

Tracheal sleeve pneumonectomy: an analysis of 13 cases

Trakeal sleeve pnömonektomi: 13 olgunun analizi

İrfan Taştepe,¹ Suat Gezer,² Gürhan Öz,¹ Taner Ege,¹ Erkmen Gülhan,¹ Ülkü Yazıcı,¹ Esra Özaydın,³ Pinar Yaran¹

Departments of ¹Thoracic Surgery, ³Pathology, Atatürk Chest Diseases and Thoracic Surgery
Training and Research Hospital, Ankara;

²Department of Thoracic Surgery, Medicine Faculty of Düzce University, Düzce

Background: In this study, we evaluated the results of our tracheal sleeve pneumonectomy (TSP) cases.

Methods: Thirteen male patients (mean age 52; range 40 to 65 years) with non-small cell lung cancer underwent TSP in our clinic between January 2000 and July 2009. The patients were evaluated for age, sex, histopathological examinations and stages, adjuvant therapies, postoperative complications and survival retrospectively. The mean and five-year survivals of patients were analyzed with Kaplan-Meier method.

Results: Eleven right and two left TSPs were performed in 13 patients. The histopathological diagnoses were squamous cell carcinoma in 11 patients, adenocarcinoma in one patient and adeno-squamous carcinoma in one patient. The tumor-node-metastasis staging was stage IIB in one patient, stage IIIA in one patient and stage IIIB in 11 patients. Four patients had complications after the surgery, and two of these were anastomosis-related. A total of three patients died during follow-up, one of them in the postoperative period. The mean survival and the five-year survival rate were 87 months and 77%, respectively.

Conclusion: Tracheal sleeve pneumonectomy is an important modality in the treatment of lung cancer that has invaded or is in close proximity with the carina. With improvements in the thoracic surgery, the morbidity and mortality of TSP have improved and are currently close to the standard pneumonectomy. Mediastinal lymph node involvement should be a contraindication. The only exception for this is subcarinal lymph node involvement, where *en block* resection is possible.

Key words: Carina resection; non-small cell lung cancer; tracheal sleeve pneumonectomy; tracheobronchial anastomosis.

Amaç: Bu çalışmada trakeal sleeve pnömonektomi (TSP) uyguladığımız olgulara ait sonuçlar incelendi.

Çalışma planı: Ocak 2000 ile Temmuz 2009 tarihleri arasında küçük hücreli dışı akciğer kanseri nedeni ile 13 erkek hastaya (ort. yaş 52; dağılım 40-65 yıl) kliniğimizde TSP uygulandı. Hastalar yaş, cinsiyet, histopatolojik muayeneleri ve evreleri ile adjuvan tedaviler, ameliyat sonrası komplikasyonlar ve sağkalım açısından geriye dönük olarak incelendi. Hastaların ortalama ve beş yıllık sağkalımları Kaplan-Meier yöntemi ile hesaplandı.

Bulgular: On üç hastanın 11'ine sağ, ikisine sol TSP uygulandı. Histopatolojik tanı, 11 hastada skuamöz hücreli karsinom, bir hastada adenokarsinom ve bir hastada adeno-skuamöz karsinom idi. Tümör, lenf nodu metastazı evrelemeleri bir hastada evre IIB, bir hastada evre IIIA ve 11 hastada evre IIIB idi. Dört hastada ameliyat sonrası komplikasyon görüldü ve bunların ikisi anastomoz ile ilişkili idi. Biri ameliyat sonrası dönemde olmak üzere takip süresince toplam üç hasta kaybedildi. Ortalama sağkalım süresi ve beş yıllık sağkalım oranları sırasıyla 87 ay ve %77 idi.

Sonuç: Trakeal sleeve pnömonektomi karınaya invaze veya yakın komşu olan akciğer kanseri tedavisinde önemli bir yöntemdir. Göğüs cerrahisindeki gelişmelerle morbidite ve mortalitesi azalmış olup bugün için standart pnömonektomininkine yakındır. Mediastinal lenf nodu tutulumu bir kontrendikasyon olmalıdır. Bunun tek istisnası, *en blok* rezeksiyonun mümkün olduğu subkarinal lenf nodu tutulumudur.

