

EXTENDED RESECTIONS FOR LOCALLY ADVANCED LUNG CANCER

Alper Toker MD, FEBTS
West Virginia University

 **WVU Heart & Vascular
Institute**

Definition

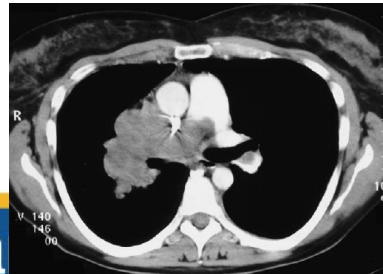
the entire lung associated with one or more of the following structures: superior vena cava (SVC), tracheal carina, left atrium, aorta, ~~chest wall, and diaphragm.~~

Extended pneumonectomy for non–small cell lung cancer: Morbidity, mortality, and long-term results

Alessandro Borri, MD,^a Francesco Leo, MD,^a Giulia Veronesi, MD,^a Piergiorgio Solli, MD,^a Domenico Galetta, MD,^a Roberto Gasparri, MD,^a Francesco Petrella, MD,^a Paolo Scanagatta, MD,^a Davide Radice, PhD,^b and Lorenzo Spaggiari, MD, PhD^{a,c}

Extended pulmonary resections of advanced thoracic malignancies with support of cardiopulmonary bypass

Karsten Wiebe^{*}, Hassina Baraki, Paolo Macchiarini, Axel Haverich



PRINCIPLES

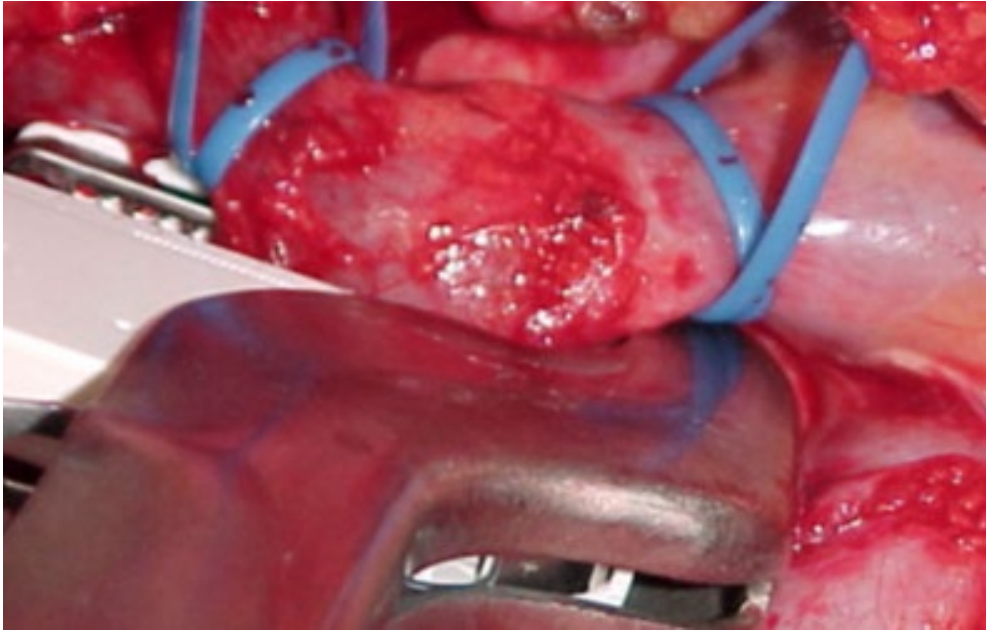
- **Preoperative full work –up, including invasive mediastinal staging**
- **Possible neoadjuvant treatment**
- **Angioplastic and bronchoplastic procedures (all technical possibilities)**
- **Alternative ways not to use or to decrease the duration of CPBP**
- **Meticulous surgical technique**
- **Clinical experience –Anesthesia and intensive care unit-**

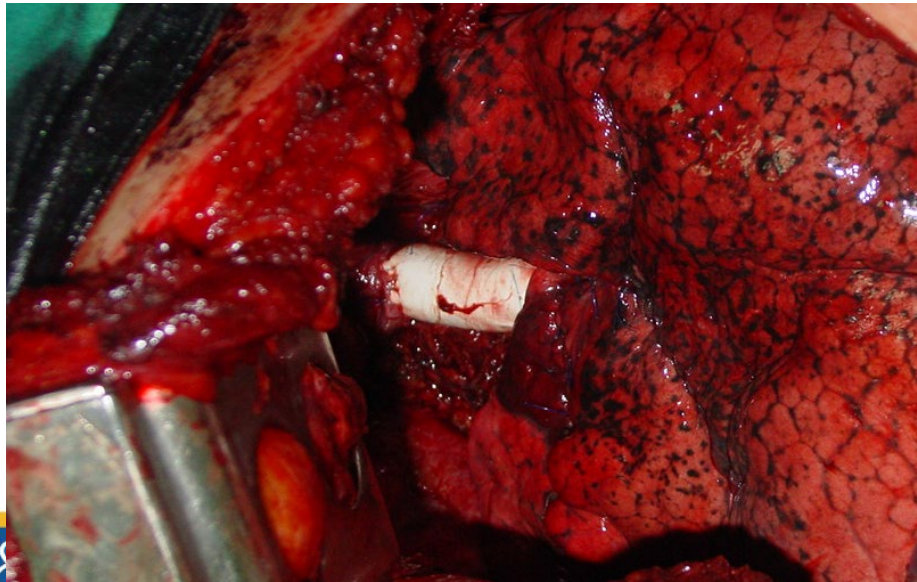
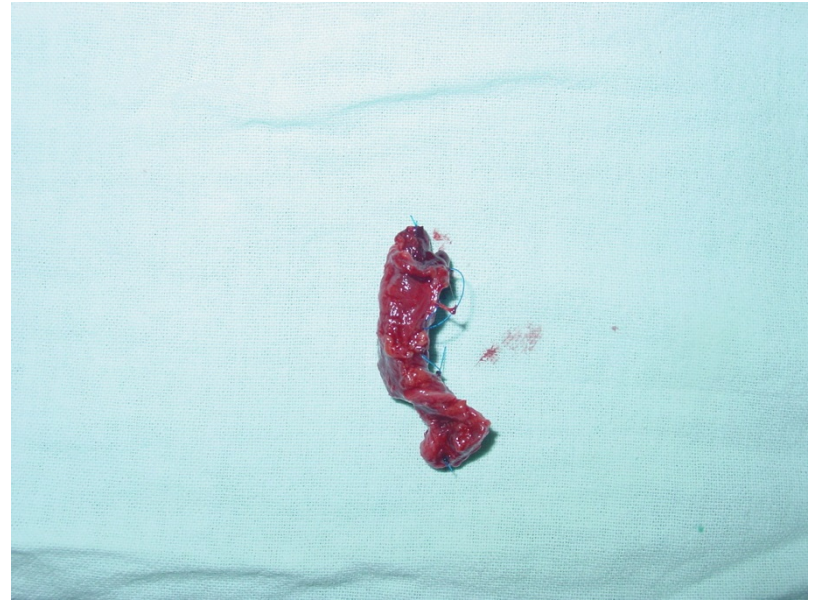
Oncologic debates

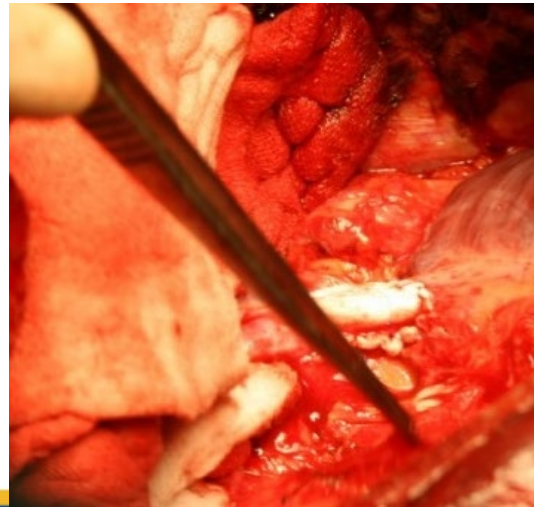
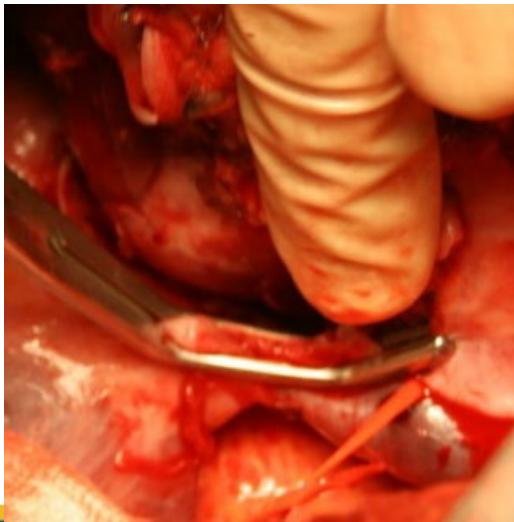
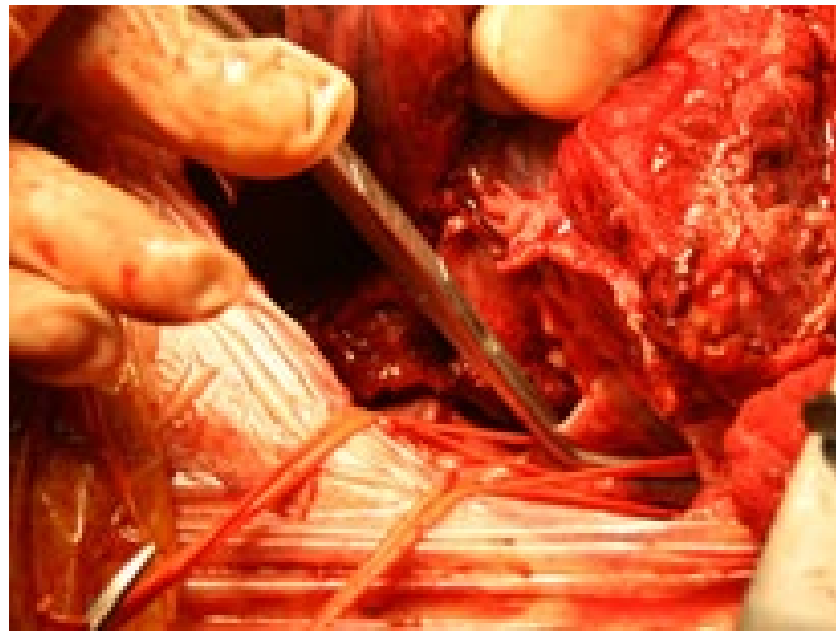
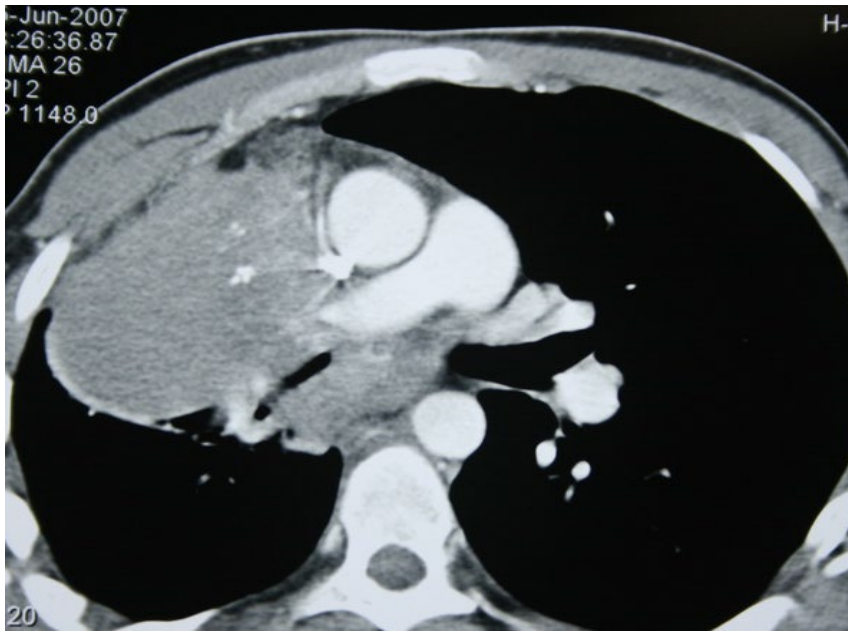
- **Performing surgery without neoadjuvant (technically possible),**
- **Attempt to downstage the type of resection**
- **Pneumonectomy vs broncho-angioplastic lobectomies**

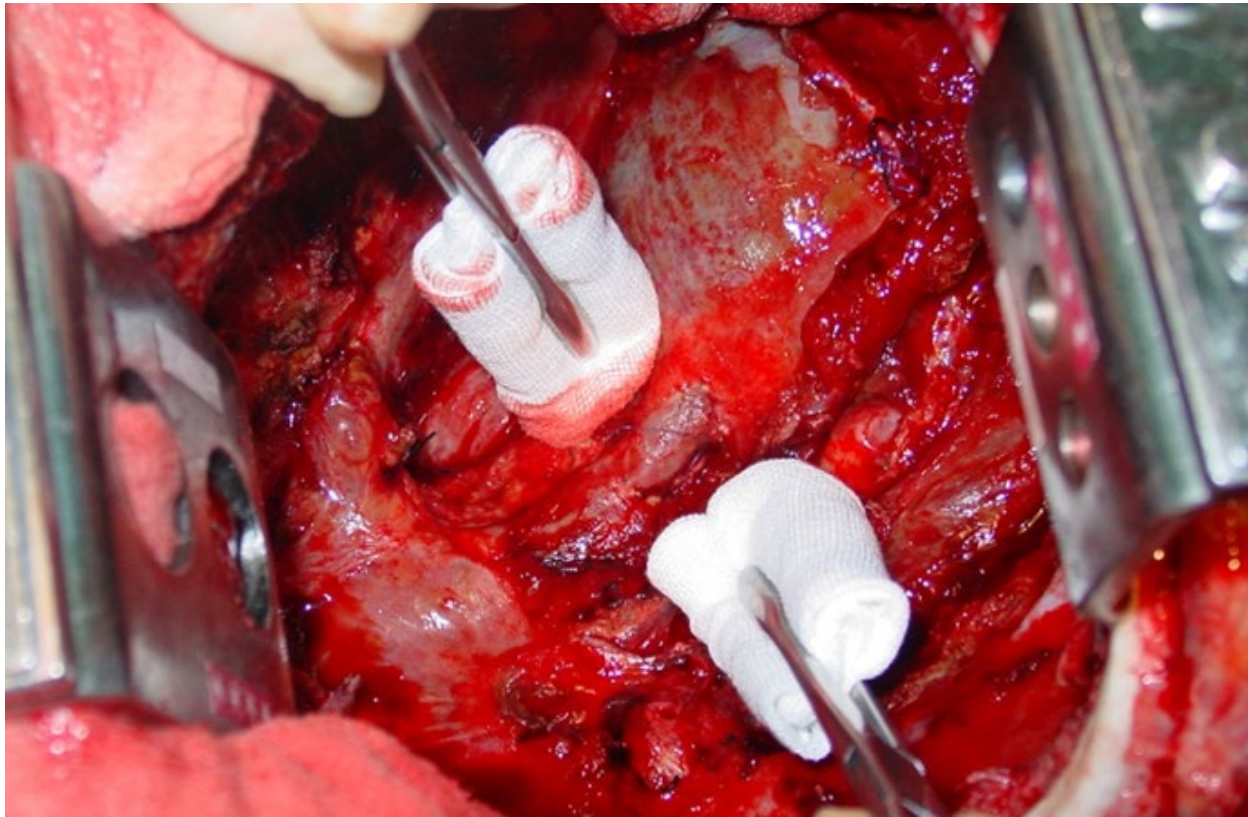
- **Neoadjuvant vs adjuvant chemo/radiotherapy**
 - **The rate of patients who could complete the adjuvant therapy is low**
- **Wider surgical margins, by shrinkage of tumor**
 - **Original resection or modification according to recent findings**
- **Systemic and mediastinal occult disease**
 - **To prevent an early recurrence**

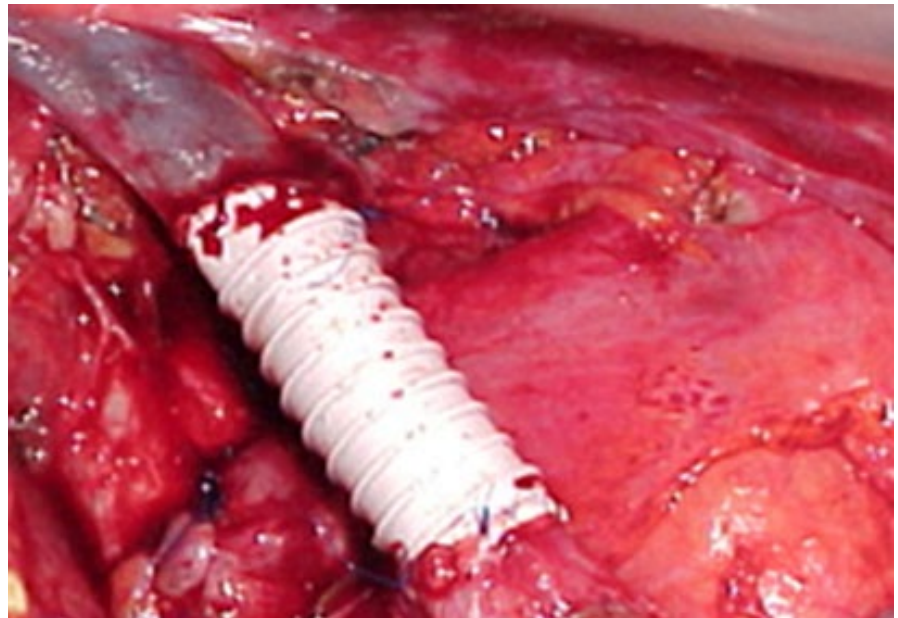
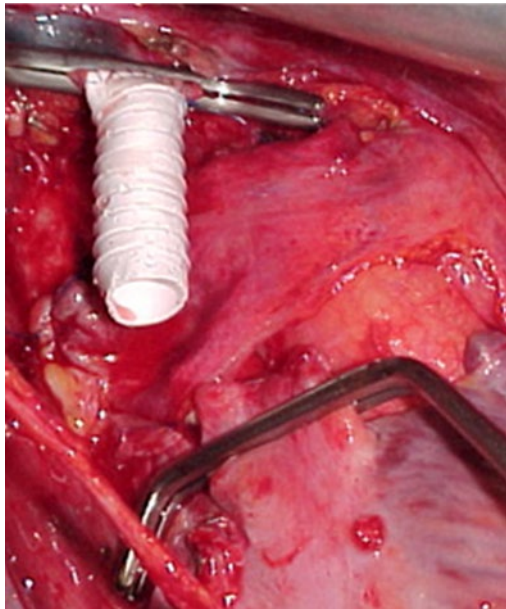
Surgical Technics SVC

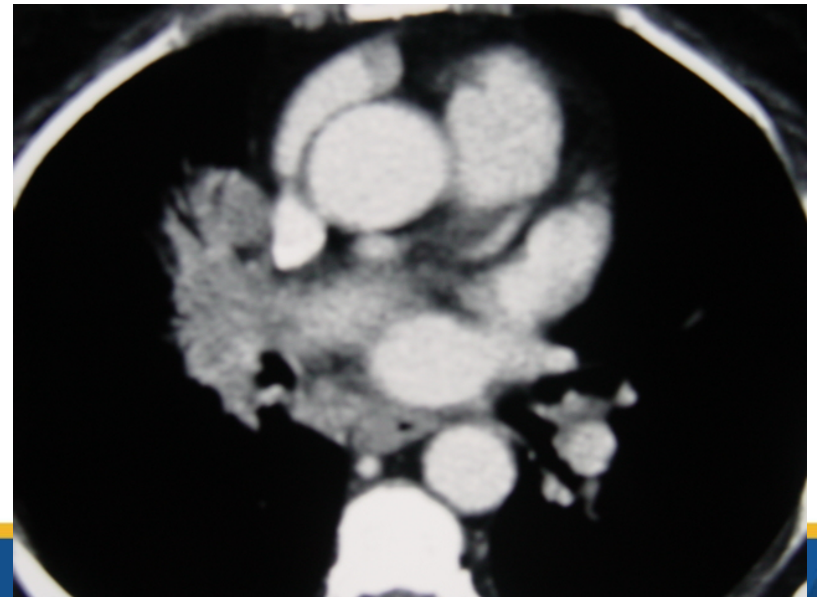
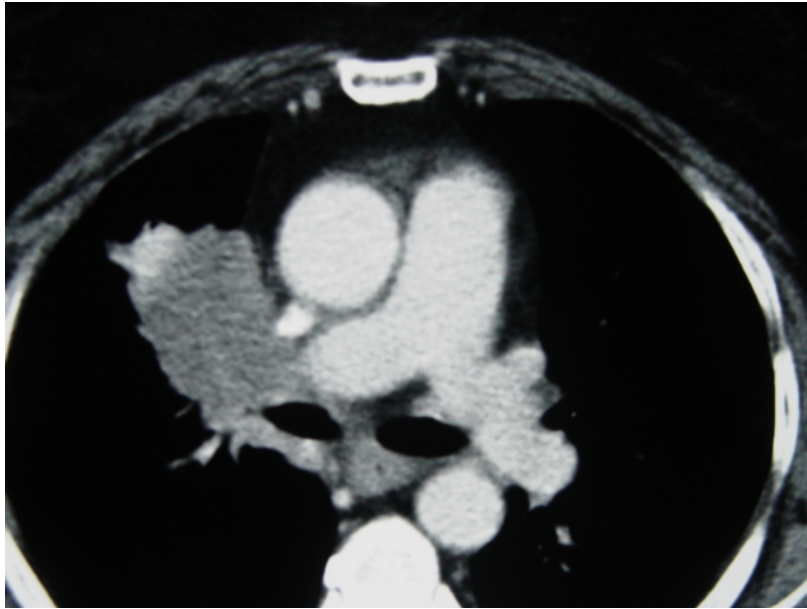


