RECONSTRUCTION OF THE HEART AND THE AORTA FOR RADICAL
RESECTION OF LUNG CANCER.

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**Glossary of abbreviations:**

- CPB: cardio-pulmonary bypass
- NSCLC: non-small-cell lung cancer
- MRI: magnetic resonance imaging
- CT: computed tomography
- FDG-PET: fluoro-deoxyglucose-positron emission tomography
- TBNA: trans-bronchial needle aspiration
- LSA: left subclavian artery
- CS: circulatory support
- AA: aortic arch
- LFA: left femoral artery
- IQRs: interquartile ranges
- DFS: disease-free survival
- OS: analysis and overall survival
- FEV1: forced-expiratory-volume in 1 second
- ICU: intensive care unit
- Pt: patient
- neoadj txp: neoadjuvant therapy
- adj txt: adjuvant therapy
- vasc: vascular

**Central Message:** Cardiac and aortic reconstruction for invasion by lung cancer can be performed safely with or without CPB and may allow survival benefit for adequately selected patients.

**Perspective statement:** Lung cancer with deep and extended infiltration of the heart and the aorta have been generally considered not suitable for radical surgery so far. This single-centre experience proves that neoplastic infiltration of these structures is no longer a condition precluding resection.

**Central picture abbreviated legend:** Prosthetic reconstruction of the heart after resection for lung cancer.
ABSTRACT

INTRODUCTION: Report of a single-centre experience of resection and reconstruction of the heart and aorta infiltrated by lung cancer in order to prove that involvement of these structures is no longer a condition precluding surgery.

METHODS: Twenty-seven patients underwent surgery for lung cancer presenting full-thickness infiltration of the heart (n=6) or the aorta (n=18) and/or the supra-aortic branches (subclavian n=3). Cardiac reconstruction was performed in 6 patients (5 atrium, 1 ventricle), with (n=4) or without (n=2) Cardio-Pulmonary Bypass (CPB), using a patch prosthesis (n=4) or with deep clamping and direct suture (n=2). Aortic or supra-aortic trunk reconstruction (n=21) was performed using a heart-beating cross clamping technique in 14 cases (8 patch, 4 conduit, 2 direct suture), or without cross-clamping by placing an endovascular prosthesis before resection in 7 (4 patch, 3 omental flap reconstruction). Neoadjuvant chemotherapy was administered in 13 patients, adjuvant therapy in 24.

RESULTS: All resections were complete (R0). Nodal staging of lung cancer was N0 in 14 cases, N1 in 10, N2 in 3. No intraoperative mortality occurred. Major complication rate was 14.8%. Thirty-day and 90-day mortality rate was 3.7%. Median follow-up duration was 22 months. Recurrence rate is 35.4% (9/26: 3 loco-regional, 6 distant). Overall 3- and 5-year survival is 60.9% and 40.6%, respectively.

CONCLUSION: Cardiac and aortic resection and reconstruction for full-thickness infiltration by lung cancer can be performed safely with or without CPB and may allow long-term survival of adequately selected patients.

Key words: Lung cancer; Heart; Aorta
TEXT

INTRODUCTION

Infiltration of the heart and the aorta by lung cancer (Figure 1a-b) has been considered a condition precluding radical surgery for a long time due to technical and oncological reasons. Most of literature data reporting the feasibility of surgical treatment in this setting refer to patients with limited left atrial infiltration from NSCLC\(^1-10\) or marginal vascular involvement\(^9-14\). However, despite the disappointing results of oncologic options of cure, tumors with extended infiltration of the cardiac wall or the aorta which cannot be managed with marginal resection or limited cardio-vascular repair have been generally considered not suitable for radical surgery so far, due to technical complexity of the interventions required, concern about related major morbidity and mortality, and doubt on prognostic benefit. Our experience including patients undergoing complete resection of lung cancer deeply invading the heart or the aorta followed in most cases by their prosthetic reconstruction with or without Cardio-Pulmonary Bypass (CPB) proves that cardiac and aortic involvement is no longer a condition precluding radical surgery.