Anahtar sözcükler: Karina rezeksiyonu; küçük hücreli dışı akciğer kanseri; trakeal sleeve pnömonektomi; trakeobronşiyal anastomoz.

Received: January 7, 2010 Accepted: February 9, 2010

Correspondence: Suat Gezer, M.D. Düzce Üniversitesi Tıp Fakültesi, Göğüs Cerrahisi Anabilim Dalı, 81620 Beçi Yörükler, Düzce, Turkey.
Tel: +90 380 - 542 13 90 e-mail: suatdr@hotmail.com

Presented at the 5th Turkish Thoracic Surgery Congress, May 14-17, 2009.

Tracheal sleeve pneumonectomy (TSP) is an aggressive surgical procedure which is applied for the resection of lung cancer invading lung, tracheobronchial angle, carina or lower end of trachea. The airway is reconstructed with anastomosis of the opposite main bronchus and lower end of the trachea. In 1950, Abbott^[1] published that he had performed resection of the carina, lower trachea and contralateral bronchus with right pneumonectomy, which was the first right TSP. From this date, TSP was performed with high morbidity and mortality rates by some surgeons.^[2,3] However, although improvements in surgical techniques and anesthesia have brought the results of those operations to a reasonable level, TSP is still seen as one of the most challenging procedures of thoracic surgery. In this study, we evaluated the results of 13 TSP cases and discussed the results of recent studies.

PATIENTS AND METHODS

Thirteen male patients (mean age 52; range 40 to 65 years) with non-small cell lung cancer underwent 11 right and two left TSP between January 2000 and July 2009 in Thoracic Surgery Clinic. All patients preoperatively underwent radiological investigations including chest X-ray and thoracic computed tomography (CT) (Fig 1). Diagnostic biopsies were taken and the necessity and feasibility of TSP were evaluated by fiber-optic bronchoscopies (FOB). For all patients, the respiratory sufficiency for resection was evaluated by measurement of forced expiratory volume in 1 second (FEV₁) and diffusing capacity of the lung for carbon-monoxide (DLCO). For patients whose FEV₁ and DLCO measures were borderline, maximum oxygen consumption during exercise (VO₂-max) and postoperative FEV₁ were measured. In addition, all patients were assessed with complete blood count, analyses of blood chemistry and coagulation parameters, and complete urine analysis. Cardiac status was routinely assessed with ECG and cardiology consultation was requested for patients older than 55-years and other patients if any pathology was suspected. All patients underwent an anesthesia clinic examination preoperatively. Mediastinal lymph node status was evaluated with mediastinoscopy (n=10) or PET-CT (n=5).

The patients were taken to the operating room and intubated with double lumen endobronchial tubes in order to achieve single lung ventilation.

For right TSP; a posterolateral thoracotomy through the 5th intercostal space was performed. The carina was mobilized after azygos vein division (Fig 2a). The right lung was resected together with the carina as a single piece. The continuity of ventilation was provided with an endobronchial tube which was placed into the left main bronchus through the operative field (Fig 2b).

Frozen section examination of the bronchial and tracheal surgical margins was made. While the anastomosis of the trachea and left main bronchus was made with interrupted suture technique on the membranous side and continuous suture technique on the cartilage side in the first cases, the anastomosis was later made with continuous technique using 3/0 monofilament absorbable suture material on all sides as a rule (Fig 2c). After completion of the anastomosis, the line was embedded in saline and air leak check under 30-40 cm-H₂O pressure was performed. The anastomosis line was embedded into pericardial fat pad or thymic remnant. A rigid bronchoscopy or FOB through endobronchial tube was performed for checking of anastomosis and bronchial toilet.