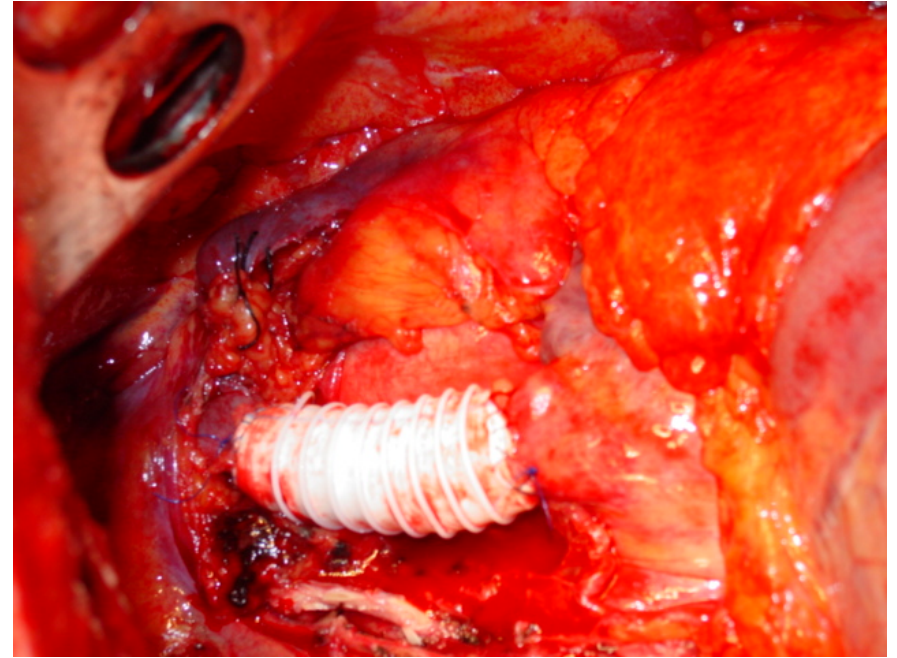
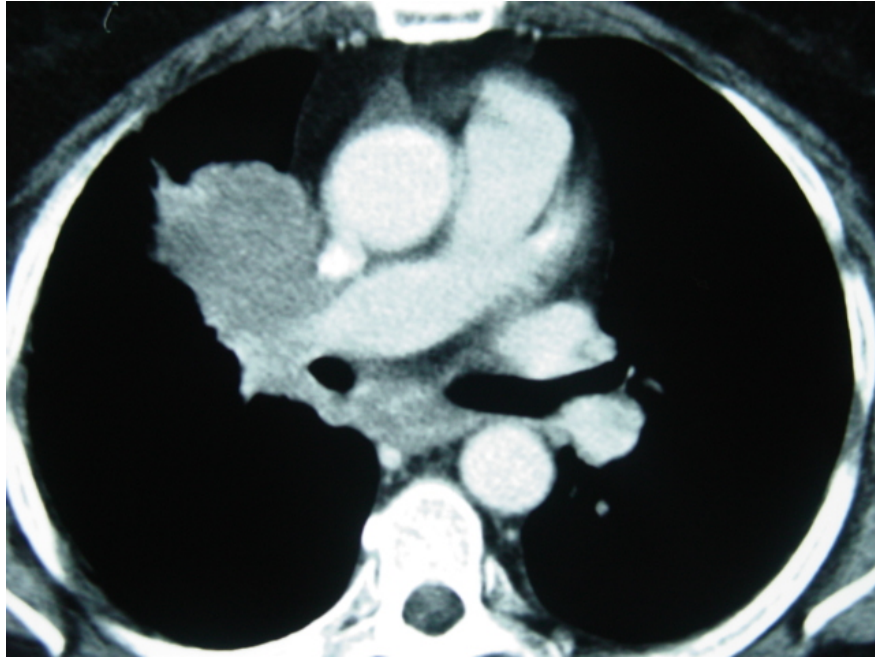












Ann Thorac Surg 2008;86:1065–75

- **39 cases of SVC invasion**
 - **32 right pneumonectomy**
- **Median surv 19 months,**
- **5YS 29%, 10YS 22.1%**
- **With carina resection 5YS 13%**
- **Non-squamous pathology and no carinal involvement good prognostic indicators**

Superior vena cava resection with prosthetic replacement for non-small cell lung cancer: long-term results of a multicentric study[☆]

Lorenzo Spaggiari^{a,*}, Pascal Thomas^b, Pierre Magdeleinat^c, Haruhiko Kondo^d, Gilles Rollet^b, Jean Francois Regnard^c, Ryosuke Tsuchiya^d, Ugo Pastorino^a

Abstract

Objectives: Superior vena cava (SVC) resection with prosthetic replacement for non-small cell lung cancer (NSCLC) is infrequently performed and oncological results are unclear. To establish a historical benchmark for this extended surgery, we have updated and reviewed data from four international centers. **Methods:** Data were obtained through retrospective chart review. Prognostic factors were analyzed using first univariate techniques and subsequently multiple regression (logistic regression). Kaplan–Meier overall survival was calculated and prognostic factors examined by log–rank test and the estimation of hazard ratios using Cox regression. **Results:** From 1985 to 2000, 100 patients underwent SVC resection with prosthetic replacement for NSCLC. During the same period, 65 patients underwent partial SVC resection. Induction treatment was performed in 25% of patients. The resection was done for T involvement in 22 patients (79%), and for N2 involvement in the remaining. There were 12 tracheal sleeve resections, four pneumonectomies, and 12 lobar or sublobar resections with or without bronchoplasty. The median clamping time was 40 min. The median diameter of the prosthesis used was No. 14. Pathologic examination showed direct SVC invasion (T4) in 79% of patients, whereas N2 disease was present in 50% of patients. Median intensive care unit and hospital stay were 3 and 20 days, respectively. The postoperative morbidity and mortality were 39 and 14%, respectively. The overall 5-year probability of survival was 15% (median of 9 months, range 0–105 months). Patients who underwent partial SVC resection during the same period had a significantly higher probability of survival ($P = 0.03$). Induction chemotherapy was associated with a significant increase of postoperative morbidity in multivariate analysis. None of the potential prognostic factors analyzed in multivariate analysis were associated with survival, but the type of resection (sleeve pneumonectomy/pneumonectomy) were borderline significant.

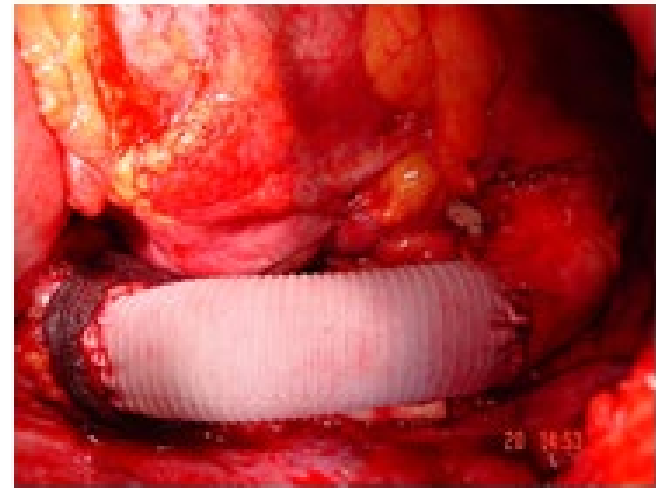
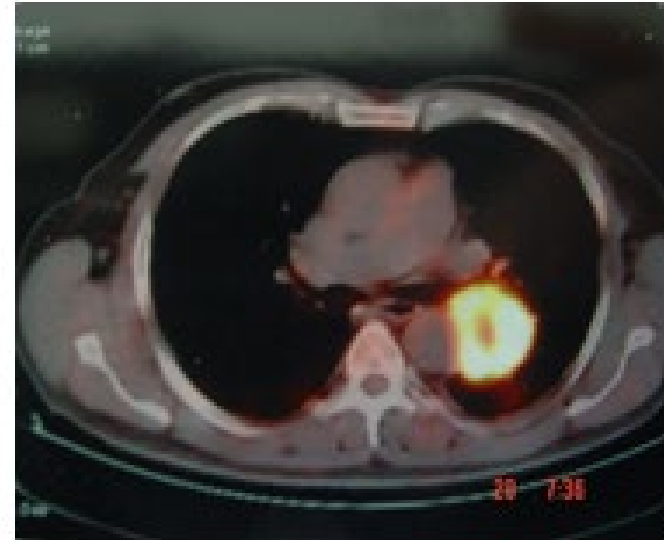
Conclusions: SVC resection with prosthetic replacement should not be considered an absolute contraindication in patients with NSCLC; however, the poor oncological results suggest more restrictive and severe criteria of patient selection (mediastinoscopy, induction treatment, no pneumonectomy, no N2 disease). © 2002 Elsevier Science B.V. All rights reserved.

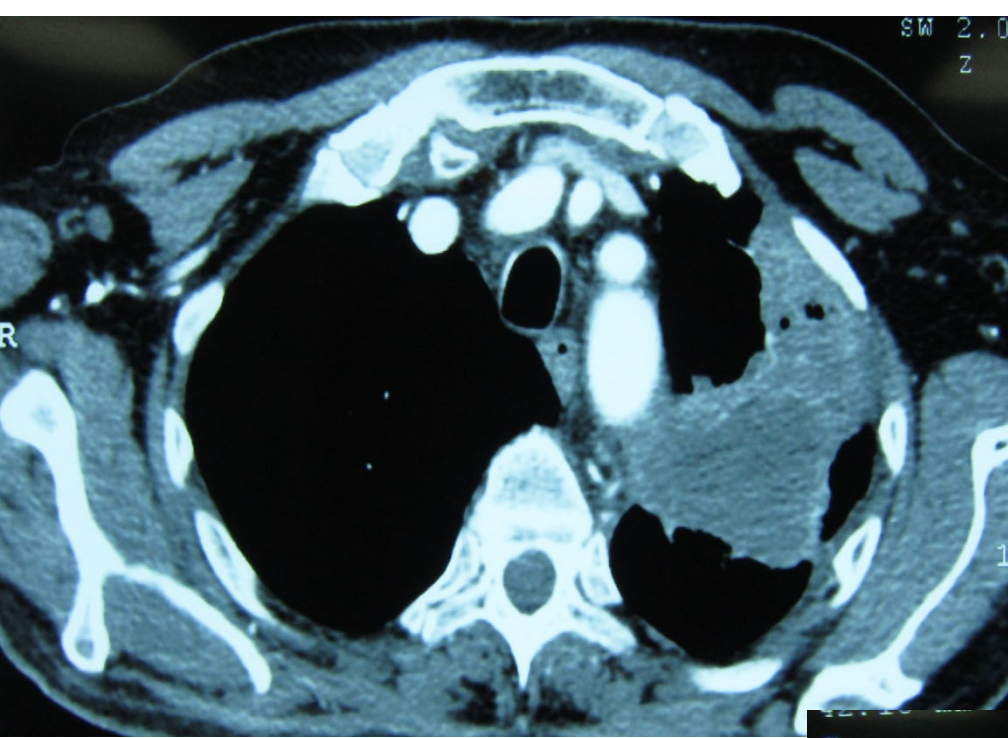
Aorta and PA Resections

- **Very limited series – almost anecdotal**
- **5 year survival rates**
- **Completeness of resection**
- **On bypass or without bypass**
- **Morbidity**

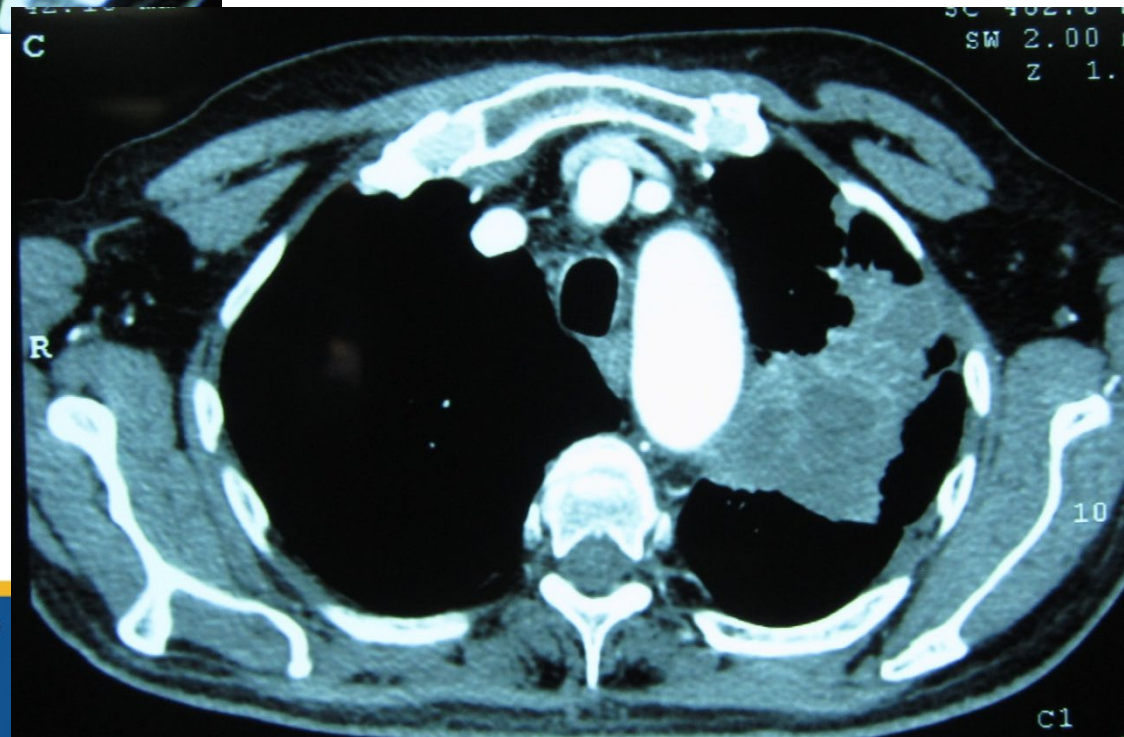
- **Being left sided pneumonectomy is a great advantage**

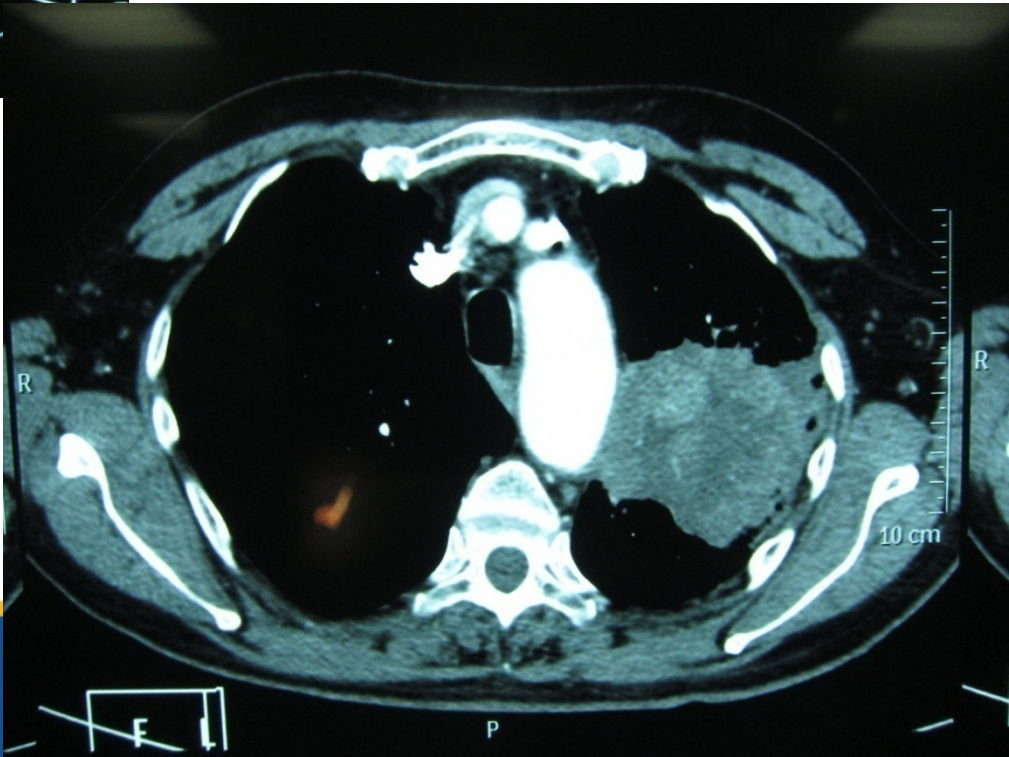
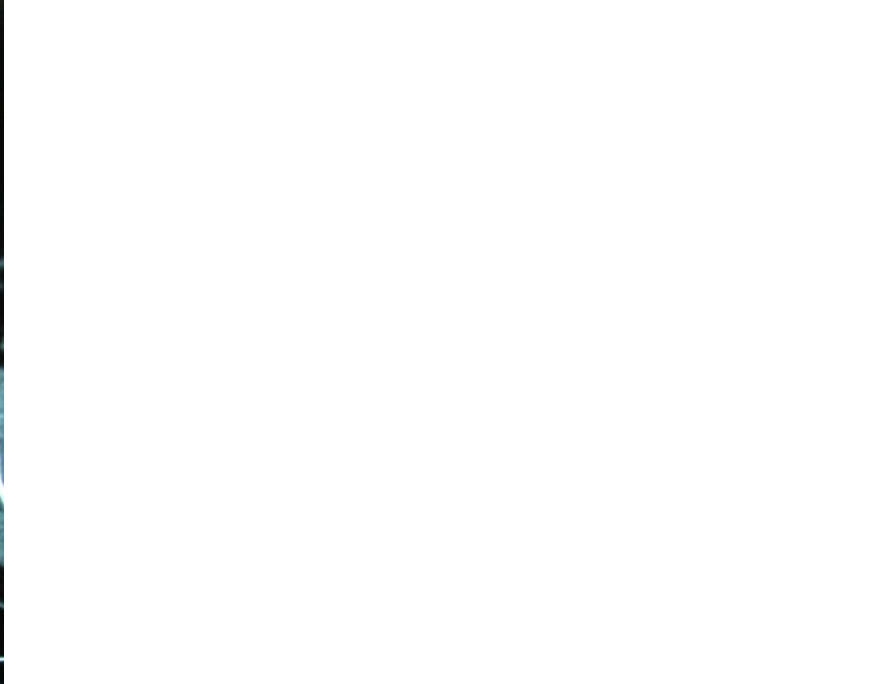
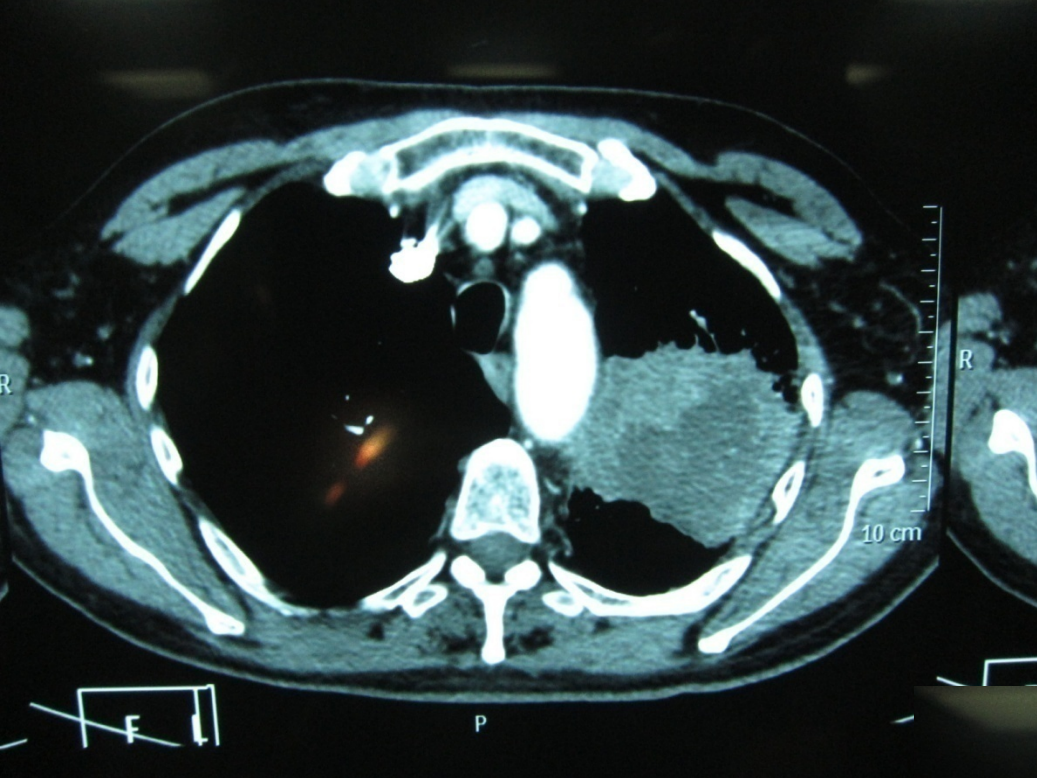
Neoadjuvant treatment Chemotx Only

