000. p. 399–409.
- Duan J, Cai H, Huang W, Lin L, Wu L, Fan J. Bronchial sleeve resection with complete pulmonary preservation: a single-center experience. *Cancer Management and Research*. 2020;12:12975–82.
- Bueno R, Wain JC, Wright CD, Moncure AC, Grillo HC, Mathisen DJ. Bronchoplasty in the management of low-grade airway neoplasms and benign bronchial stenoses. *Ann Thorac Surg*. 1996;62:824–829.
- Escalon JC, Detterbeck FC. Carcinoid Tumors. In: Shields TW, LoCicero J, Reed CE, Feins RH, editors. *General Thoracic Surgery*. 7th edition. Philadelphia: Lippincot Williams & Wilkins; 2009. p. 1539–1554.
- Komminoth P, Kloppel G, Korbonsits M, Mete O, Scoazec J-Y, Stratakis CA. Chapter 7: Inherited tumor syndromes. In: Lloyd RV, Osamura RY, Klöppel G, Rosai J, editors. *WHO classification of tumors of endocrine organs (IARC WHO Classification of Tumors) Fourth Edition*. Lyon: IARC; 2017. p. 241–282.
- Nistor C, Motaş N, Motaş C, Davidescu M, Teţu M, Vasilescu F, Horvat T. Surgical procedures in broncho-pulmonary carcinoids – our experience of 92 consecutive cases. *Acta Endocrinologica*. 2009;3:359–370.
- Terzi A, Lonardon A, Feil B, Spilimbergo I, Falezza G, Calabro F. Bronchoplastic procedures for central carcinoid tumors: clinical experience. *Eur J Cardiothorac Surg*. 2004;26(6):1196–1199.

8. Uchino K, Okada M, Sakamoto T, Yuki T, Mimura T, Tsubota N. Bronchoplasty for bronchial carcinoid tumor without removing lung parenchyma. *J Thorac Cardiovasc Surg.* 2006; 54:345-347.
9. Frist WH, Mathisen DJ, Hilgenberg AD, Grillo HC. Bronchial sleeve resection with and without pulmonary resection. *J Thorac Cardiovasc Surg.* 1987;93(3):350-357.
10. Cerfolio RJ, Deschamps C, Allen MS, Trastek VF, Pairolero PC. Mainstem bronchial sleeve resection with pulmonary preservation. *Ann Thorac Surg* 1996; 61:1458-63.
11. Yavuzer S, Yuksel C, Kutlay H. Segmental bronchial sleeve resection: preserving all lung parenchyma for benign/low-grade neoplasms. *Ann Thorac Surg.* 2010;89(6):1737-1743.
12. Xingtao J, Xiaopeng D, Xiaogang Z, Chuanliang P. Bronchial sleeve resection distal to the main bronchus with complete pulmonary preservation for benign or low-grade malignant tumors. *Ann Thorac Surg.* 2007;84:e19-e21.
13. Bolukbas S, Schirren J. Parenchyma-sparing bronchial sleeve resections in trauma, benign and malign diseases. *Thorac Cardiovasc Surg.* 2010; 58(1): 32-37.
14. Ciuche A, Nistor C, Motaş C, Horvat T. Minimally invasive surgery in the treatment of malignant pleuro-pericardial effusions. *Chirurgia (Bucur).* (2012);107(2):206-212.