For left TSP; a right thoracotomy was performed first. The tracheal lower end and right main bronchus were divided and the carina was left on the left main bronchus. After frozen section examination of the bronchial and tracheal surgical margins, the trachea and right main bronchus were anastomosed with the same technique described for the right TSP. After closing the right thoracotomy, the patient was turned and the left lung was resected together with the carina through a left posterolateral thoracotomy.

The patients were followed in intensive care unit for 72 hours. All patients had expectorant agents, incentive spirometry and chest physiotherapy in order to prevent secretion retention. The patients who had secretion retention despite those applications underwent FOB for bronchial toilet. In addition, the patients underwent FOB on the 7th postoperative day for anastomosis line check. The patients without any complication were discharged on the 15th postoperative day.

After discharge, patients were followed up in outpatient clinic for the first time on the 20th day and once every three months for the rest of the first year and twice a year for the following years.

The records of those patients were re-evaluated for age, sex, histopathological examinations and stages, adjuvant therapies, postoperative complications and survival. The mean and five-year survivals of patients were analyzed with Kaplan-Meier statistics method. The obtained data were discussed and compared with the literature.

RESULTS

The histopathological diagnoses were squamous cell cancer in 11 patients, adenocarcinoma in one and adeno-squamous cancer in one.

Postoperative tumor node metastasis (TNM) staging was stage 2B in one patient, stage 3A in one and stage 3B in 11. There was residual tumor on bronchial

surgical margins in two patients. One of these patients was lost on the 6th postoperative day and the other who had adjuvant chemotherapy presented with local recurrence on the 4th postoperative year and is still alive after chemotherapy and radio-surgery.

Four patients (31%) had complications after surgery, and three patients (13%) were lost during follow-up. One patient had infection of incision. His infection was resolved in the early period but he also had pleural empyema on the 3rd postoperative year, the etiology was unknown in this patients. He underwent thoracomyoplasty and is still alive without any problem on the 10th postoperative year. One patient had anastomosis leak on the first postoperative day and underwent revision. One patient had esophago-pleural fistula on the 6th postoperative month. He had endoesophageal clipping of the fistula opening and is still under follow-up in the 10th postoperative month. One patient died of anastomosis dehiscence notified on the 6th postoperative day, one due to respiratory failure on the 70th postoperative day and one due to cardiologic problems on the 3rd postoperative month.

All patients, except two who were lost on the 6th and 70th postoperative days had adjuvant therapies. Of those, two had chemo-radiotherapy and nine had chemotherapy.

One right TSP patient with bronchial surgical margin positivity presented with local recurrence on the 39th postoperative month. He had chemotherapy and radio surgery and is under follow-up on the 54th postoperative month.

The follow-up times of living patients are between 10 and 112 months. Mean and five-year survival calculated by the Kaplan-Meier method are 87 months and 77 percent respectively. The data of the patients are summarized in table 1.

DISCUSSION

Patients with lung cancer invading the proximal main bronchus, carina and distal thoracic trachea may benefit from the TSP operation including ipsilateral pneumonectomy, carina resection and anastomosis of trachea and opposite bronchus.^[4] However, that operation has been seen as unfavorable due to potential morbidity, mortality