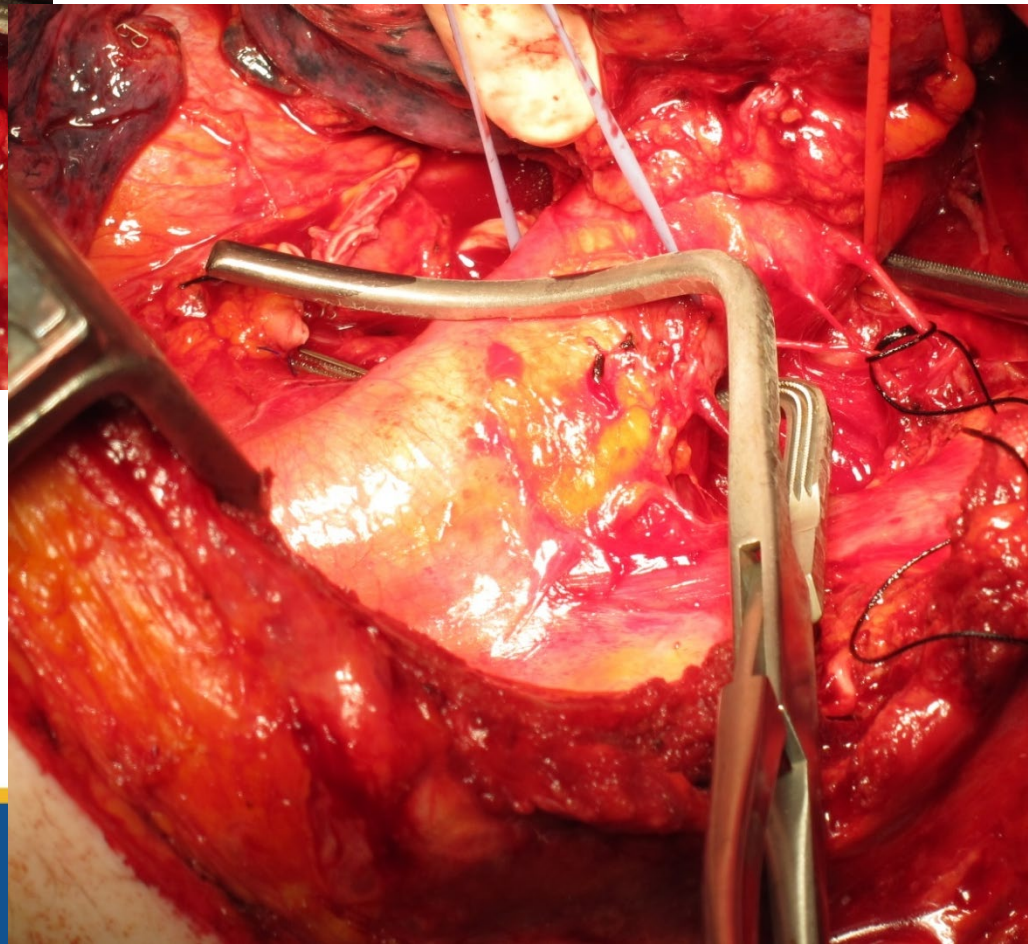
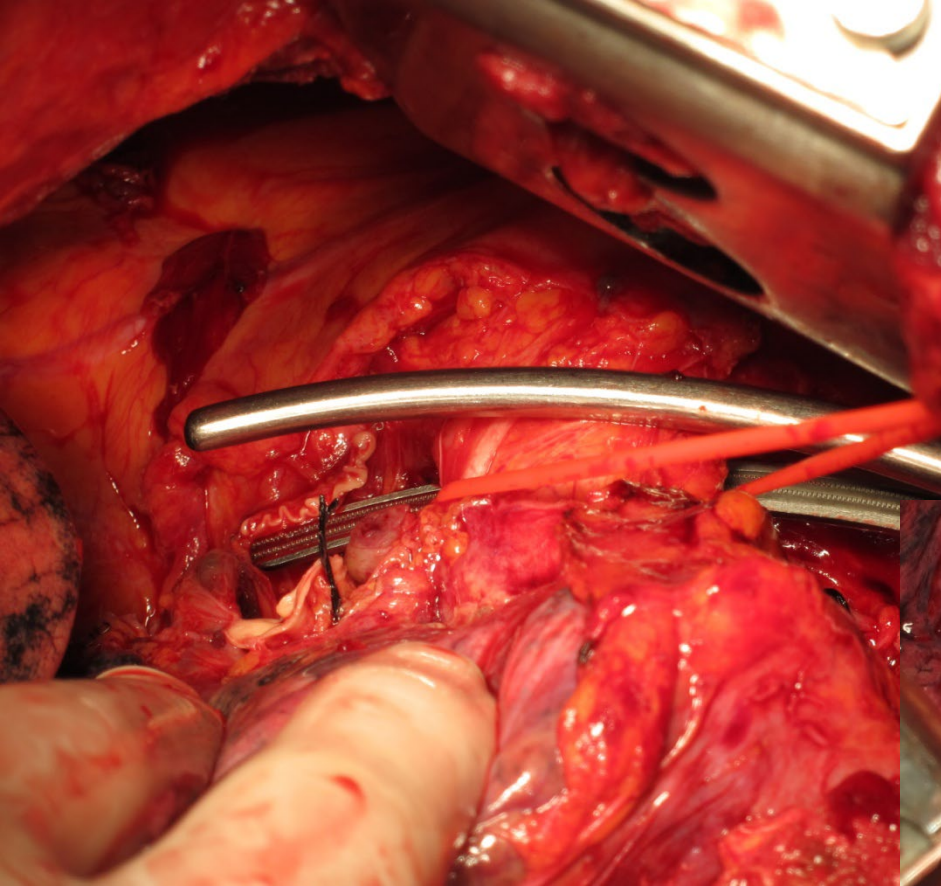


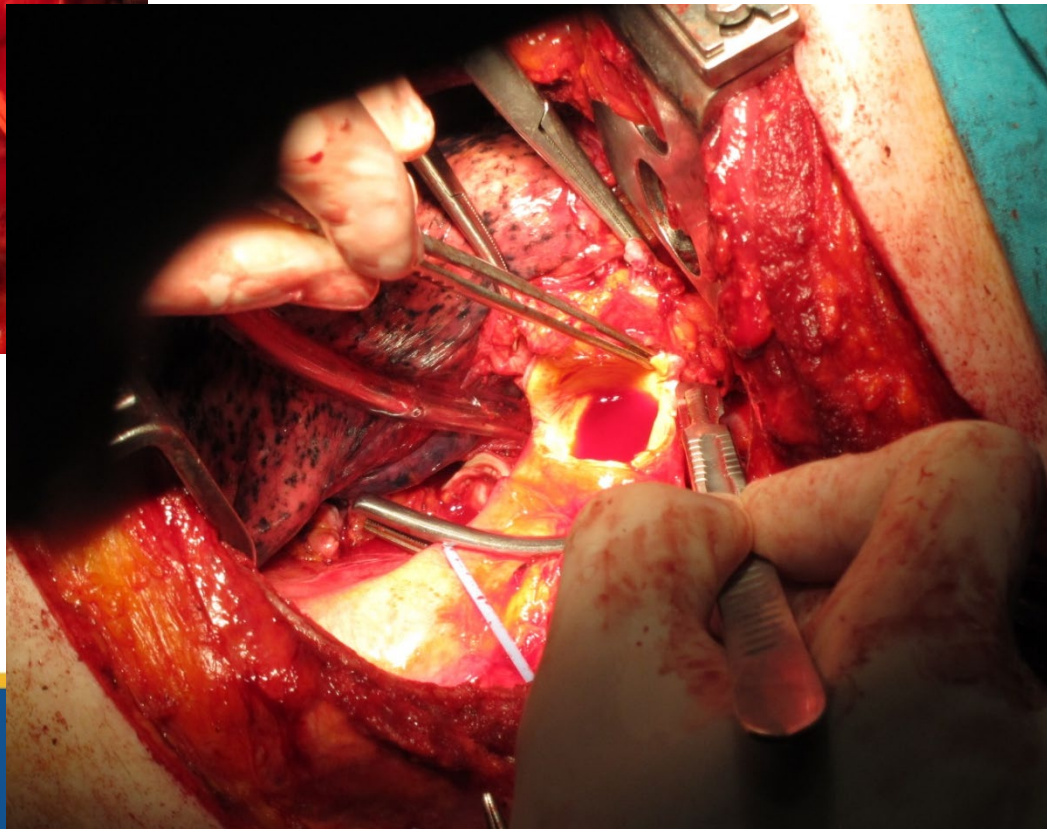
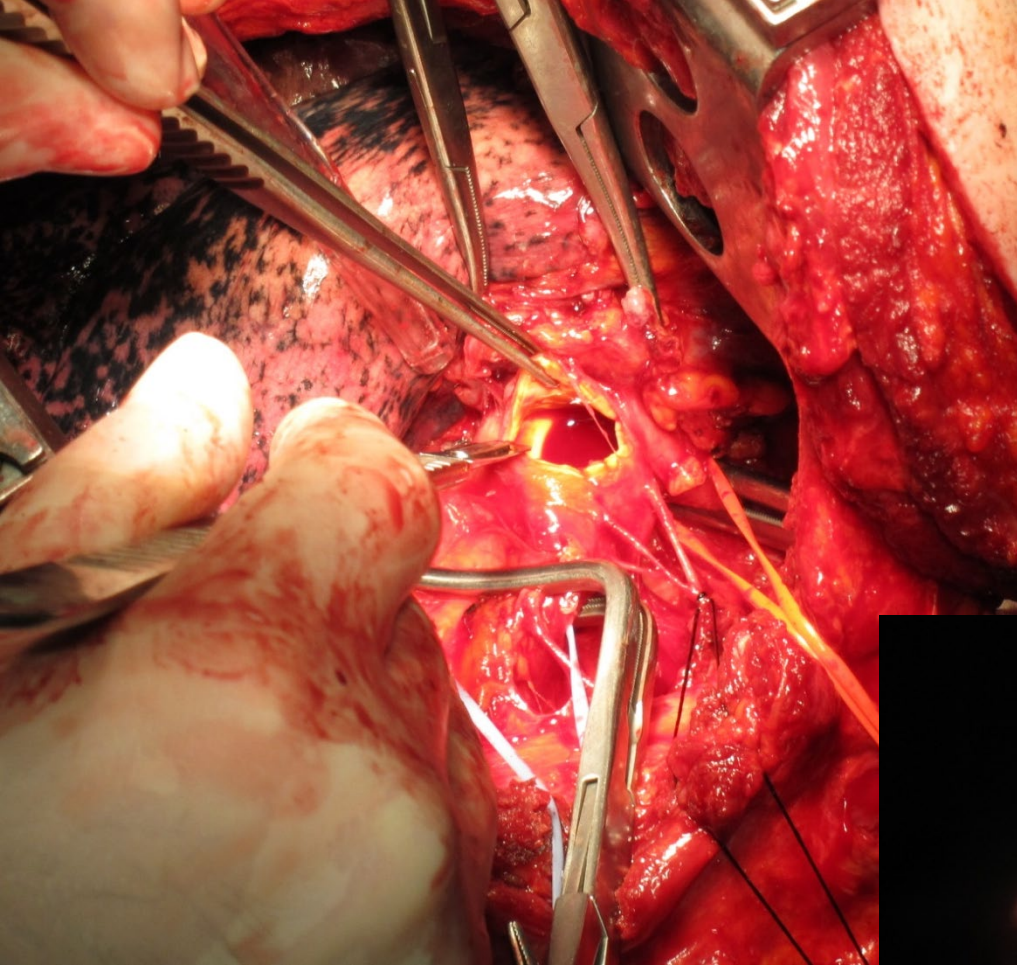


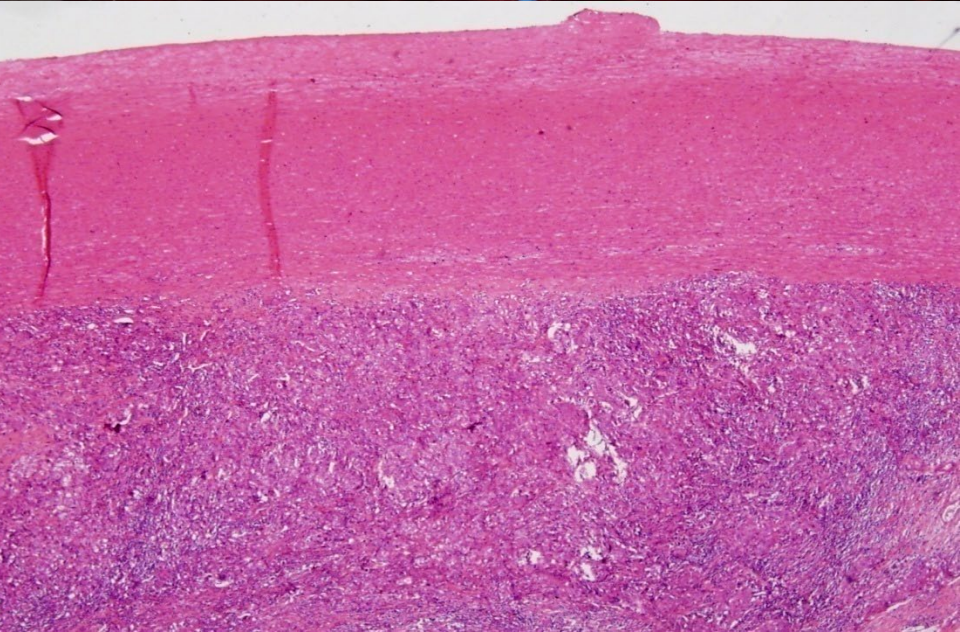
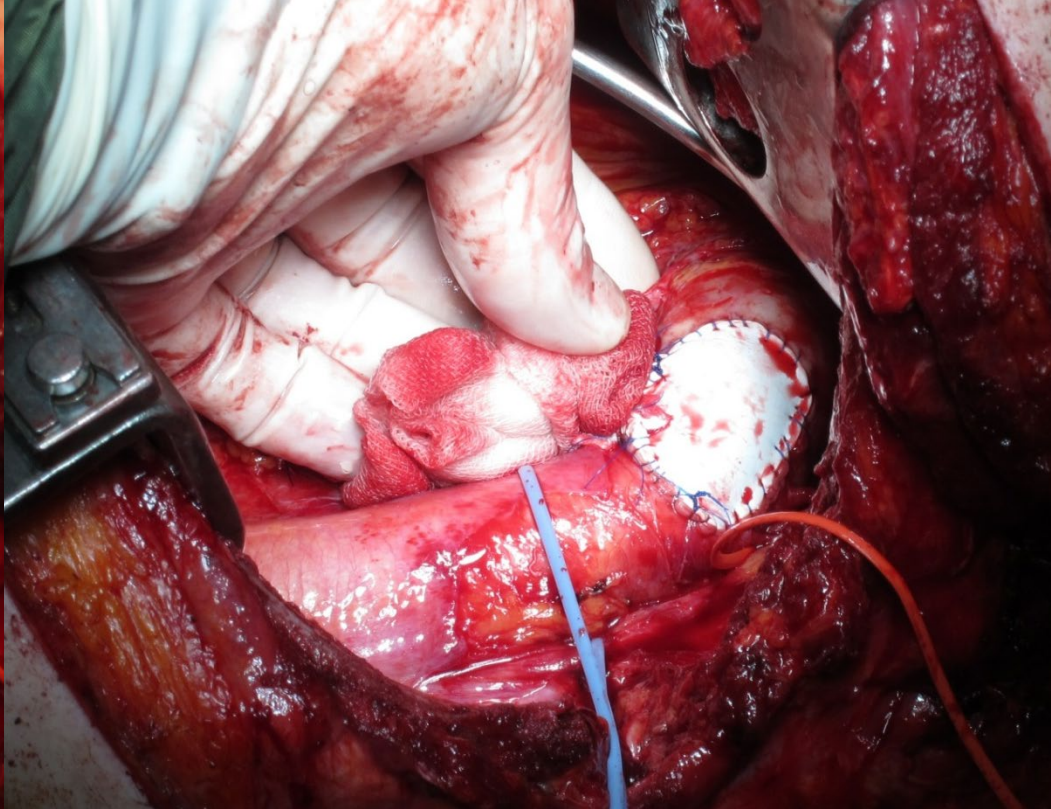
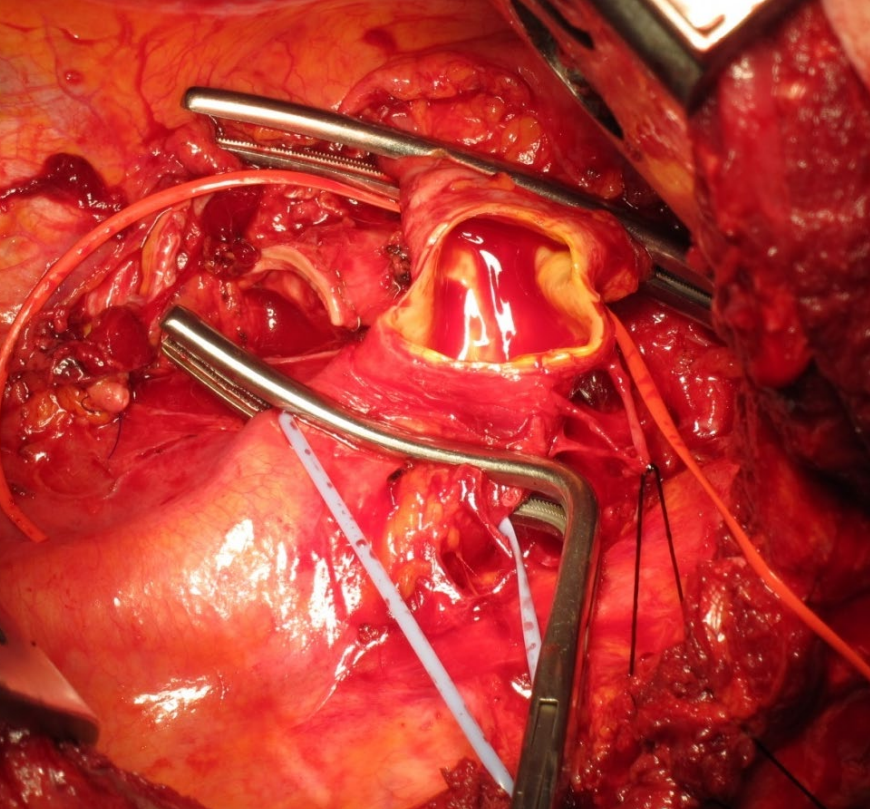
Neoadjuvant treatment Chemotx Only