METHODS

Between October 2014 and January 2021, 27 patients (19 males, 8 females) with a mean age of 64.3±10.5 years old (range 27-78) underwent radical surgery for lung cancer presenting full-thickness infiltration of the heart (n=6) or the aorta (n=18) and/or the supra-aortic branches (subclavian n=3). Patients undergoing marginal atrial resection with staple suture or subadventitial resection of the aorta or the supra-aortic trunks were not included in this study. Neoadjuvant chemotherapy was administered in 13 patients, adjuvant therapy in 24. Postoperatively, 18 patients received chemotherapy, 4 chemo-radiotherapy and 2 immunotherapy.
During the study period 5 other patients underwent reconstruction of the heart (1 right atrial patch) or of the aorta (2 conduits and 1 patch) or supra-aortic branches (1 conduit reconstruction of the carotid artery) for radical resection of mediastinal tumors which are not considered in the present analysis.

**Pre-operative workup**

Preoperative workup and staging included whole-body contrast-enhanced Computed Tomography (CT). Magnetic Resonance Imaging (MRI) was performed in case of doubt on cardio-vascular infiltration or on brain metastasis, bone scintigraphy if indicated. Fluorodeoxyglucose-Positron Emission Tomography (FDG-PET) was performed if preoperative cytological- or histological diagnosis of the primary tumor was not achieved or in case of doubt about the presence of metastatic lesions.

Bronchoscopy was performed in all patients to assess the potential involvement of the bronchial tree. Video-Mediastinoscopy or Trans-bronchial Needle Aspiration (TBNA) was performed in the presence of enlarged peritracheal or subcarinal lymph nodes (long-axis diameter>1.5cm) on CT scan. Patients with histologically or cytologically proven N2 disease underwent induction chemotherapy. Mediastinal restaging of NSCLC patients after chemotherapy and before the operation was performed by FDG-PET with contrast-enhanced CT scan. TBNA was performed only in selected cases with doubt about N2 disease persistence after induction therapy. Induction therapy was also considered in some patients with the aim of primary tumor reduction.

Main criteria for patient selection included: good performance status (ECOG 0-1), clinical N0-1 status (even after induction therapy), tumor infiltration not too extended to preclude a prosthetic reconstruction of the aorta or the cardiac chambers.
All patients enrolled for surgical treatment presented N0-1 preoperative clinical status, some after induction therapy, at the time of resection. Adjuvant therapy was considered indicated and administered to all patients except those who refused it (2).

**SURGICAL TECHNIQUE**

Surgical access was lateral thoracotomy in 13 patients, postero-lateral thoracotomy in 13 and median sternotomy in 1.

**Tumors invading the heart**

*Interventions under CPB.* For patients presenting with extended infiltration of the cardiac structures requiring prosthetic reconstruction (Figure 1a), CPB was instituted via ascending aorta and right atrial or bicaval cannulation (N=4), following full heparinization (Figure 2a). Once CPB was started, the aorta was cross clamped and the heart arrested by means of cold blood cardioplegia allowing for the excision of the mass and surgical reconstruction of the cardiac chamber involved (Fig. 2a-b).

Reconstruction of the cardiac wall (left atrium in 3 cases and right ventricle in 1) was performed with a bovine pericardial patch fixed with a running 5/0 or 4/0 Prolene suture (Figure 2b).

*Intervention without CPB.* In patients (2) with the left atrium full-thickness infiltration who did not require prosthetic reconstruction, en bloc resection was accomplished by previous deep clamping of the atrium and subsequent direct 4-0 Prolene running suture.

**Tumors invading the aorta**

*Interventions with endovascular stent without cross-clamping.* For patients with tumor invading the descending aorta or the lower arch distally to the origin of the left subclavian artery (LSA), en bloc resection of the infiltrated vascular wall was planned after placement of an aortic endograft according to the previously described technique (Figure 1b). Endovascular stent placement was performed under general anesthesia using a retrograde femoral approach. Endografts of different types were used including Zenith (Cook,Brisbane,Australia), Gore-TAG (W.L.Gore,Flagstaff-AZ)
and Valiant (Medtronic, Minneapolis-MN). Endovascular stent was inserted 2 to 10 days before resection. To avoid endograft dislocation after resection, proximal and distal landing zones were targeted including about 4-cm length of healthy aorta. Resection of the infiltrated aortic wall was performed en bloc with the planned lung resection\textsuperscript{15}. The presence of the endovascular stent allowed safe resection with no blood leaks. Subsequent vascular reconstruction was accomplished covering the defect with the underlying endoluminal stent using a Dacron patch (fixed to the aortic wall with a 4-0 Prolene running suture) or an omental vascularized flap transposed into the pleural cavity through the diaphragm according to a previously described technique\textsuperscript{16}.