Table 1. Summary of tracheal sleeve pneumonectomy cases

No	Age/sex	Operation side	Mediastinal evaluation	Histopathology	Stage	Adjuvant therapy	Follow-up
1	47/M	Right	M	Squamous cell carcinoma	T4N0M0/IIIB	ChT	3 rd year: empyema, thoracomyoplasty 9 year-4 month: ADf
2	50/M	Right	M	Squamous cell carcinoma	T4N2M0/IIIB Surgical margin (+)	-	6 th day: anastomosis dehiscence and exitus
3	52/M	Right	M	Squamous cell carcinoma	T4N1M0/IIIB	ChT	5 year-4 month ADf
4	40/M	Right	M	Adenocarcinoma	T4N0M0/IIIB	ChT	5 year-2 month ADf
5	58/M	Right	M	Squamous cell carcinoma	T4N1M0/IIIB	ChT	3 rd month: exitus due to cardiologic problem
6	40/M	Right	M	Squamous cell carcinoma	T4N1M0/IIIB Surgical margin (+)	RT+ChT	39 th month: local recurrence; ChT, radio surgery 4 year-6 month ADf
7	62/M	Right	P+M	Squamous cell carcinoma	T4N2M0/IIIB	-	70 th day: exitus due to respiratory failure
8	65/M	Right	P+M	Squamous cell carcinoma	T4N2M0/IIIB	ChT	1 st day: anastomosis leakage, revision. 2 year-2 month ADf
9	44/M	Right	M	Squamous cell carcinoma	T4N0M0/IIIB	ChT	20 th month ADf
10	42/M	Left	M	Adeno-squamous carcinoma	T3N0M0/IIB	ChT	18 th month ADf
11	64/M	Right	P	Squamous cell carcinoma	T4N0M0/IIIB	ChT	17 th month ADf
12	53/M	Right	P	Squamous cell carcinoma	T3N2M0/IIIA	ChT	6 th month: esophago-pleural fistula, endoscopic clipping of fistula. 10 th month ADf
13	59/M	Left	P	Squamous cell carcinoma	T4N0M0/IIIB	ChT+RT	10 th month ADf

ADf: Alive and disease free; ChT: Chemotherapy; M: Mediastinoscopy; P: PET/CT; RT: Radiotherapy.

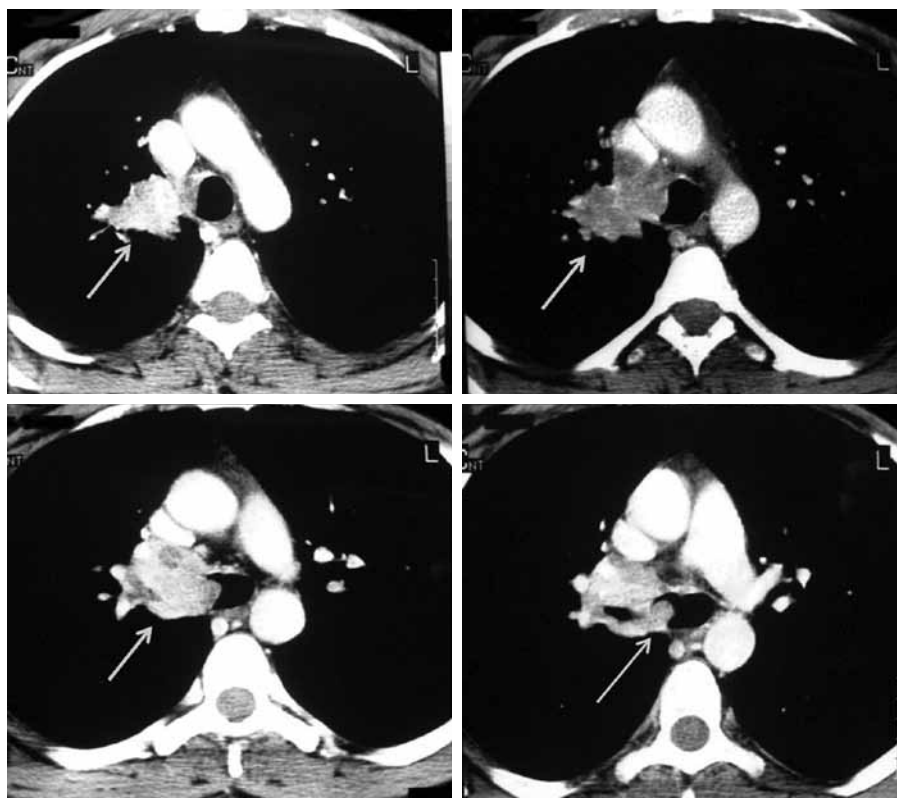


Fig. 1. Thoracic computed tomography of patient no 5 in the table 1: A tumor invading proximal right main bronchus and lower end of trachea.

and uncertain long-term survival.^[5] Furthermore, the staging of tumors invading the carina as T₄ (stage IIIB) raised questions about the advantage of the operation in those patients.^[6]