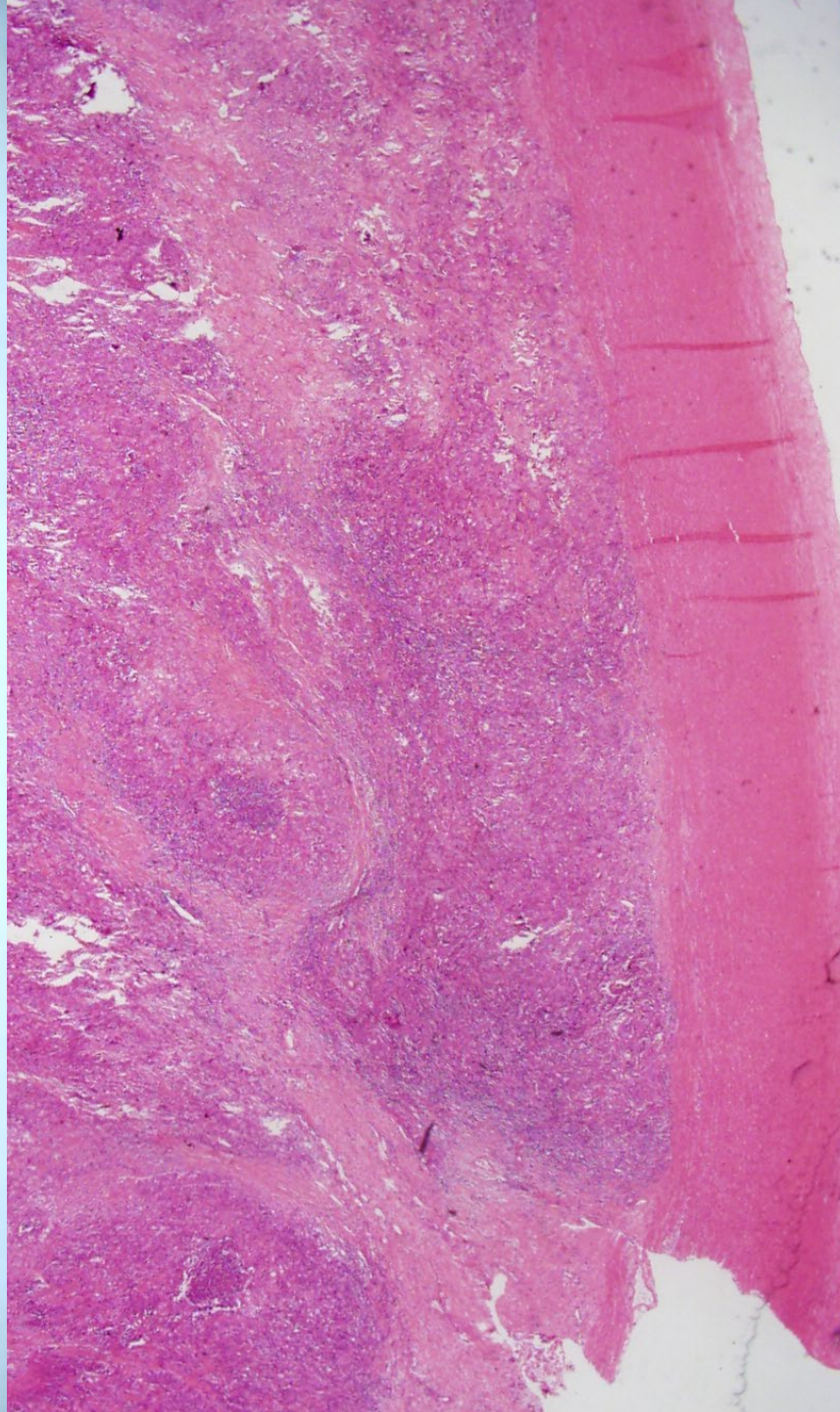
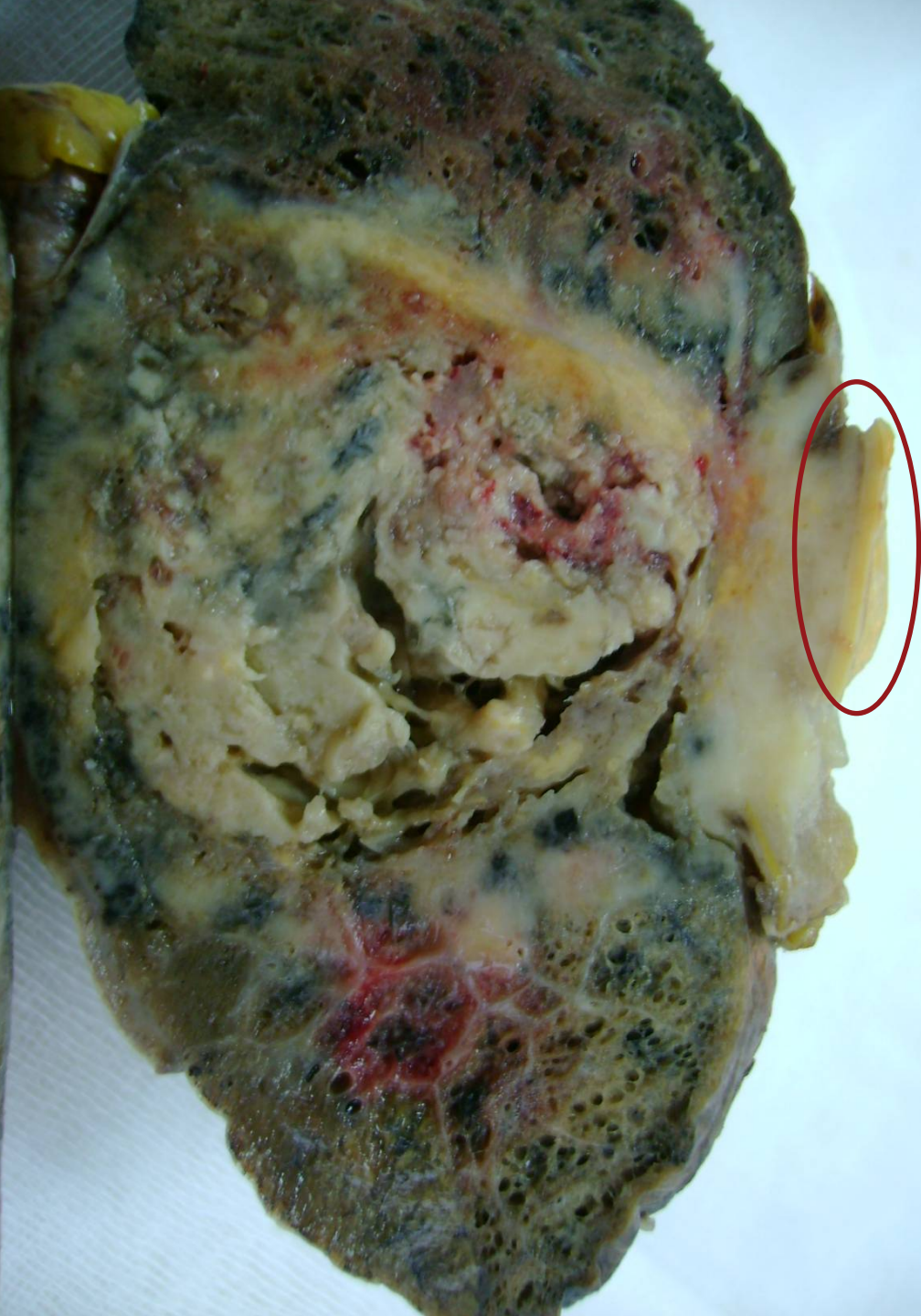




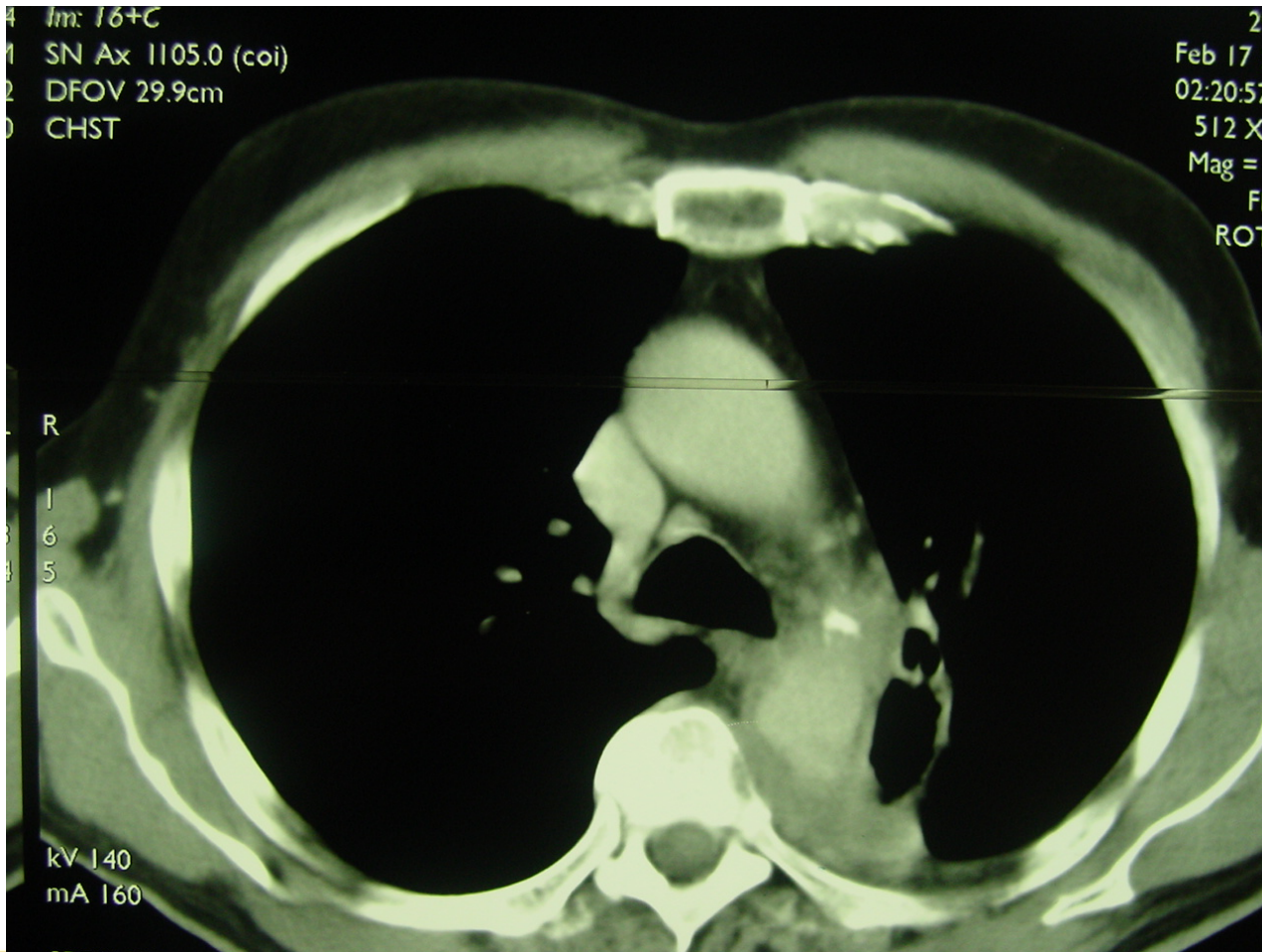




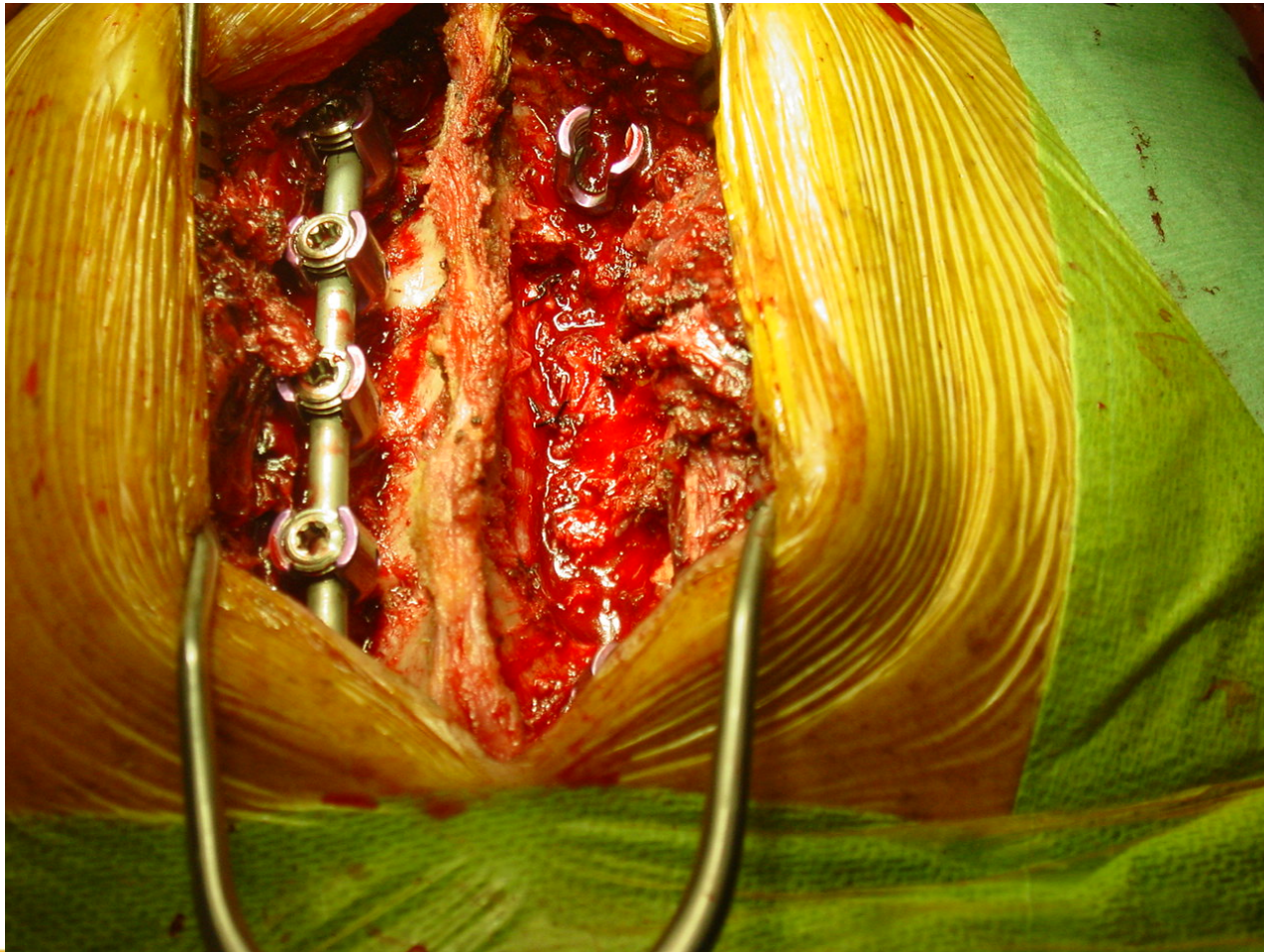




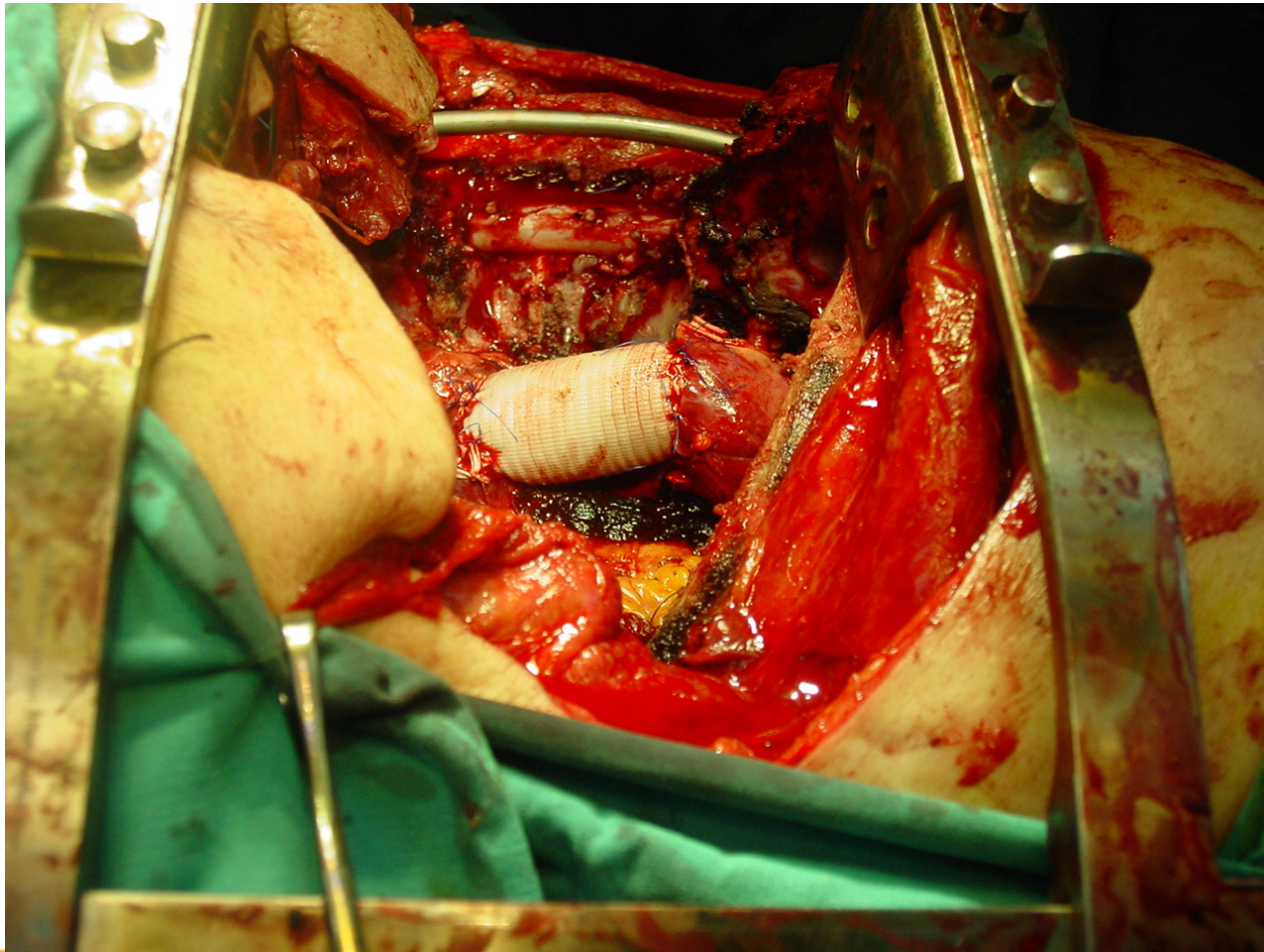
Aorta and Vertebra Invasion

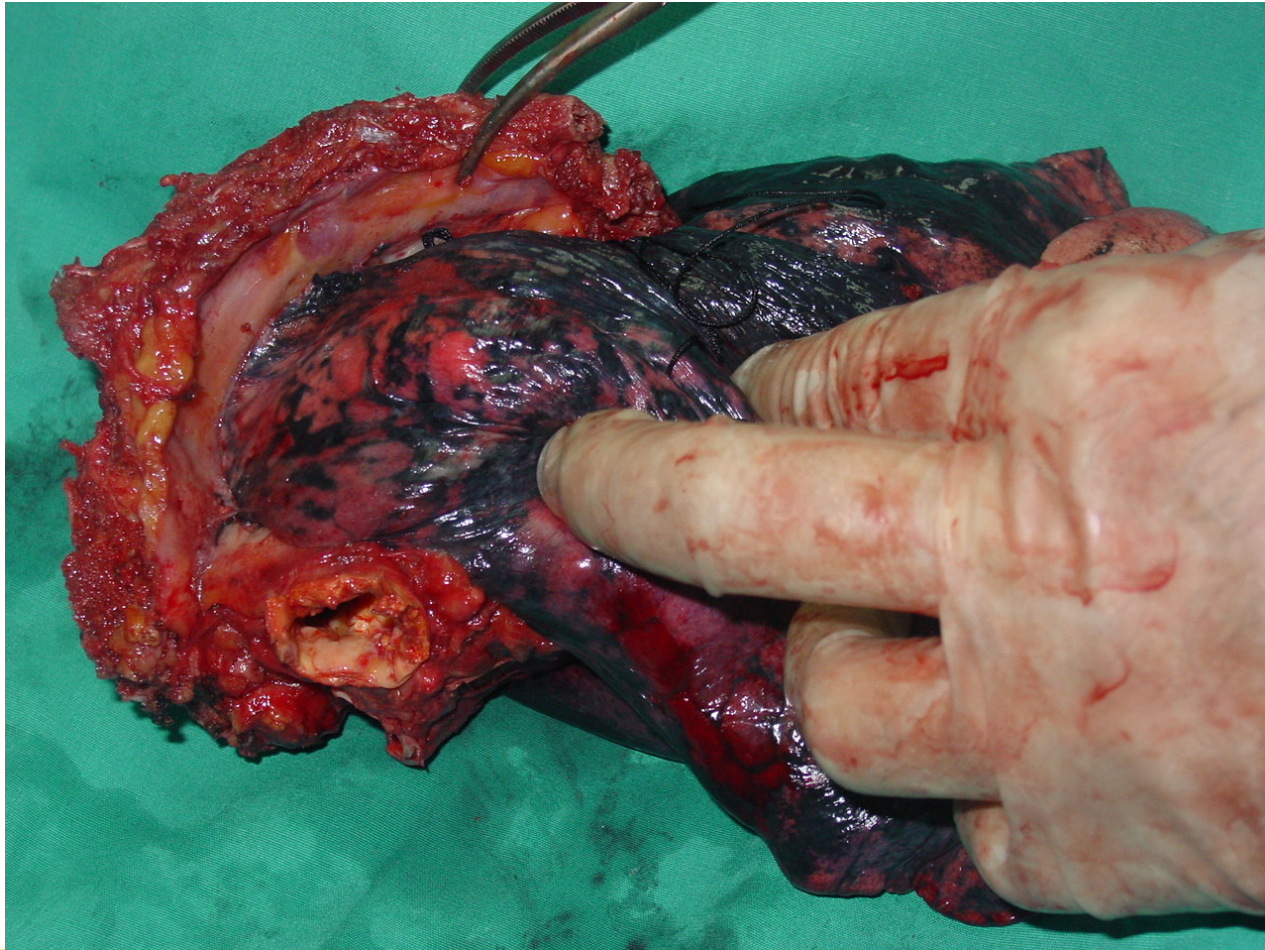


Vertebral Instrumentation First

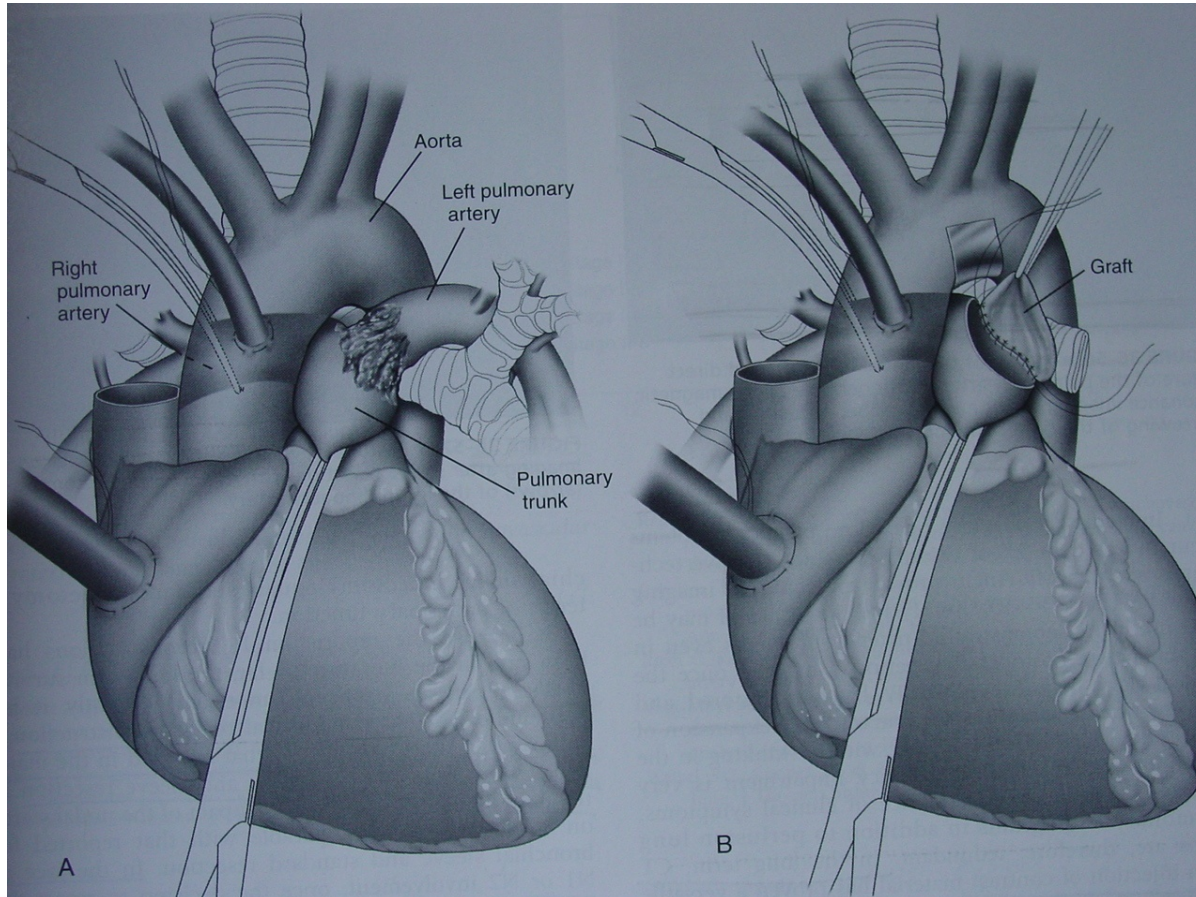


Resection of Vertebra and Aorta and Reconstructions





PA resections with CPBP



The decision making and techniques in lung cancer patients with aortic resection and reconstruction: surgery for lung cancer with aortic wall invasion

