

Surgical resection and survival of patients with unsuspected single node positive lung cancer (NSCLC) invading the descending aorta

Chirurgische Therapie und Überleben von Patienten mit Lungenkrebs (NSCLC), tumoröser Invasion der Aorta descendens und nicht vorbekannter solitärer Lymphknotenmetastase

Abstract

Background: Surgical treatment of non-small cell lung cancer (NSCLC) with aortic invasion is still debated.

Methods: Thirteen patients with locally advanced (T4) NSCLC and invasion of the descending aorta underwent pneumonectomy (n=9) or lobectomy (n=4) together with aorta en bloc resection and reconstruction (n=8) or subadventitial dissection (n=5), complete lymph node dissection, and had microscopic unsuspected node metastasis at N1 (n=5) and N2/3 (n=8) levels of whom 12 received radiation therapy. Clamp-and-sew was used to resect and reconstruct the aorta.

Results: Operative mortality and morbidity rate was 0% and 23%, respectively. Four patients died of systemic tumor relapse and 2 of local recurrence. Six patients were alive after a median follow-up of 40 months (range 15–125 months). Overall 5-year survival rate was 45%. Median survival time and 5-year survival rate of patients after aortic resection was 35 months and 67%, respectively, and was 17 months and 0%, respectively, after aortic subadventitial dissection (p=0.001). N1 and N2 nodal status adversely affected survival, but survival difference was not significant (N1 versus N2/3; 52% versus 39% at 5 years; p=0.998).

Conclusions: Aortic resection with single station node positive T4 lung cancer can achieve long-term survival. The data indicate that aortic resection-reconstruction is associated with better outcome than subadventitial dissection.

Keywords: lung cancer surgery, aortic operation, off pump, outcomes

Zusammenfassung

Hintergrund: Die chirurgische Behandlung nicht-kleinzelliger Lungentumore mit Aortawandinvasion wird kontrovers diskutiert.

Methoden: 13 Patienten mit lokal fortgeschrittenem (T4) nicht-kleinzelligem Lungencarcinom, tumoröser Invasion der Aorta descendens und präoperativ negativem N-Staging wurden in kurativer Intention primär operiert. Operative Prozeduren: Pneumonektomie 8-mal, Lobektomie 4-mal in Kombination mit segmentaler aortaler en-bloc-Resektion „clamp-and-sew“ in 8 Fällen oder subadventitieller Aortawanddissektion in 5 Fällen und systematischer Lymphknotendissektion. 12 Patienten mit definitiv solitärer, mikroskopischer Lymphknotenmetastase in N1- (n=5) oder N2-Position (n=8) erhielten eine adjuvante Radiotherapie.

Ergebnisse: Die Krankenhaus-, resp. 90-Tage-Mortalität betrug 0%, die Morbidität 23%. Im weiteren Verlauf verstarben 4 Patienten an disseminierter Metastasierung und 2 Patienten am lokalen Tumorrezidiv. Bei einem mittleren Nachbeobachtungszeitraum von 40 Monaten leben noch 6 Patienten (15–125 Monate). Die kumulativ prospektive 5-Jahresüberlebensrate der 13 Patienten betrug 45%. Die mittlere Überle-

Peter Wex¹

Thomas Graeter¹

Francesco Zaraca²

Victor Haas¹

Steffen Decker¹

Hansanali Bugdayev¹

Heinrich Ebner²

1 Department of Thoracic and Vascular Surgery, Clinic Loewenstein, Germany

2 Departement of Vascular and Thoracic Surgery, Ospedale Generale Regionale Di Bolzano, Italy

benszeit und 5-Jahresüberlebensrate nach Aortaresektion betrug 35 Monate und 67%, nach Aortawanddissektion respektive 17 Monate und 0% ($p=0,001$). Der N1- und N2/3-Lymphknotenstatus beeinträchtigten das Langzeitüberleben (N1 versus N2/3; 52% versus 39% nach 5 Jahren). Der Überlebensunterschied erreichte kein Signifikanzniveau ($p=0,998$).

Schlussfolgerungen: Bei einer lokal fortgeschrittenen Lungenkrebskrankung ist in ausgewählten Fällen, auch bei Vorliegen einer solitären Lymphknotenmetastase, mit einer primären, erweiterten Resektionstherapie ein Langzeitüberleben erzielbar. Nach unseren Ergebnissen ist bei umschriebener aortaler Infiltration der aortalen en-bloc-Resektion gegenüber der subadventitiellen Aortawanddissektion der Vorzug zu geben. Weitere Studien sollten den Nutzen multimodaler Therapiekonzepte evaluieren.

Schlüsselwörter: Lungenkrebsoperation, Aortaresektion, Off pump, Ergebnisse

Introduction

Initial reports of extended resections required for lung cancer with infiltration of adjacent organ structures were associated with high rates of incomplete resection considerable morbidity and mortality and poor long-term outcome [1], [2]. Newer data has yielded promising survival rates between 30% and 40%, if no mediastinal lymph node metastases are present and complete resection is achieved [3], [4]. However, recent series has provided 25% up to 40% long-term survival data of resected patients with multiple and single node unsuspected N2 disease [5]. Various resection techniques have been refined for locally advanced (T4) tumors, mostly non-small cell lung cancer (NSCLC) with invasion of the carina, vena cava and spine [6]. Regarding T4 tumors, predominantly N2 NSCLC with aortic invasion few reports exist [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17] with limited numbers of patients which were treated with different therapeutic regimens. The studies vary for surgical technique and use of bypass adjuncts, and reveal non-homogeneous early outcome and survival (Table 1).