The first series of TSP had operative mortality rates as high as 29-40%.^[3,7-9] However, with improvements in anesthesia, surgical techniques and postoperative care subsequent studies gave better results. The operative mortalities of the studies in the last decade are between 4% and 16% and are generally related to pulmonary complications (Table 2).^[6,10-17] Those results are close

to the 6% (range 5-15%) mortality of classical pneumonectomy.^[16,17] Darteville et al.^[4] reported a 40% five-year survival in a series of 55 patients. That rate was given as 42% in 60 patients by Mitchell et al.,^[10] and 26.5% in 65 patients by Regnard et al.^[6] Regnard et al.^[6] concluded this lower survival rate was due to higher N₂ disease numbers in the study. Rea et al.^[11] reported a 56.5% five-year survival in N₀ disease. Many authors accept the N₂ disease as a contraindication to advanced surgical interventions such as TSP. Darteville et al.^[4] published no long-term survival after TSP in N₂

Table 2. The literature of the new millennium about tracheal sleeve pneumonectomy (some includes also carina resections)

Autors	Number of patients	30 day mortality (%)	Postoperative anastomotic complication rate (%)	Five-year survival for	
				Overall (%)	N ₀ -N ₁ disease (%)
Rea et al. ^[13]	49	6.1	4	27.5	56-17
de Perrot et al. ^[16]	119	7.6	10	44	53
Macchiarini et al. ^[15]	50	4	16	51	–
Regnard et al. ^[6]	65	7.7	15.4	26.5	38
Roviaro et al. ^[17]	53	7.5	2	33.4	–
Porhanov et al. ^[14]	231	16	25.1	27.4	32
Mitchell et al. ^[12]	60	15	16.6	42	51-32
<i>Current study</i>	13	7.6	15.3	77	–

disease. Mitchell et al.^[10] and Porhanov et al.^[12] reported five-year survivals of 12% and 7.5% respectively in N₂ disease. We also accept N₂ disease as a contraindication to TSP but subcarinal lymph node involvement is the unique exception when an *en bloc* resection is possible.^[4] We had four N₂ cases in our study. One was referred to our clinic with complete obstruction of the right main bronchus, severe stenosis of the left main bronchus and severe shortness of breath. We could not procure a bronchial stent. We urgently operated on the patient to be able to give a survival chance. However, despite a 6 cm tracheobronchial resection, surgical margins could not be cleared from microscopic tumor and the patient was lost on the 6th postoperative day due to anastomotic dehiscence. This was our unique operative mortality. One had paratracheal lymph node involvement which could not be detected preoperatively the patient died on the 70th postoperative day. One had pulmonary ligament lymph node positivity, which again could not be detected preoperatively and had esophago-pleural fistula on the 6th postoperative month. One had subcarinal lymph node positivity and is free of disease on the 3rd postoperative year.

The continuity of ventilation is an important point of TSP procedure. High frequency jet ventilation is an optimal modality for ventilation of the opposite lung during the operation.^[6] It provides the opportunity of ventilation through a small tube. In case of lack or insufficiency of jet ventilation, the ventilation could be performed through a conventional endotracheal tube from the operative field.^[6] We use this method in TSP and tracheal surgery since we did not have the opportunity of jet ventilation in our hospital and did not experience any difficulty or problem with the method. The “Apneic hyper-oxygenation technique” is another method used by some centers in TSP surgery anesthesia.^[13]

Although there is a consensus on the use of right thoracotomy in right TSP, the route in left TSP is a matter of discussion because the aortic arch limits exposure of the carina. While some authors prefer consecutive bilateral thoracotomies, others prefer median sternotomy plus left thoracotomy. Porhanov et al.^[12] first divided the pulmonary veins and pulmonary ligament through a left sided VATS and then performed the resection and anastomosis via median sternotomy. We used consecutive bilateral thoracotomies in left TSP patients.