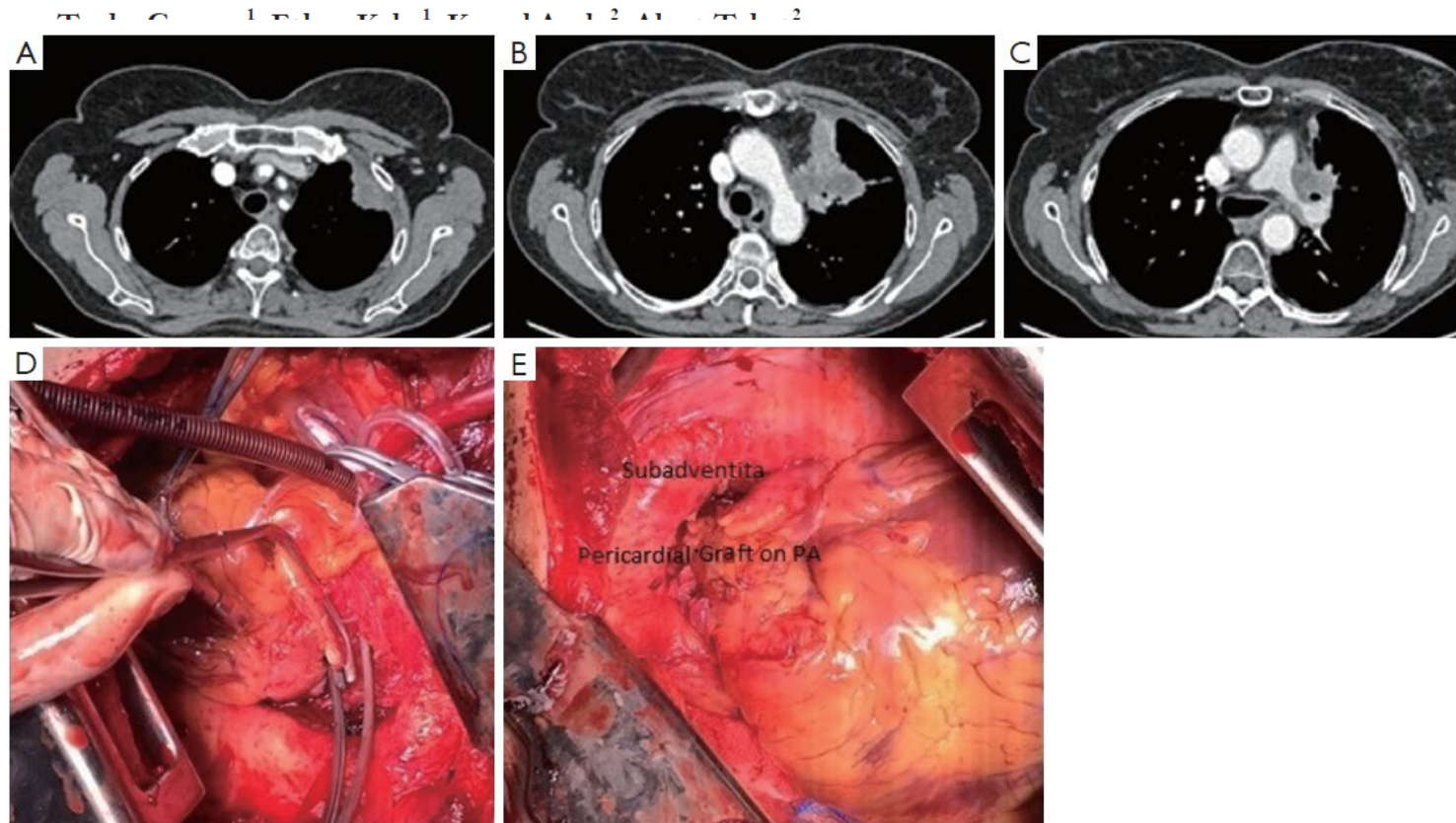
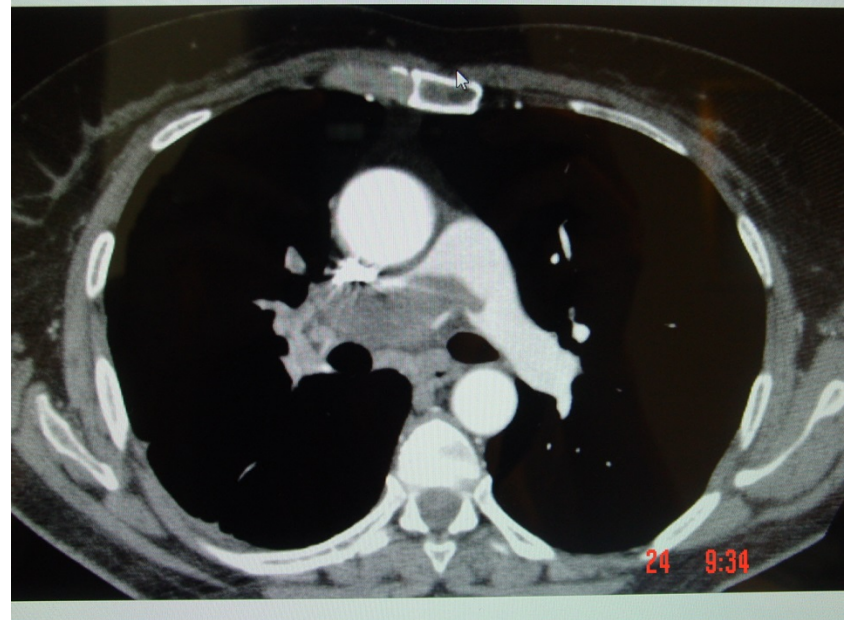
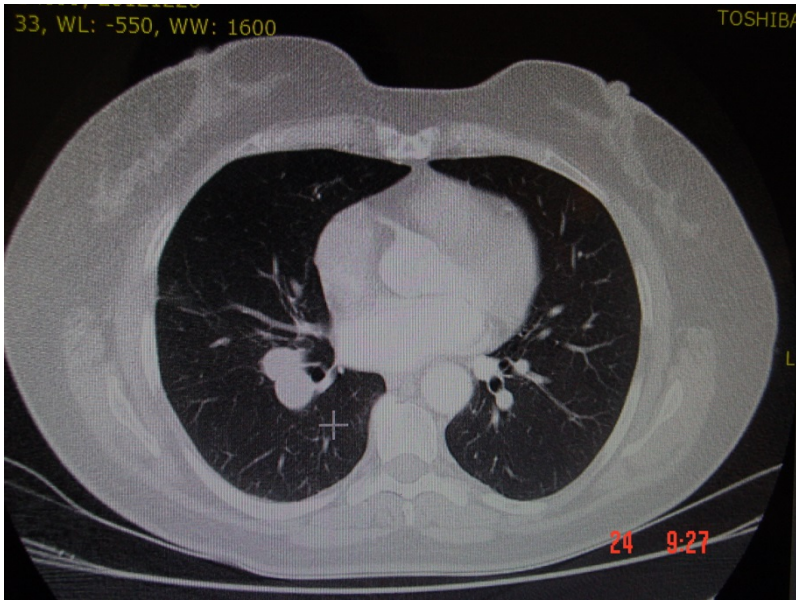
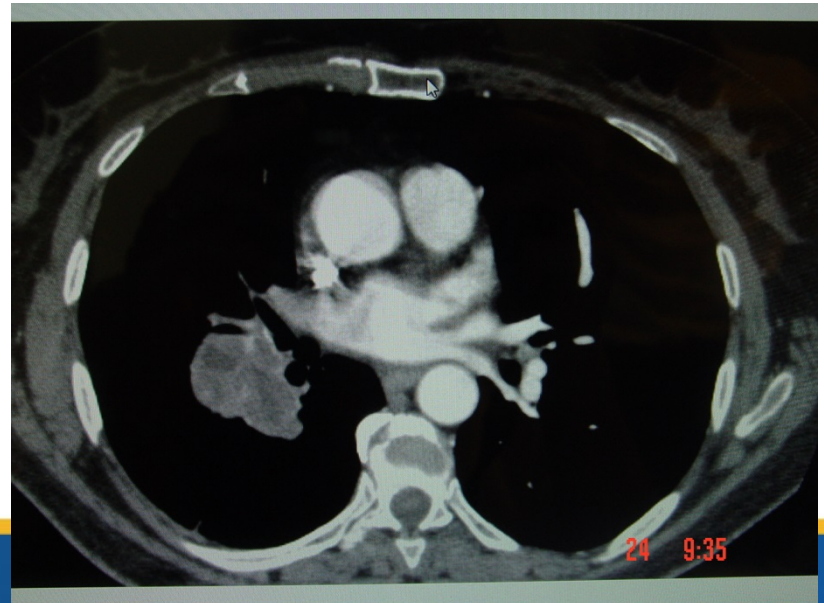
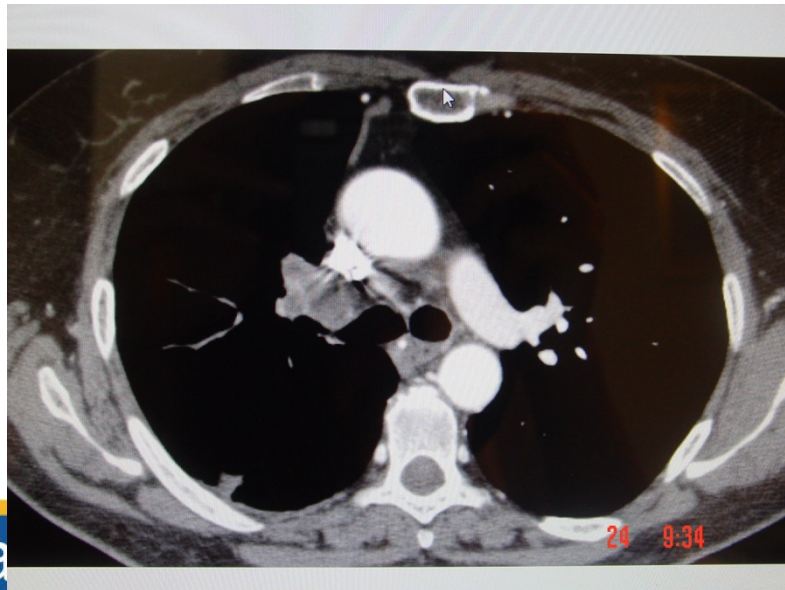
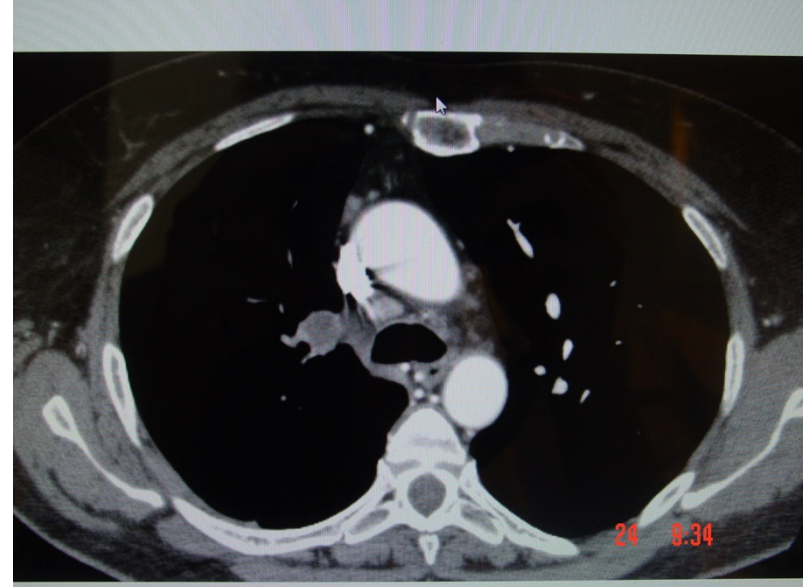
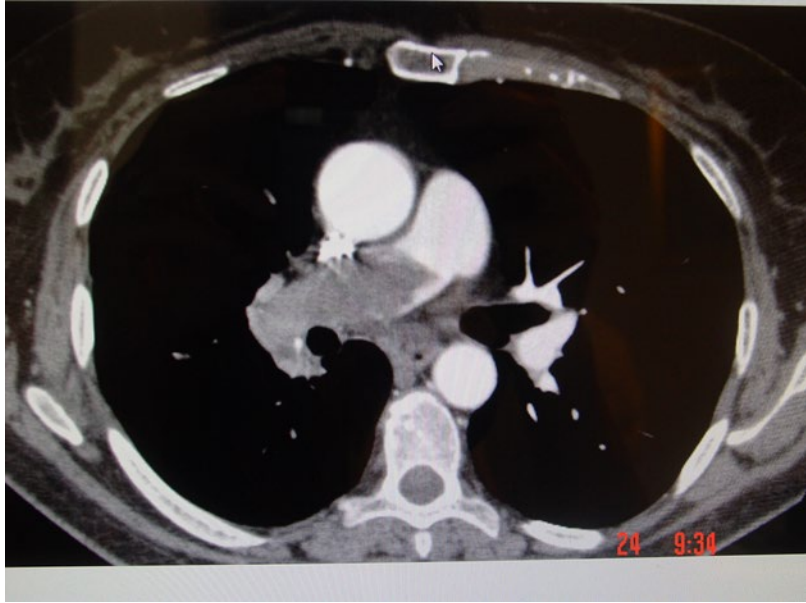


Figure 2 Large tumor with (A) chest wall, (B) subadventitial aorta, (C) pulmonary artery (PA) invasion. She underwent induction chemotherapy. Mediastinoscopy showed no N2 involvement. (D) Pericardial patch plasty to main PA under CPB. (E) Aortic involvement was resected subadventitially.