\textit{Interventions with cross-clamping with or without Circulatory Support (CS).} For patients showing tumor infiltration of the aortic arch (AA) close to the origin or with actual involvement of the LSA direct cross-clamping with or without a CS was required. In every case, arrangements for potential heart-beating circulatory assistance were made before the operation by positioning a guide-wire in the left femoral artery (LFA) for possible subsequent cannulation. CS, when required, consisted in a left ventricular assistance to preserve blood flow to the lower body keeping the heart beating. The circuit consisted of an inflow catheter inserted through the left atrial appendage using the thoracotomy approach, a venous reservoir, a centrifugal pump and an arterial cannula directly into the descending aorta or peripherally into the LFA. This allowed for a safe excision and reconstruction of the aorta. The actual use of CS was established on the basis of the estimated duration and complexity of the surgical procedure. At the end of the procedure, patients were weaned from the CS and operations completed in the usual fashion.

Non-invasive cerebral monitoring (oximetry near-infrared spectroscopy) and renal blood perfusion monitoring were used. After complete dissection and exposure of the AA and supra-aortic trunks, the vascular segment infiltrated was cross-clamped. The proximal clamp was placed on the AA between the origins of the left carotid artery and LSA, whereas distal clamping was usually at the level of the superior descending aorta. The LSA was clamped with a tourniquet on
its distal and upper portion. After clamping, the portion of AA or LSA infiltrated was resected en bloc with the tumor enclosed within the lung parenchyma. Frozen section analysis was performed to confirm the radicality of resection. In case of limited aortic wall resection subsequent reconstruction was performed by direct suture or patch prosthesis of polyethylene-terephthalate (Dacron) or bovine pericardium. For patients requiring a circumferential resection of the AA or LSA a Dacron conduit reconstruction was performed (Figure 3a-b). A running suture of 4-0 monofilament non-absorbable material (Prolene) was used in every reconstruction. Due to the high pressure of the reconstructed vessels, heparinization was performed only when heart beating CS was used.

Post-operative management

Patients who underwent vascular prosthetic reconstruction received antiplatelet agents post-operatively. Oral anticoagulation was not routinely used postoperatively due to high pressure of the reconstructed vascular structures. Patients undergoing patch reconstruction of the heart received subcutaneous low-weight heparin during hospitalization shifted to oral anticoagulation after discharge until clinical control at 3 months in the absence of rhythm abnormalities. Pain management was performed according to standardized protocol in use for patients receiving thoracotomy: Intraoperative intercostal blocks with 7.5mg/ml Ropivacain to be repeated postoperatively “on demand” and continuous intravenous infusion of tramadol (10 mg/h) and ketoralac tromethamine (3 mg/h). Patients undergoing cardiac reconstruction were also evaluated by dynamic MRI or CT of the heart within the first month of the operation. Volume rendering-CT and MRI were used to assess the patency and flow of the reconstructed vessels. Postoperative oncological follow-up was performed with contrast-enhanced total-body CT scan, and FDG-PET scan. Follow-up evaluations were planned every 3 months for the first 2 years and every 6 months...
for the following 3 years. All living patients were available for follow-up for at least the first 5 years. The last date of follow-up was 31 January 2022.

The study was approved by the local ethics committee (IRB no.:284-SA_2022) and conducted in accordance with the Declaration of Helsinki. All patients provided written informed consent for the operation and inclusion of personal data in a scientific database.

**Statistical Analysis**

Continuous variables were reported as either the means and standard deviation or median and interquartile ranges (IQRs) according to their distribution, as assessed by the Shapiro-Wilk normality test. Categorical variables were reported as percentages.

To assess recurrence and mortality rates of patients undergoing complete resection we used disease-free survival (DFS) analysis and overall survival (OS) analysis performed by Kaplan-Meier approach. The DFS and OS differences in terms of resection type (e.g., heart or aorta by NSCLC and reconstruction with or without CPB) were tested by log-rank test and represented by Kaplan-Meier curves. The recurrence and mortality probability were computed at 36 and 60 months if data was available, 30 and 48 months otherwise. All statistical analyses were performed by R Studio statistical software version 4.2.2.

**RESULTS**

Preoperative mean forced-expiratory-volume in 1 second (FEV1) of the 27 patients with NSCLC was 93.2±22. All resections were complete (R0). Lung cancer histology is reported in TABLE1.