In conclusion, TSP is an important modality in therapy for lung cancer invading the proximal main bronchus, carina and distal thoracic trachea. With improvements in anesthesia, surgical techniques and postoperative care the morbidity and mortality of TSP have improved and are closer to those of standard pneumonectomy

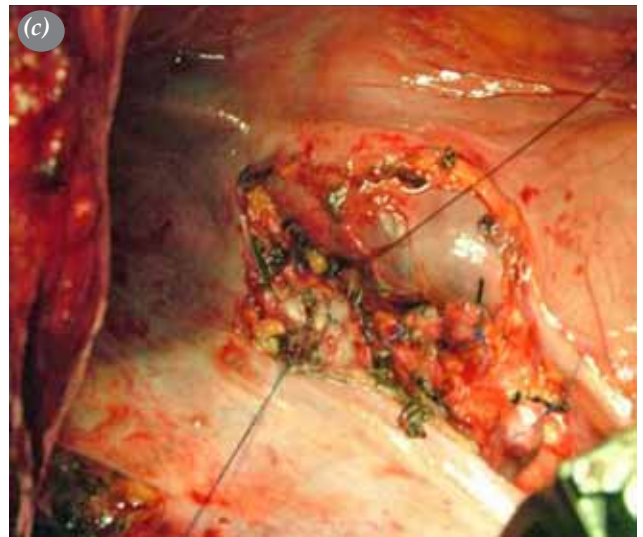
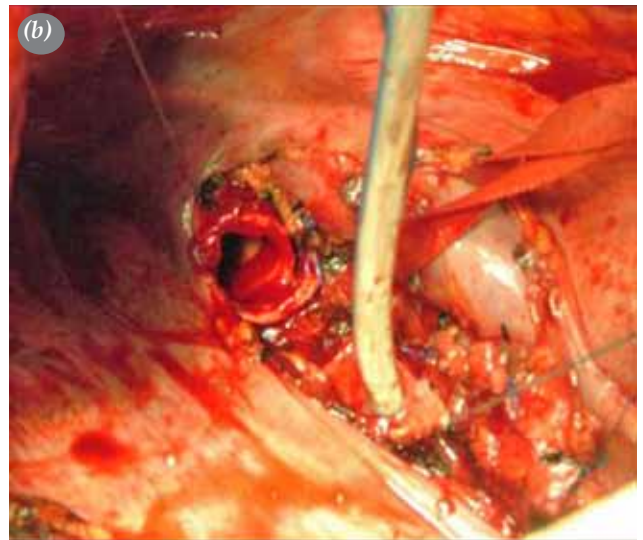
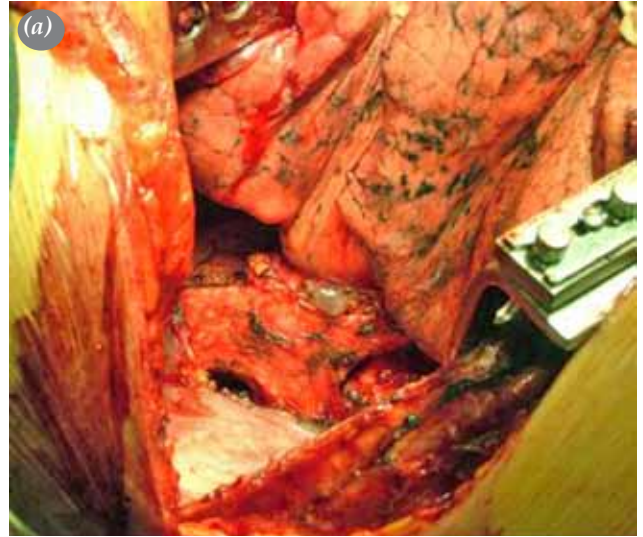


Fig. 2. Intraoperative view from same patient. (a) Invasion of carina region. (b) Ventilation of the left lung from operation field after removal of carina and right lung. (c) Ended tracheobronchial anastomosis.

today. Paratracheal lymph node involvement should be a contraindication but surgery should be considered for subcarinal lymph node involvement when *en bloc* resection can be possible.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