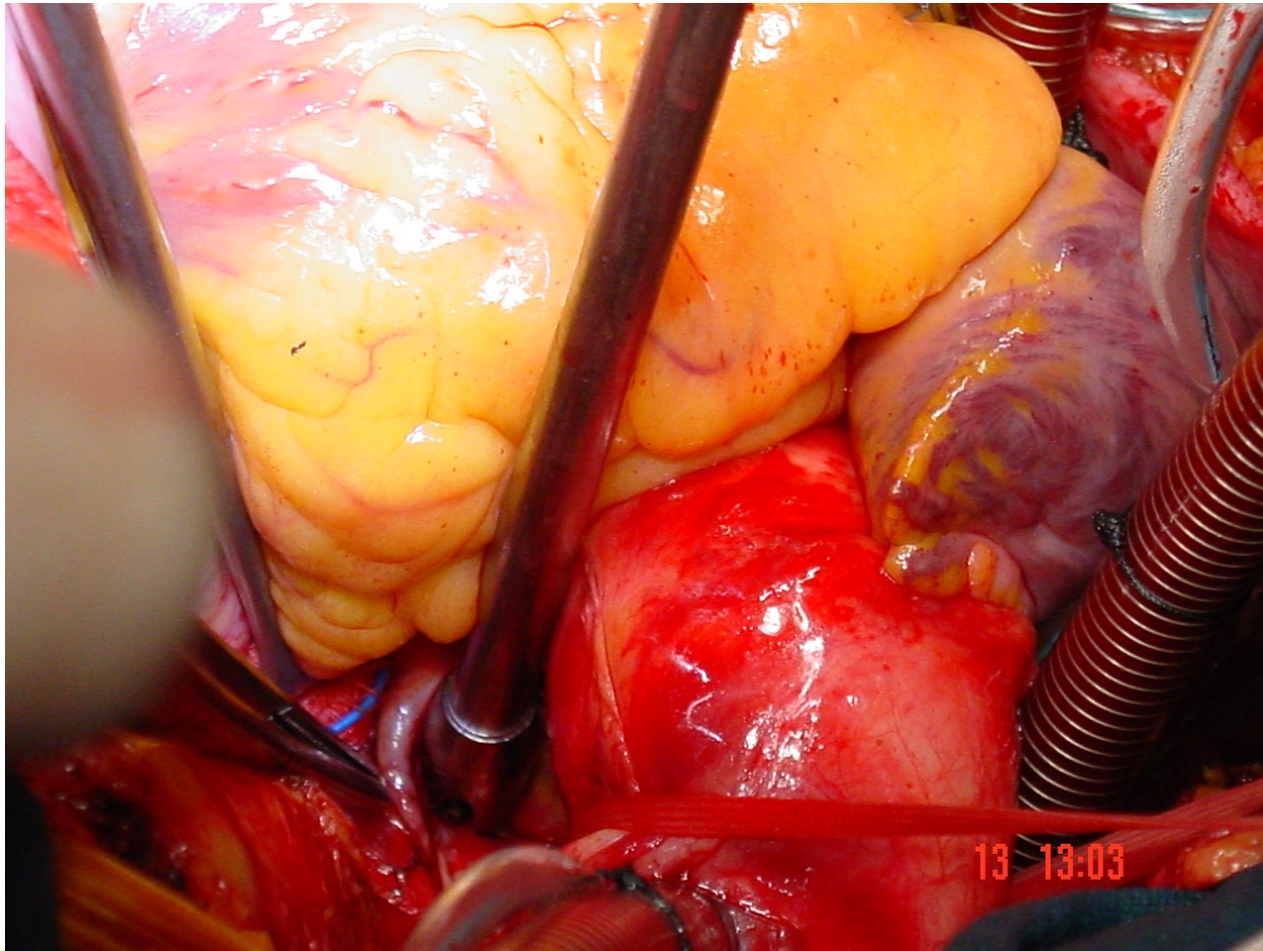


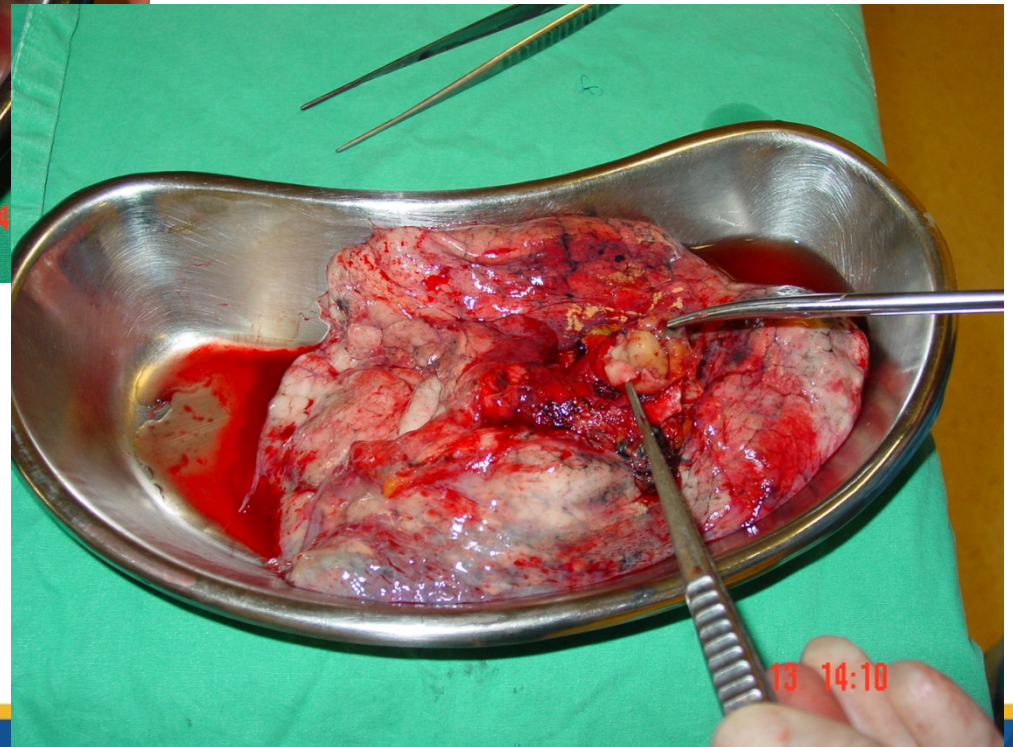
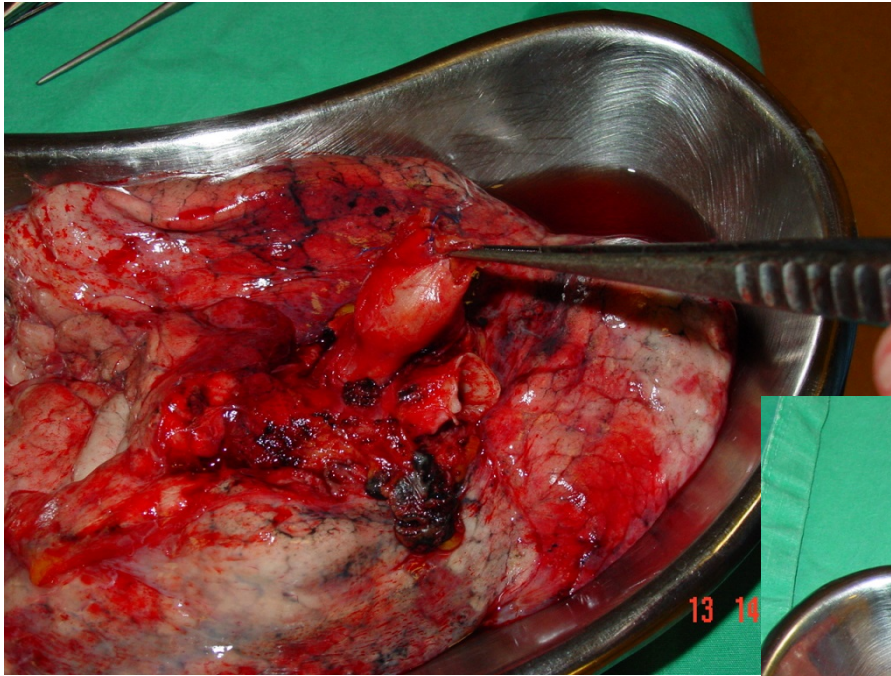
Pulmonary Artery sarcoma;
First diagnosis was PE





Main PA Clamping And primary repair







Extended pulmonary resections of advanced thoracic malignancies with support of cardiopulmonary bypass

Karsten Wiebe^{*}, Hassina Baraki, Paolo Macchiarini, Axel Haverich

Department of Thoracic and Cardiovascular Surgery, Hannover Medical School, 30623 Hannover, Germany

Received 3 August 2005; received in revised form 26 October 2005; accepted 31 October 2005; Available online 20 December 2005

Abstract

Objective: Complete resection of advanced pulmonary malignancies infiltrating the heart or the great vessels may require the application of cardiopulmonary bypass (CPB). Extracorporeal circulation, however, is known to cause lung injury and may be harmful especially in pneumonectomies. **Methods:** Over a period of 10 years extended pulmonary resections requiring cardiopulmonary bypass were analyzed in a retrospective study. **Results:** From August 1993 to August 2003, 13 patients underwent an extended pulmonary resection for curative indications, requiring support by CPB. Underlying diseases were sarcomas ($n = 8$), non-small cell lung carcinomas ($n = 3$), and others ($n = 2$). Pneumonectomies were performed in nine and lobectomies in four cases. In the majority of cases, several cardiac structures, predominantly the left atrium ($n = 9$), were affected. In four patients (31%), the indication for a CPB-supported procedure was not electively planned, but made intraoperatively. Complete en-bloc resection (R0) was achieved in 12 of 13 cases (92%). The 30-day mortality rate was 15% ($n = 2$). Major complications observed were acute lung injury ($n = 4$), right heart failure ($n = 1$), and multi-organ failure ($n = 1$). The cumulative survival at 1, 3, and 5 years in patients presenting with sarcomas was 62.5% compared to 33%, 0%, and 0%, respectively, in patients with non-small cell carcinoma ($n = 3$). **Conclusions:** Our results encourage the application of CPB in extended pulmonary resections to achieve complete resections. In carefully selected patients, especially those with sarcomas, the radical surgical procedure associated with increased pulmonary complications allows for significantly prolonged survival and quality of life.

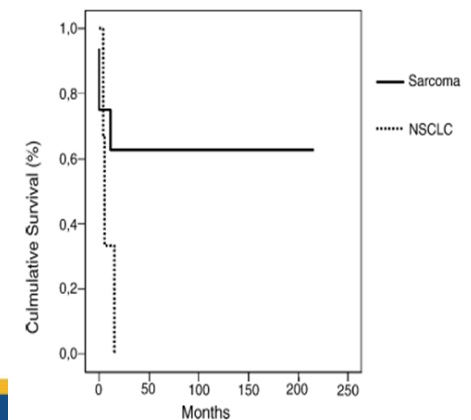
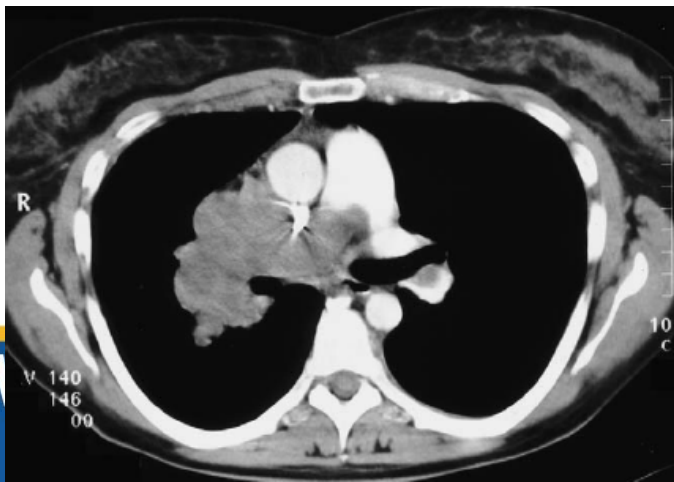
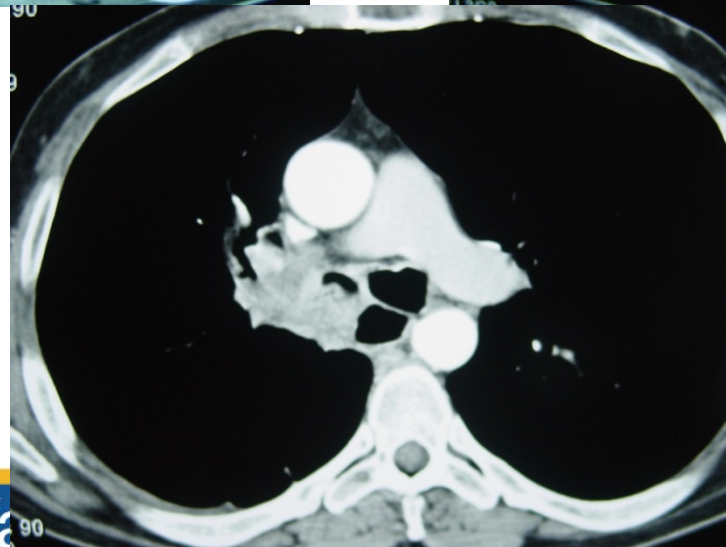
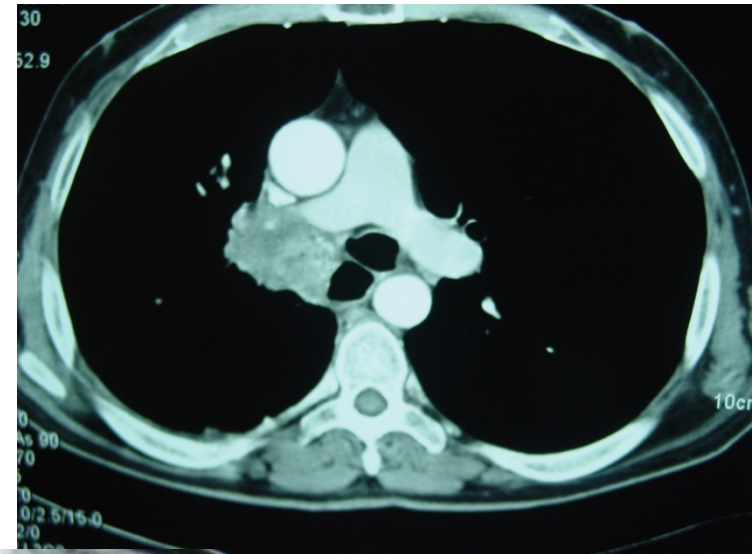
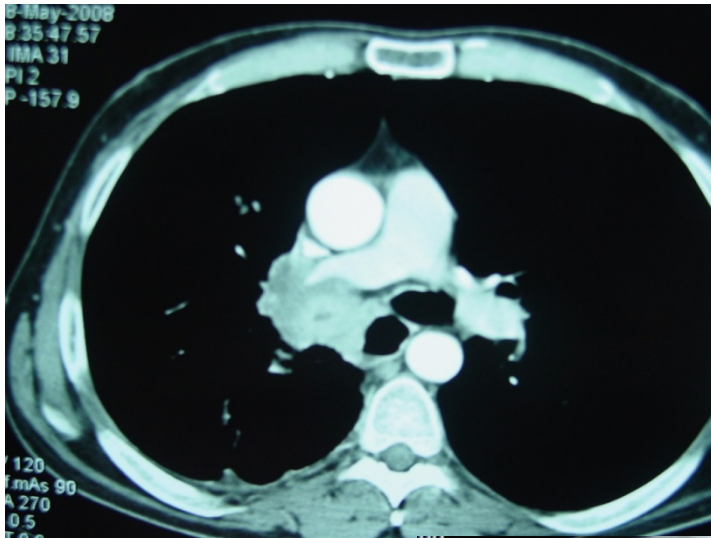
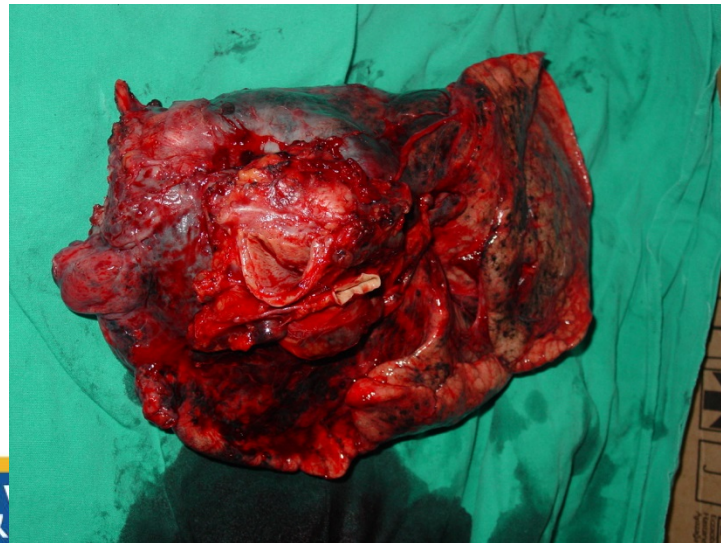
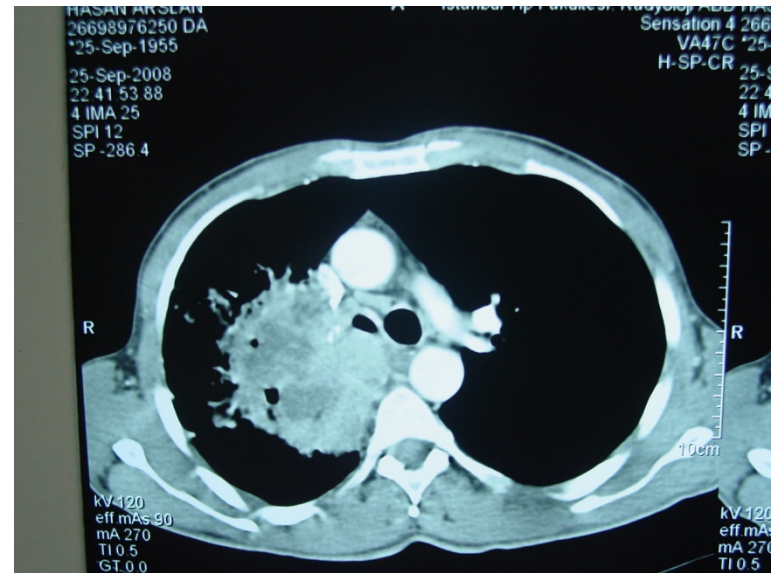
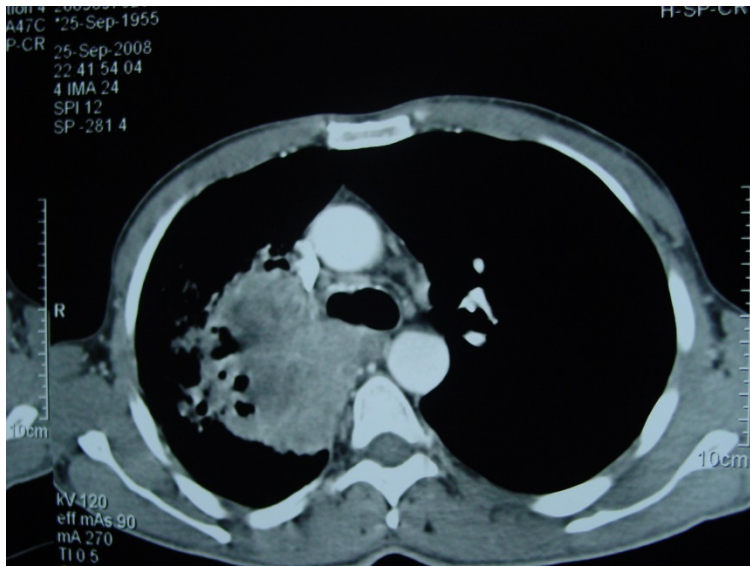
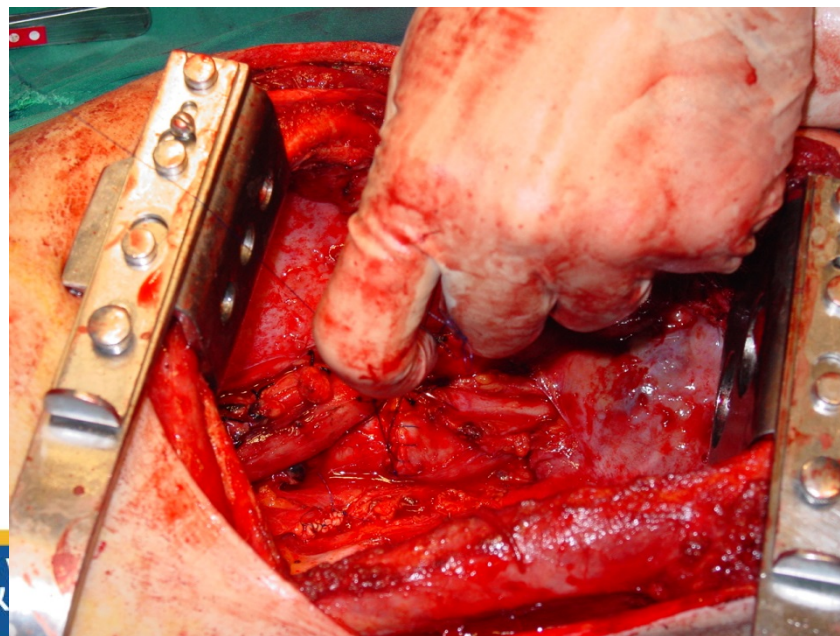
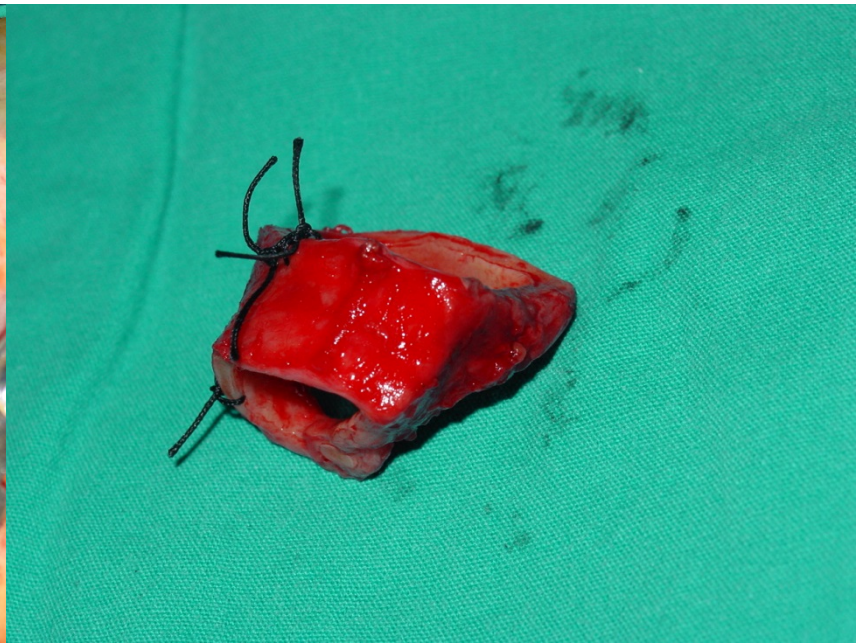
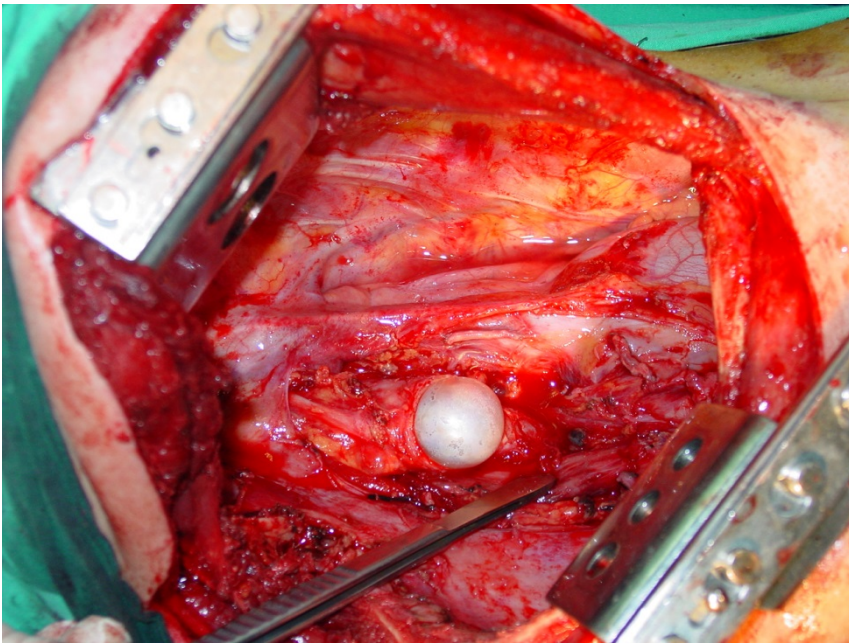


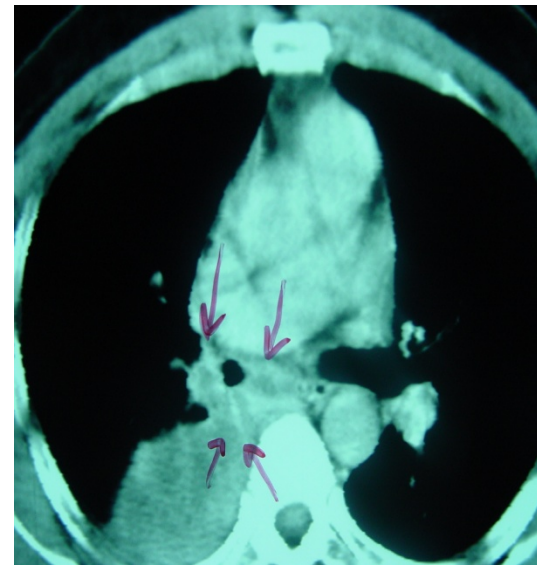
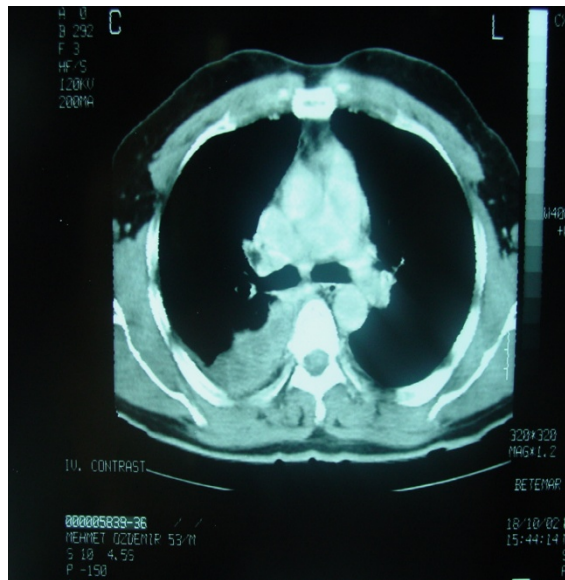
Fig. 2. Survival after extended pulmonary resections with CPB: long-term outcome of patients presenting with sarcoma ($n = 8$) and non-small cell carcinoma ($n = 3$), including two perioperative deaths. Kaplan-Meier analysis of cumulative survival.