Cardiac reconstruction was performed in 6 patients with (n=4) or without (n=2) CPB, using a patch prosthesis (n=4 with CPB) or with deep clamping and direct suture (n=2; no CPB). There were 5 left atrial, and 1 right ventricle reconstructions. Aortic or supra-aortic trunk reconstruction (n=21) was performed using a heart-beating direct cross-clamping technique in 14 patients (8
patch, 4 conduit, 2 direct suture), or without cross-clamping by placing an endovascular prosthesis before resection in 7. Reconstruction and reinforcement of the aortic wall in this group of patients was accomplished in 4 cases with a Dacron patch, and in 3 cases by an omental flap transposed through the diaphragm without additional surgical access. In the cross-clamping group, patch reconstruction was performed using Dacron prosthesis in 6 patients and bovine pericardium in 2, while conduit replacement was performed with Dacron prosthesis in all cases. In 7 out of 14 patients undergoing heart-beating cross-clamping technique a left CS was used. Associated parenchymal resections are reported in TABLE1. Overall mean operative time was 221.4±49.1 minutes. For patients receiving aortic and supra-aortic trunks reconstruction, mean operative time was 214.3±53 minutes with a mean clamping time of 29.3±3.3. Mean operative time for patients undergoing cardiac reconstruction was 230.8±41.6. Mean CPB time for patients who required it was 51.5±12 minutes. No intraoperative mortality occurred. Thirty-day and 90-day mortality rate was 3.7% (1/27). The only postoperative death occurred 12 days after the operation in a patient who underwent right pneumonectomy associated with left atrial resection and patch reconstruction. It was due to cardiac failure occurring on postoperative day 3 during Intensive Care Unit (ICU) stay.

Postoperative hospital-stay ranged between 6 and 20 days (mean 9.8±4.4). Patients undergoing cardiac reconstruction had a longer mean postoperative hospital stay (10.25±3.7; range 6-20 days) if compared with patients receiving aorta or supra-aortic trunks reconstruction (9.6±4.8 range; 7-16 days). Overall mean ICU stay was 3.08±1.47 days.

Major complication rate was 14.8% (4/27: 1 bleeding requiring re-thoracotomy, 1 laryngeal nerve injury, 1 chylothorax and 1 cardiac failure resulting in death). Pathological nodal staging was N0 in 14 patients, N1 in 10, N2 in 3 [TABLE1].

Median follow-up duration was 22 months (range 5-72). OS at 3 and 5 years was 60.9% and 40.6%, respectively (Kaplan-Meier) (Figure 4). Patients with heart infiltration had an OS of 44.4%
at 3 and 4 years, while patients with aorta infiltration had an OS of 65.4% at 3 years and at 4 years (Figure 5).

Recurrence rate was 34.6% (9/26:3 loco-regional, 6 distant). DFS was 68.3% at 3 years and 51.2% at 5 years. Patients undergoing pneumonectomy had a trend towards worse survival without reaching statistical significance (p=.06) at univariate analysis (Figure 6). There was no difference in survival related to: histotype (squamous vs other; p=.14), the use of CPB (p=.18) or CS (p=.24) at univariate analysis. A multivariate analysis for risk factors influencing long-term survival was not performed due to the too limited statistical sample.

Complete long-term patency of the reconstructed vessels (aorta or supra-aortic trunks) has been shown in all patients by dynamic MRI performed 1 month and 1 year (for living patients) after surgery.

DISCUSSION

Heart and aorta can be infiltrated by T4 lung cancer. Invasion of these structures has been considered a contraindication for radical surgery for a long time. This is principally due to technical reasons related to the complexity of the cardio-angioplastical procedures required to achieve a radical resection, but also due to the weak evidence of related oncological benefit on long term outcome available in the literature. Over the last decades only few limited experiences worldwide have reported the feasibility and safety of extended operations for radical resection of T4-NSCLC invading the aorta or the heart (usually the left atrium). If considering resection of tumors invading the thoracic aorta, most of the interventions reported in published series include subadventitial dissection procedures. So far, there are only small case series reporting angioplastical procedures in this setting. The reported perioperative mortality ranges between 2.9% and 12.5% and major morbidity between 7% and 37%. Published studies reporting results of lung resection extended to the left atrium over the last two decades include limited number of
patients, frequently with tumor invasion confined to the base of the Pulmonary Veins and heterogeneous data in terms of perioperative mortality ranging from 0% to 20%. Very few experiences of en bloc radical resection have been reported also for anterior mediastinal tumors invading the aorta or the heart\textsuperscript{18-20}.