REFERENCES

- Abbott OA. Experiences with the surgical resection of the human carina, tracheal wall, and contralateral bronchial wall in cases of right total pneumonectomy. *J Thorac Surg* 1950; 19:906-22.
- Deslauriers J, Beaulieu M, Bénazéra A, McClish A. Sleeve pneumonectomy for bronchogenic carcinoma. *Ann Thorac Surg* 1979;28:465-74.
- Jensik RJ, Faber LP, Kittle CF, Miley RW, Thatcher WC, El-Baz N. Survival in patients undergoing tracheal sleeve pneumonectomy for bronchogenic carcinoma. *J Thorac Cardiovasc Surg* 1982;84:489-96.
- Dartevelle PG, Macchiarini P, Chapelier AR. 1986: Tracheal sleeve pneumonectomy for bronchogenic carcinoma: report of 55 cases. Updated in 1995. *Ann Thorac Surg* 1995;60:1854-5.
- Mathisen DJ, Grillo HC. Carinal resection for bronchogenic carcinoma. *J Thorac Cardiovasc Surg* 1991;102:16-22.
- Regnard JF, Perrotin C, Giovannetti R, Schussler O, Petino A, Spaggiari L, et al. Resection for tumors with carinal involvement: technical aspects, results, and prognostic factors. *Ann Thorac Surg* 2005;80:1841-6.
- Tsuchiya R, Goya T, Naruke T, Suemasu K. Resection of tracheal carina for lung cancer. Procedure, complications, and mortality. *J Thorac Cardiovasc Surg* 1990;99:779-87.
- Maeda M, Nakamoto K, Ohta M, Nakamura K, Nanjo S, Taniguchi K, et al. Statistical survey of tracheobronchoplasty in Japan. *J Thorac Cardiovasc Surg* 1989;97:402-14.
- Pearson FG, Todd TR, Cooper JD. Experience with primary neoplasms of the trachea and carina. *J Thorac Cardiovasc Surg* 1984;88:511-8.
- Mitchell JD, Mathisen DJ, Wright CD, Wain JC, Donahue DM, Allan JS, et al. Resection for bronchogenic carcinoma involving the carina: long-term results and effect of nodal status on outcome. *J Thorac Cardiovasc Surg* 2001; 121:465-71.
- Rea F, Marulli G, Schiavon M, Zuin A, Hamad AM, Feltracco P, et al. Tracheal sleeve pneumonectomy for non small cell lung cancer (NSCLC): short and long-term results in a single institution. *Lung Cancer* 2008;61:202-8.
- Porhanov VA, Poliakov IS, Selvaschuk AP, Grechishkin AI, Sitnik SD, Nikolaev IF, et al. Indications and results of sleeve carinal resection. *Eur J Cardiothorac Surg* 2002;22:685-94.
- Macchiarini P, Altmayer M, Go T, Walles T, Schulze K, Wildfang I, et al. Technical innovations of carinal resection for nonsmall-cell lung cancer. *Ann Thorac Surg* 2006; 82:1989-97.
- de Perrot M, Fadel E, Mercier O, Mussot S, Chapelier A, Dartevelle P. Long-term results after carinal resection for carcinoma: does the benefit warrant the risk? *J Thorac Cardiovasc Surg* 2006;131:81-9.
- Roviaro G, Vergani C, Maciocco M, Varoli F, Francese M, Despini L. Tracheal sleeve pneumonectomy: long-term outcome. *Lung Cancer* 2006;52:105-10.
- Deslauriers J, Grégoire J, Jacques LF, Piraux M, Guojin L, Lacasse Y. Sleeve lobectomy versus pneumonectomy for lung cancer: a comparative analysis of survival and sites or recurrences. *Ann Thorac Surg* 2004;77:1152-6.
- Ferguson MK, Karrison T. Does pneumonectomy for lung cancer adversely influence long-term survival? *J Thorac Cardiovasc Surg* 2000;119:440-8.