Carina resections

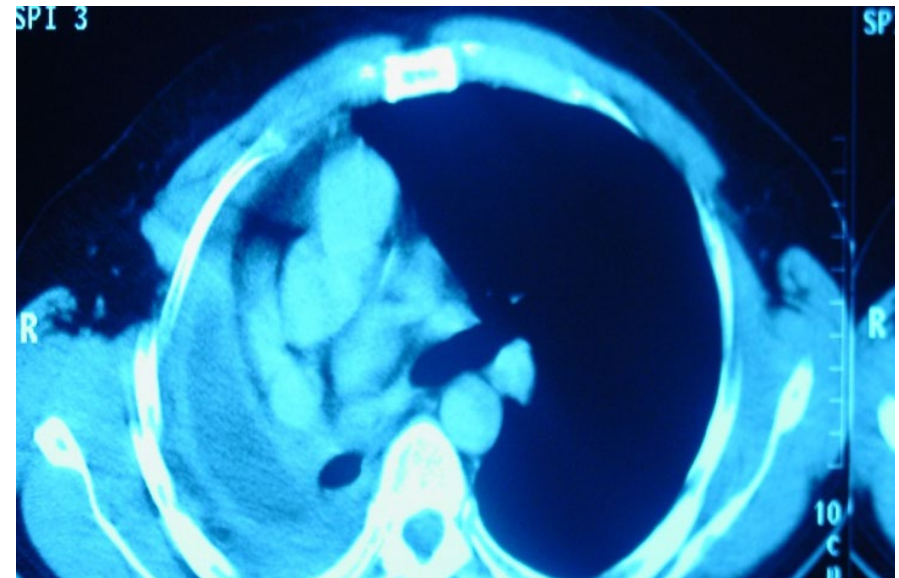
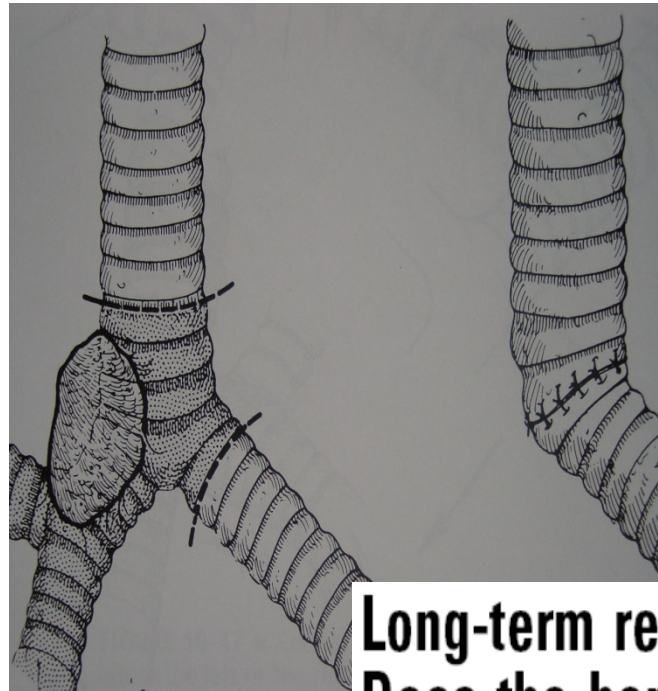








tion [7]. Induction therapy seems to improve survival if the mediastinal nodes can be sterilized before the lung resection. However, induction therapy could potentially be associated with increased operative morbidity and mortality in patients requiring right carinal pneumonec- tomy. Recently, it has been reported that operative mor- tality increased from 6.7% to 13% after induction therapy



Long-term results after carinal resection for carcinoma: Does the benefit warrant the risk?

Resection for Tumors With Carinal Involvement: Technical Aspects, Results, and Prognostic Factors

Jean-François Regnard, MD, Cédric Perrotin, MD, Riccardo Giovannetti, MD, Olivier Schussler, MD, Antonio Petino, MD, Lorenzo Spaggiari, MD, Marco Alifano, MD, and Pierre Magdeleinat, MD

Thoracic Surgery Unit, Hôtel-Dieu Hospital, Paris, France

Background. Resection of tumors with carinal involvement remains a challenge because of specific problems of operative technique and airway management. We reviewed our experience with carinal resection and studied factors influencing postoperative course and long-term survival.

Methods. Between 1983 and 2002, 65 patients underwent a carinal resection for non-small-cell lung cancers involving the carina (54 squamous cell carcinomas and 11 adenocarcinomas).

Results. Fifty-eight right sleeve pneumonectomies and 2 left sleeve pneumonectomies were performed. In addition, five tracheocarinal resections with double bronchial reimplantation (no lung resection) were also performed. The intraoperative airway management consisted of high-frequency jet ventilation in 83% of patients and

intermittent conventional ventilation through the operative field in the remaining 17% of patients. Operative mortality was 7.7%. Resection was complete in 61 patients. The overall 5-year and 10-year survival rates were 26.5% and 10.6%, respectively. Patients with N0 or N1 disease had a 5-year survival of 38% compared with 5.3% for those with N2 disease ($p < 0.01$). At multivariate analysis only nodal status (N0, N1 versus N2; $p = 0.0046$) had a significant impact on long-term survival.

Conclusions. Carinal resection provides acceptable results in terms of operative mortality and long-term survival rates. Patients should be carefully selected and probably enrolled in a multimodality treatment program in case of anticipated mediastinal lymph node involvement.

(Ann Thorac Surg 2005;80:1841-6)

© 2005 by The Society of Thoracic Surgeons

Long-term results after carinal resection for carcinoma: Does the benefit warrant the risk?

Marc de Perrot, MD, Elie Fadel, MD, Olaf Mercier, MD, Sacha Mussot, MD, Alain Chapelier, MD,
and Philippe Dartevielle, MD

Objective: We sought to determine whether the benefit warrants the risk in patients undergoing carinal resection for carcinoma.

Methods: This was a retrospective single-center study.

Results: Between June 1981 and August 2004, 119 patients underwent carinal resection for carcinoma in our institution. Carinal pneumonectomy was performed in 103 cases (96 right and 7 left pneumonectomies), carinal resection plus right upper lobectomy in 3, carinal resection after left pneumonectomy in 2, and carinal resection without pulmonary resection in 11. Superior vena caval resection was combined with carinal pneumonectomy in 25 patients with bronchogenic carcinoma (13 patients had complete superior vena caval resection with graft interposition). Nine (7.6%) patients died in the hospital or within 30 days of the operation. Follow-up was complete for 117 (98%) patients up to August 2004 or to the date of death. The 5- and 10-year survivals were 44% and 25%, respectively, for patients with bronchogenic carcinoma ($n = 100$). However, survival was significantly better in patients with N0 or N1 disease ($n = 73$) than in those with N2 or N3 disease ($n = 27$; 53% vs 15% at 5 years, respectively). The 5- and 10-year survivals in the remaining 19 patients reached 66% and 48%, respectively, and were best in patients with neuroendocrine carcinoma (100% survival at 10 years) and adenoid cystic carcinoma (69% survival at 10 years).

Conclusions: Surgical intervention for carcinoma involving the carina is feasible, with acceptable mortality and good long-term survival in selected patients. The presence of positive N2 disease should, however, be considered a potential contraindication to carinal resection in patients with bronchogenic carcinoma because of the poor long-term survival.

Refinement in techniques of tracheal surgery and bronchial sleeve lobectomy has made carinal resection and reconstruction possible. However, the potential for complications remains high, and few centers only have accumulated sufficient expertise to safely perform the operation. Although the risks of carinal resection and reconstruction are certainly justifiable in patients with benign and low-grade malignancies, the usefulness of carinal surgery for carcinoma involving the carina is still questionable. Few series have reported long-term survival after carinal resection for bronchogenic carcinoma or adenoid cystic carcinoma involving the carina.¹⁻³ The objective of this article is to review our experience in carinal resection for carcinoma and to determine whether the benefit warrants the risk.

Materials and Methods

Patient Data

All patients who underwent carinal resection for carcinoma in our institution between June 1981 and August 2004 were reviewed. Patients undergoing carinal resection for benign

Long-term results after carinal resection for carcinoma: Does the benefit warrant the risk?

Marc de Perrot, MD, Elie Fadel, MD, Olaf Mercier, MD, Sacha Mussot, MD, Alain Chapelier, MD,
and Philippe Dartevielle, MD

Objective: We sought to determine whether the benefit warrants the risk in patients undergoing carinal resection for carcinoma.

Methods: This was a retrospective single-center study.

Results: Between June 1981 and August 2004, 119 patients underwent carinal resection for carcinoma in our institution. Carinal pneumonectomy was performed in 103 cases (96 right and 7 left pneumonectomies), carinal resection plus right upper lobectomy in 3, carinal resection after left pneumonectomy in 2, and carinal resection without pulmonary resection in 11. Superior vena caval resection was combined with carinal pneumonectomy in 25 patients with bronchogenic carcinoma (13 patients had complete superior vena caval resection with graft interposition). Nine (7.6%) patients died in the hospital or within 30 days of the operation. Follow-up was complete for 117 (98%) patients up to August 2004 or to the date of death. The 5- and 10-year survivals were 44% and 25%, respectively, for patients with bronchogenic carcinoma ($n = 100$). However, survival was significantly better in patients with N0 or N1 disease ($n = 73$) than in those with N2 or N3 disease ($n = 27$; 53% vs 15% at 5 years, respectively). The 5- and 10-year survivals in the remaining 19 patients reached 66% and 48%, respectively, and were best in patients with neuroendocrine carcinoma (100% survival at 10 years) and adenoid cystic carcinoma (69% survival at 10 years).

Conclusions: Surgical intervention for carcinoma involving the carina is feasible, with acceptable mortality and good long-term survival in selected patients. The presence of positive N2 disease should, however, be considered a potential contraindication to carinal resection in patients with bronchogenic carcinoma because of the poor long-term survival.

From the Department of Thoracic and Vascular Surgery and Heart-Lung Transplantation, Centre Chirurgie Thorax-Landweide, Le Plessis-Robinson, France.

Read at the Eighty-fifth Annual Meeting of The American Association for Thoracic Surgery, San Francisco, Calif, April 10-13, 2005.

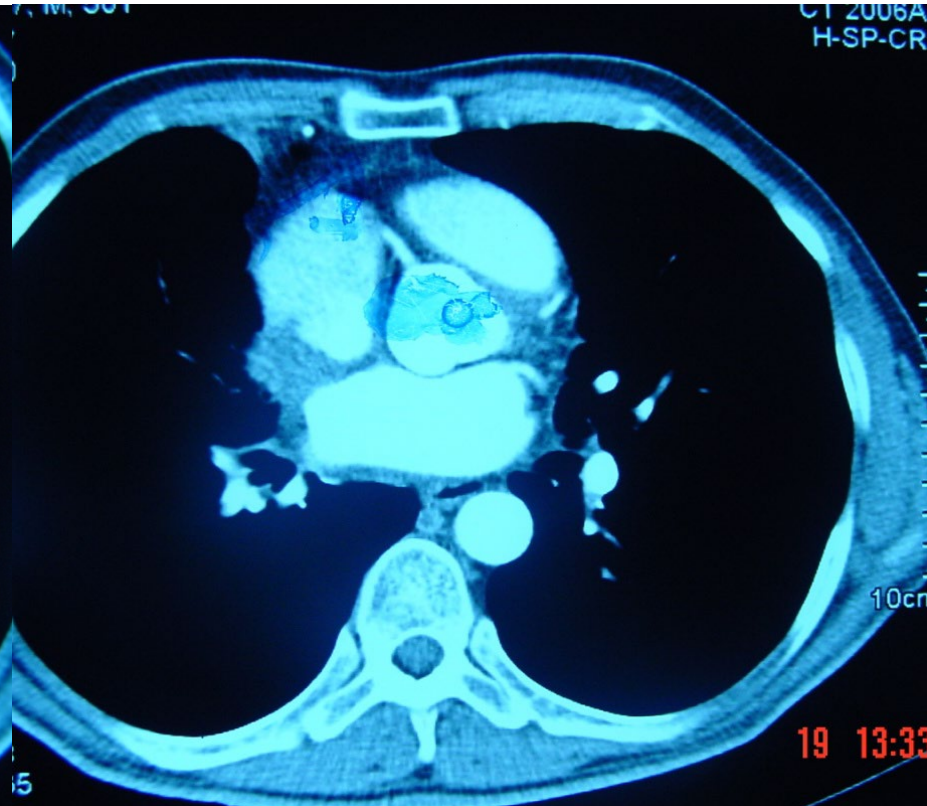
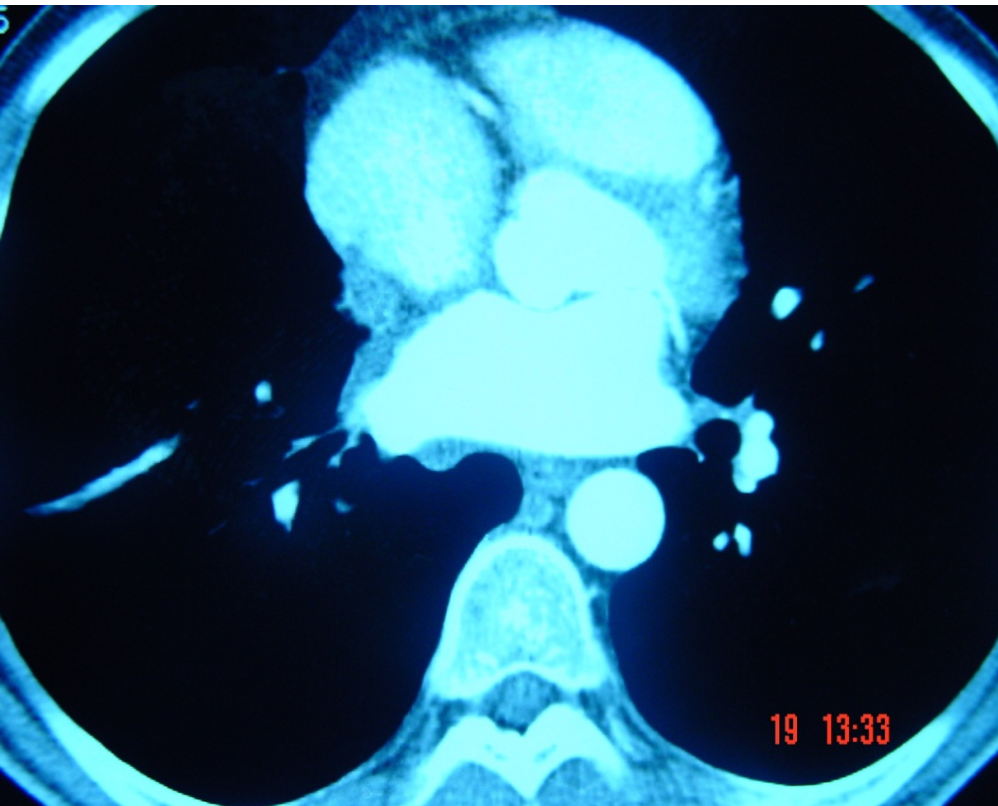
Received for publication April 14, 2005; revision received July 10, 2005; accepted for publication July 19, 2005.

Address for reprints: Philippe Dartevielle, MD, Department of Thoracic and Vascular Surgery and Heart-Lung Transplantation, Centre Chirurgie Thorax-Landweide, 133 Avenue de la Resistance, 92350 Le Plessis-Robinson, France.

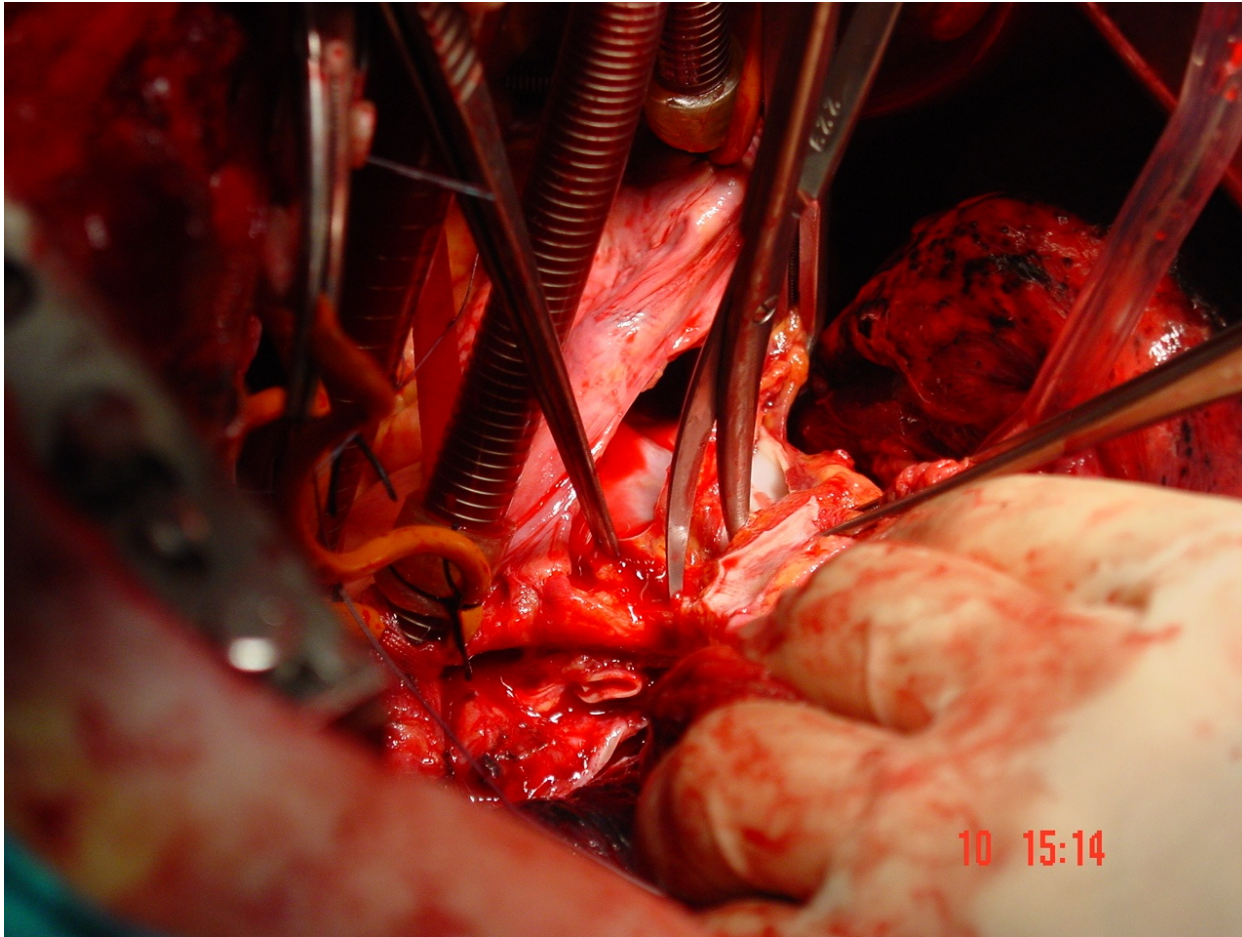
J Thorac Cardiovasc Surg 2006;131:81-9
0022-5223/06