At present, according to current clinical practise guidelines\textsuperscript{21,22}, patients with biopsy-proven T4-N0 NSCLC should be considered surgical candidates if a radical resection is potentially achievable. However, when considering tumors with deep and extended infiltration of the aorta or the heart, the possibility to achieve a complete resection of the disease is principally related to the technical expertise of the centre in cardio-vascular reconstructive procedures and may require CS in most cases.

When the tumor invades the aorta, technical options to reconstruct this vascular structure depend on the depth, the extension and the site (AA or descending aorta) of the neoplastic infiltration.

In case of tumor invading the descending aorta the placement of endografts (commonly employed for aneurysm treatment) has been successfully used to allow a safe resection of the infiltrated vascular wall without need for cross-clamping and CS because of full protection guaranteed by the endoluminal stent across the infiltrated area\textsuperscript{15}. Furthermore, it helps reduce intraoperative bleeding due to the exclusion of adjacent intercostal arteries. After the first description of this off-label use of aortic endografts\textsuperscript{15,23}, we have confirmed the safety and efficacy of this technique in a series of 8 patients so far (7 with lung and 1 with mediastinal tumor). Placement of endovascular prosthesis is generally preferred within 7-10 days of the planned resection based on histologic evidence reported in experimental studies which show inflammatory reaction of the aortic wall causing progressive graft embedment with consequent increase of technical difficulty when performing vascular wall resection after longer time\textsuperscript{24}. One-stage graft insertion soon before resection is discouraged by some authors due to possible complications related to stenting procedure (paraplegia, endo-leaks), but in other investigators’ opinion it can offer some
advantages since it allows avoiding additional anaesthesia and potential useless procedure if actual invasion of the aortic wall is not confirmed at thoracic surgical exploration\textsuperscript{15}. The maximal possible extent of the aortic wall resection with this technique has still not completely defined. In our series we have proven the safety of aortic wall resection up to about one half of the vessel circumference. The use of endografts with long margins of uninvolved aorta has ensured safety in cases of partial-thickness vascular wall resection with no patch reconstruction avoiding endoleaks and aneurysm formation\textsuperscript{15,17}. However, for more extended aortic infiltration and full thickness resection we prefer to perform a vascular reconstruction using a synthetic patch (usually Dacron) or a vascularized omental flap applied over the defect. The latter option is preferred especially if a concurrent bronchial stump reinforcement is required due to previous induction therapy. Reconstruction of the aortic wall confers increased protection and stability to the resected area preventing the occurrence of aortic narrowing or proximal dilatation as reported by other authors\textsuperscript{24}. This endograft procedure for radical resection of lung cancer invading the descending aorta has been performed with limited major complication rates, no perioperative mortality and no local recurrence in our and other selected centres experience\textsuperscript{15,17,23}. Conversely, in the case of tumor invading the AA and the supra-aortic trunks the cross-clamping technique still remains the option of choice. This can be performed with or without CS. The present experience proves that vascular resection and reconstruction can be performed safely with both options either with prosthetic patch, conduit technique or with tangential suture repair. Concerning interventions for tumors invading the heart, only limited experiences of small partial cardiac chamber resection, generally the left atrium, without prosthetic reconstruction have been reported in the English literature so far. There are only few published studies including series ranging between 12 and 46 patients, most of which with less than 25 patients. A recent systematic review and meta-analysis\textsuperscript{26} has analysed all the published studies in this setting (18) up to 2021 collecting a total of 483 patients worldwide. Reported operative mortality ranged between 0% and
20%, and complication rate ranged from 7.1% to 52.6%. Pneumonectomy was performed in the vast majority of patients (84%), neoadjuvant treatment (chemotherapy or chemo-radiotherapy) was administered in 36% of cases and adjuvant therapy in 56%. CPB was used only in 1.2% of patients. Estimated pooled 5-year OS rate was 19.9%. Estimated 3-year OS was 23.1%. Median OS ranged from 10 months\(^{10}\) to 29 months\(^{9}\). Unanimously, good survival rate can be achieved in very well selected patients (according to general status), with N0-1 disease if a complete resection is achieved.