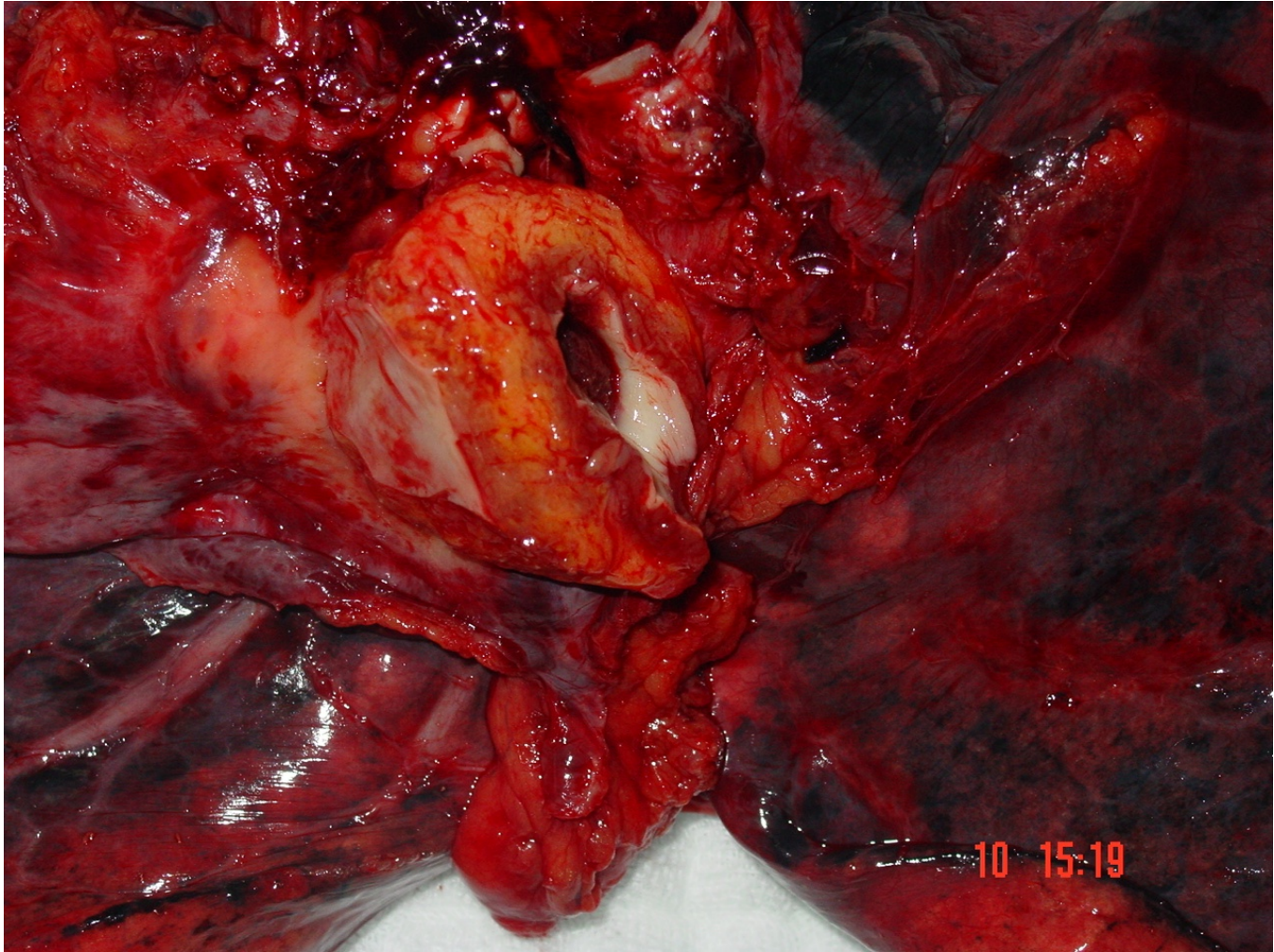
Copyright © 2006 by The American Association for Thoracic Surgery
doi:10.1016/j.jtcvs.2005.07.062

Resections of Atrium requiring CPBP

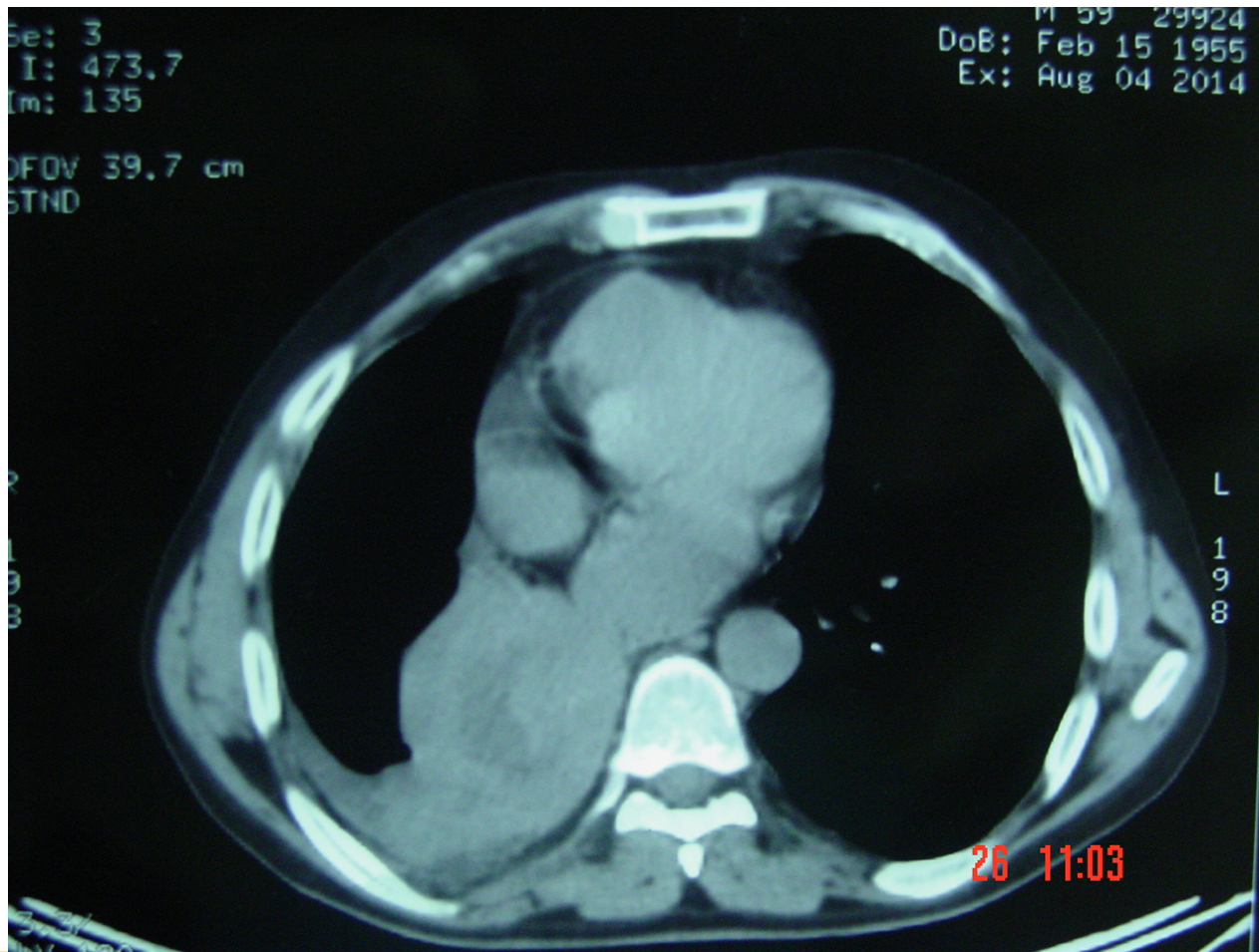


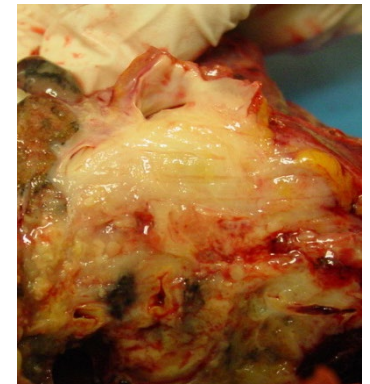
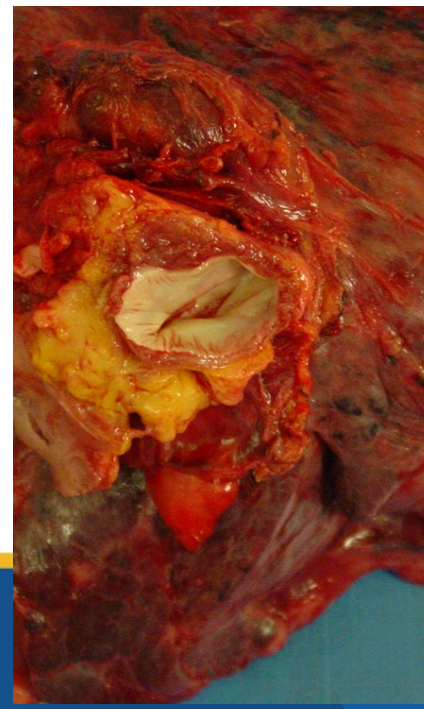
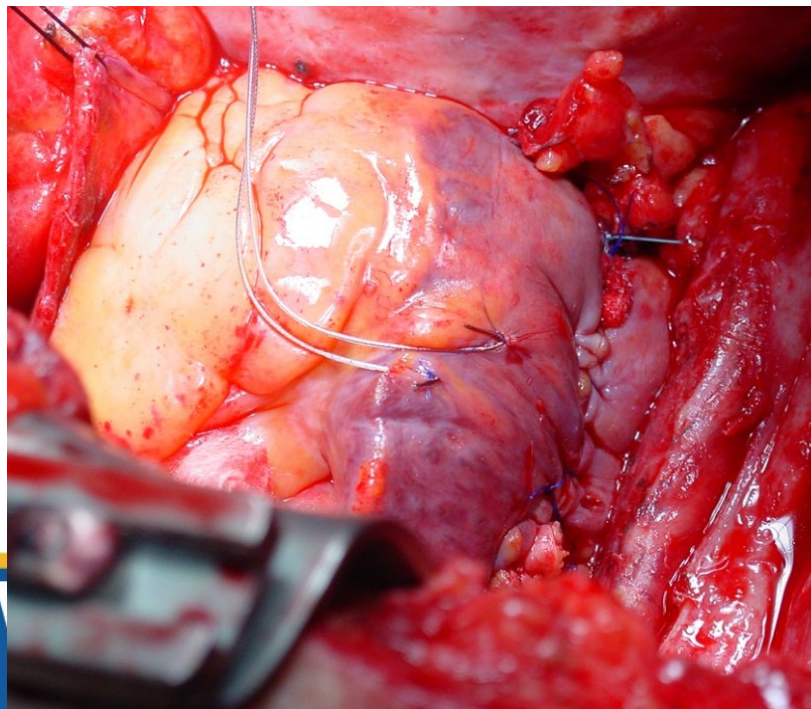
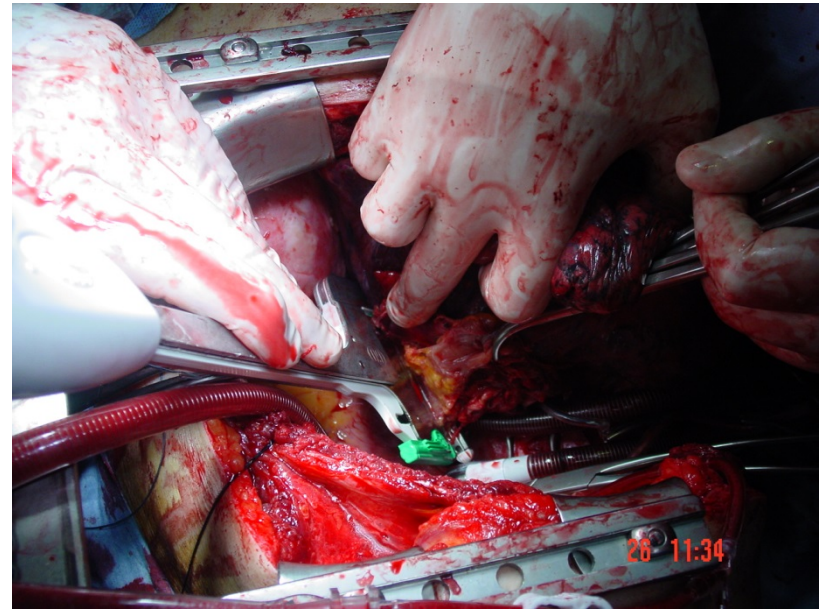
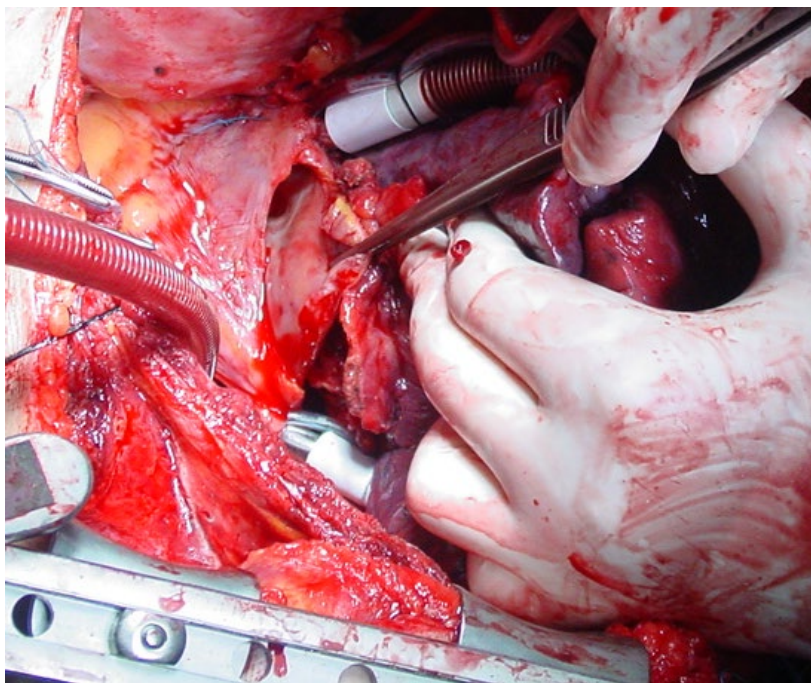
Biatrial resection





Unplanned CPBP





Results of Primary Surgery With T4 Non-Small Cell Lung Cancer During a 25-Year Period in a Single Center: The Benefit is Worth the Risk

Bedrettin Yıldızeli, MD, Philippe G. Dartevelle, MD, Elie Fadel, MD, Sacha Mussot, MD, and Alain Chapelier, MD

Department of Thoracic and Vascular Surgery and Heart-Lung Transplantation, Hôpital Marie-Lannelongue, Paris-Sud University, Le Plessis Robinson, France

Background. The purpose of this study was to assess operative mortality, morbidity, and long-term results of patients with surgically resected T4 non-small cell lung carcinoma.

Methods. A retrospective review of 271 patients with T4 non-small cell lung carcinoma between 1981 and 2006 was undertaken. They were divided into four subgroups: 126 patients with superior sulcus tumors, 92 with carinal involvement, 39 with superior vena cava replacement, and 14 with the tumor invading other mediastinal structures. There were 221 men and 50 women with a mean age of 56.3 years. Resection was complete in 249 (92%) patients. The pathologic N status was N0/N1 in 208 and N2/N3/M1 in 63 patients.

Results. Operative mortality and morbidity rates were 4% and 35%, respectively. Overall 5-year survival rate was 38.4%. It was 36.6% for superior sulcus tumor, 42.5% for carinal involvement, 29.4% for superior vena cava

replacement, and 61.2% for mediastinal group. By multivariate analysis, only three factors influenced survival: nodal status (N0/N1 versus N2/3/M1; 43% versus 17.7% at 5 years, respectively; $p = 0.01$), complete resection (R0 versus R1; 40.4% versus 15.9%, respectively; $p = 0.006$), and invasion of the subclavian artery (with versus without invasion; 24.9% versus 41.7%, respectively, $p = 0.02$).

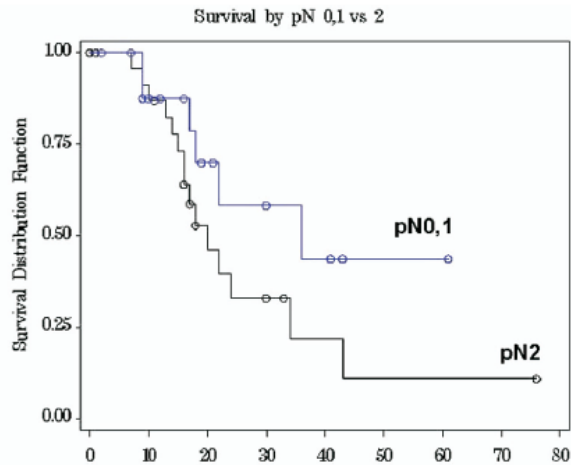
Conclusions. In highly qualified centers, radical surgery of T4 N0/N1 non-small cell lung carcinoma can be performed with a 4% mortality rate and may yield a 43% 5-year survival rate. These results seem to indicate primary surgery as the treatment of choice for T4 non-small cell lung carcinoma, whenever a complete resection is thought to be technically feasible and the patient's condition is compatible with the extent of the planned surgery.

(Ann Thorac Surg 2008;86:1065-75)

© 2008 by The Society of Thoracic Surgeons

Extended pneumonectomy for non-small cell lung cancer: Morbidity, mortality, and long-term results

Alessandro Borri, MD,^a Francesco Leo, MD,^a Giulia Veronesi, MD,^a Piergiorgio Solli, MD,^a Domenico Galetta, MD,^a Roberto Gasparri, MD,^a Francesco Petrella, MD,^a Paolo Scanagatta, MD,^a Davide Radice, PhD,^b and Lorenzo Spaggiari, MD, PhD^{a,c}



Patients at risk	0	10	20	30	40	50	60
pN0,1	21	12	10	4	2	1	1
pN2	26	20	12	6	2	1	1

Figure 1. Patients who had mediastinal nodal metastases (N2) had a lower 5-year survival rate compared of those without mediastinal involvement (N0 and N1, $p = 0.13$).

- **N2 Disease**
- **INDUCTION CHEMOTREATMENT**

Results: Between 1998 and 2005, 47 EPs were performed. The “extended” procedure included left atrium resection in 15 patients, combined SVC and carinal resection in 9 patients, aortic resection in 8 patients (in 3 patients with prosthetic replacement), chest wall or diaphragmatic resection in 6 patients, SVC resection in 4 patients, and carinal resection in 4 patients. A partial esophageal muscular resection was performed in 1 patient. Overall 60-day mortality was 8.5%. Major postoperative complications occurred in 8 patients (17%). The 2- and 5-year survival rates for the overall population were 42% and 22.8%, respectively. Interestingly, long-term survivors were recorded only in the group of patients who received induction treatment.

Conclusions: Extended pneumonectomy is a feasible procedure with an acceptable risk factor. To improve the selection of patients, all candidates should undergo preoperative mediastinoscopy and induction chemotherapy. In patients with positive response to chemotherapy or stable disease, extended pneumonectomy may afford a radical resection in more than 80% of cases and may result in a permanent cure in some instances.

Results of surgical treatment of T4 non-small cell lung cancer

Cordula C.M. Pitz^a, Aart Brutel de la Rivière^b, Henry A. van Swieten^c, Cees J.J. Westermann^a,
Jan-Willem J. Lammers^d, Jules M.M. van den Bosch^{a,*}

^aDepartment of Pulmonology, Sint Antonius Hospital, PO BOX 2500, 3430 EM Nieuwegein, The Netherlands

^bDepartment of Cardio-Thoracic Surgery, University Medical Center, Utrecht, The Netherlands

^cDepartment of Thoracic Surgery, Sint Antonius Hospital, PO BOX 2500, 3430 EM Nieuwegein, The Netherlands

^dDepartment of Pulmonary Diseases, University Medical Center, Utrecht, The Netherlands

Received 7 April 2003; received in revised form 11 July 2003; accepted 23 July 2003

Abstract

Objective: Because of location and invasion of surrounding structures, the role of surgical treatment for T4 tumors remains unclear. Extended resections carry a high mortality and should be restricted for selected patients. This study clarifies the selection process in non-small cell T4 tumors with invasion of the mediastinum, recurrent nerve, heart, great vessels, trachea, esophagus, vertebral body, and carina, or with malignant pleural effusion. **Methods:** From 1977 through 1993, 89 patients underwent resection for primary non-small cell T4 carcinomas. Resection was regarded as complete in 34 patients (38.2%) and incomplete in 55 patients (61.8%). Actuarial survival time was calculated and risk factors for late death were identified. **Results:** Overall hospital mortality was 19.1% ($n = 17$). Mean 5-year survival was 23.6% for all hospital survivors, 46.2% for patients with complete resection and 10.9% for patients with incomplete resection ($P = 0.0009$). In patients with complete resection, mean 5-year survival for patients with invasion of great vessels was 35.7%, whereas mean 5-year survival for invasion of other structures was 58.3% ($P = 0.05$). Age, mediastinal lymph node involvement, type of operative procedure, and postoperative radiotherapy did not significantly influence survival. **Conclusion:** In certain T4 tumors complete resection is possible, resulting in good mean 5-year survival especially for tumors with invasion of the trachea or carina. High hospital mortality makes careful patient selection imperative.

© 2003 Elsevier B.V. All rights reserved.

lobe or recurrences were excluded. Resection was considered complete when (1) the surgeon was morally certain that all known disease was removed; (2) resection margins were histologically free; and (3) the highest mediastinal lymph node was negative by microscopy. Staging pro-

CONCLUSION II

In Case of Pneumonectomies

- Experienced Centers
 - Anesthesiology - ICU - Surgery
- Young Patients
 - DLCO > %70
 - Proper cardiac evaluation
- Maneuvers to decrease duration of PUMP
- Proper patient selection – Oncologic perspectives-