Differently, patients with lung cancer showing more extended infiltration of the cardiac chambers which cannot be completely resected with limited atrial wall resection and direct suture have been considered unresectable so far. Our here reported experience including 6 NSCLC patients undergoing resection of a wide portion of the atrium or the ventricle, 4 of which requiring prosthetic reconstruction under CPB, proves that even this condition should not be considered an absolute contraindication for radical surgery and that patch repair of large portions of the cardiac chambers can be performed safely under CPB without early oncologic recurrence.

There is a controversial approach in the literature concerning the use of CPB for oncological interventions. No increase of distant metastases and tumor recurrence has been reported in a systematic review by Muralidaran and coll.\(^{27}\). Conversely, Tsukioka and coll.\(^{28}\) have reported early relapse resulting in death in both patients receiving atrial resection under CPB in their experience. These authors hypothesize that increased intraoperative tumor cells dissemination promoted by the extracorporeal circulation could have been responsible for the early relapse, as previously advocated by other authors\(^{29}\). However, both the above mentioned patients in the latter study presented with pathological N1-N2 disease representing a factor of increased tumor recurrence risk itself. In our series, none of patients who underwent cardiac reconstruction under CPB showed locoregional recurrence or distant metastasis within 6 months of the operation, and 2 out of the 3 patients who did not experience perioperative fatal complications are still alive with
no evidence of disease at 15 and 30 months, respectively. This evidence does not confirm the hypothesis of increased rate of early recurrence for tumors resected under CPB.

The role of neoadjuvant therapy on long-term prognosis, which has been well defined in other categories of locally advanced NSCLC (i.e.: N2 disease), is still object of debate for T4-NSCLC and in particular for patients showing infiltration of the heart and the aorta. Looking at literature data, only 36% of patients undergoing atrial resection received induction therapy, and although some authors have observed better survival in this group of patients, a clear evidence of prognostic benefit has still not been proven. In the present series induction therapy was administered in about half of NSCLC patients without showing a significant improvement of long-term survival. Several reports in the literature have advocated a potential detrimental effect of induction treatment from a technical point of view affecting the perioperative risk of morbidity, especially if a reconstructive procedure is required. The present authors have confirmed even in the series here reported the safety of extended resections and reconstructive procedures after neoadjuvant therapy, as already reported in previous studies.

Main limitation of the present study is represented by the small statistical sample which is justified by the rarity of the complex interventions included and by the restrictive indications for resection in patients with such oncological status. Strengths are related to the homogeneity concerning indications for surgery, intraoperative technical management and perioperative management of a single centre experience.

In conclusion the present experience proves that cardiac and aortic resection and reconstruction for full-thickness infiltration by lung cancer can be performed safely with or without CPB and may allow long-term survival for adequately selected patients.
REFERENCES


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FIGURE LEGENDS

Figure 1. NSCLC invading the heart (A) and the aorta (B). A) Right lung cancer with extensive invasion of the heart. B) Left lung cancer extensively infiltrating the aorta with endoluminal stenting.

Figure 2. Prosthetic reconstruction of the right ventricle after resection of T4 NSCLC. A) The infiltrated portion of the right ventricle has been resected under CPB leaving a large defect on the cardiac wall. B) Prosthetic reconstruction of the cardiac wall with a bovine pericardial patch has been completed.

Figure 3. Prosthetic reconstruction of the aorta after resection of T4 NSCLC. A) Anastomotic conduit reconstruction of the distal aortic arch with cross-clamping under left circulatory support. B) Distal aortic arch replacement with a Dacron conduit has been completed.

Figure 4. Overall Survival – Kaplan-Meier Curve.

Figure 5. Survival curve (Kaplan-Meier) of patients undergoing resection of tumor invading the heart (blue) or the aorta (red).

Figure 6. Survival Curves (Kaplan-Meier) of patients undergoing pneumonectomy (red) vs other resections (blu).
Table 1. Patients’ characteristics, interventions and survival.

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# after neoadjuvant *local; **other cause; †30-day mortality; ‡
Overall Survival
Heart-Aorta groups

Survival percentage

95% Confidence Interval
p = 0.25

Time in years

Number at risk

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Time in years
Overall Survival

Pneumonectomy: No - Blue, Yes - Red

Survival percentage
95% Confidence Interval
p = 0.061

Time in years

Number at risk

Pneumonectomy
No
Yes

Time in years

19 16 11 3 3 2 1
8 7 1 1 1 0 0