In this paper we discuss the surgical outcomes of patients with N1 unsuspected N2 T4NSCLC and aortic involvement according to distinct surgical procedures of aorta resection-reconstruction and subadventitial dissection.

Patients and methods

Between 1993 and 2005 thirteen patients underwent extended resection of locally advanced lung cancer with aortic involvement, and were retrospectively reviewed. The patients were given a clinical diagnosis of a primary NSCLC of the left upper lobe ($n=12$) and lower-lobe ($n=1$). Aortic infiltration (clinical T4) was diagnosed with a chest computed tomographic scan (Figure 1).

All patients underwent a bone scan, abdominal CT imaging, and magnetic resonance or CT imaging of the head to rule out distant metastasis. Absence of mediastinal lymphadenopathy was diagnosed when lymph nodes had

a short diameter of less than 1.0 cm on the CT image, and was histologically confirmed by performing staging mediastinoscopy. Positron emission tomography (PET-CT) has become available at our institution only at the end of 2006. PET-CT, just as thoracoscopy or thoracotomy, were not used for the staging of the T and N status; whereas EBUS, EUS-FNA were accidentally used for suspicious targets detected on CT scan. Selection criteria included patients less than 70 years of age without significant cardiac disease (echo, stress-echo), renal disorders, or considerable co-morbidities, and a predicted post-operative FEV1 more than 40% by perfusion scan in combination with pulmonary function tests. Written informed consent was obtained from all patients based on the current surgical results and risks of extended surgery for T4 lung cancer, in particular of aortic surgical repair.

Operative techniques

The operative approach was an axillary anterior thoracotomy. The pericardium was completely incised around the hilar vessels. Posteriorly, the pericardiotomy was extended upward to an U-shaped hilar release. The descending aorta was encircled with a tape just below the aortic tumor adherence. Anteriorly the ductus arteriosus was divided giving access to the aortic arch, which was laid free and encircled with a tape between the origin of the left carotid and subclavian artery. Absence of tumor invasion of the carotid arteries and the thoracic spine below spine level Th 9 indicated that resection could be carried out without the use of a bypass support. Initially the lung resection as either pneumonectomy or lobectomy was performed in a standard fashion. The bronchus was cut and closed by simple interrupted sutures of 4-0 vicryl, followed by nodal dissection (levels 7, 10, 4, and 9) including N1 nodes, where appropriate for the surgical procedure; whereas nodal stations 5, 6, 8 were removed together with the tumor, thus processing a complete lymph node dissection. Full exposure of the tumor and

Table 1: Literature research: aortic resection for lung cancer (1989–2005)

First Author	No. Patients	Tube Replacement/ Patch/Direct Closure	Subadventitial Dissection	Bypass Support FF	CPB	AA	Cross- Clamp	Operative Mortality (%)	Survival Rate (5-year)
Nakahara [7] (1989)	3	3		2	1			0	11 mo, median
Horita [8] (1993)	2	2		2				NA	NA
Tsuchiya [9] (1994)	28	5/2	21	7	5	2		NA	14.2 (3y)
Fukuse [10] (1995)	13	3/1	9	4				0	31,8 (3y)
Okubo [11] (1996)	1	1		1				0	10 mo
Klepetko [12] (1999)	5	5		4	1			0	25 (4y)
Bernard [13] (2001)	8		8					NA	17 (2y)
Spaggiari [14] (2004)	1	1					1	NA	NA
Ohta [15] (2005)	16	10/5/1		10	3	3		12,5	70/16,7 ^b
De Perrot [16] (2005)	3	3		3				0	23 mo, median ^c
Shiraishi [17] (2005)	16	5/1	10	6	1		g ^a	12,5	36,5 (5y) ^d
Total	96	38/9/1	48	32	11	15			

NA, not available; ^a tangential side biting clamp; ^b N0/N2, N3; ^c calculated from survival data; ^d survival of cases with complete resection.

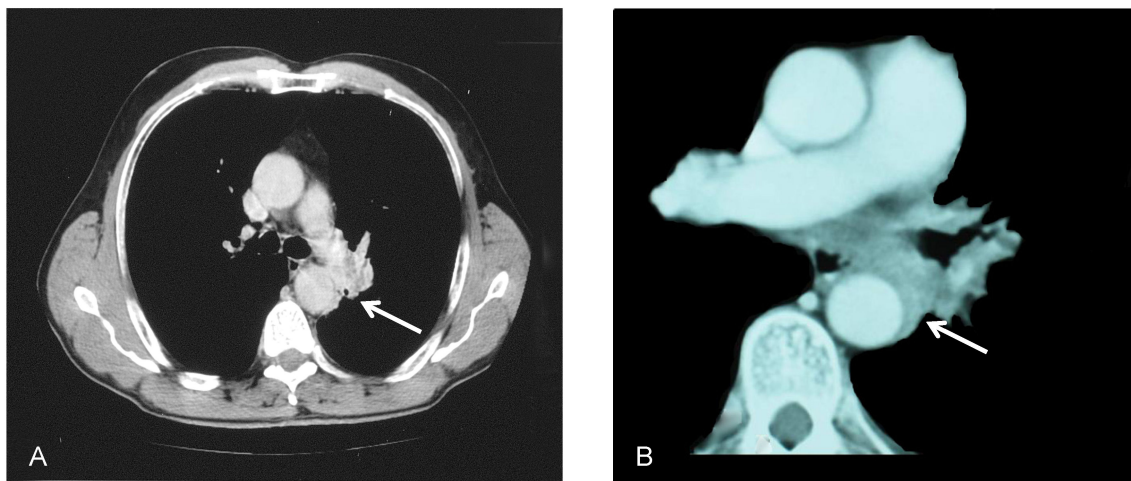


Figure 1: (A) Chest computed tomographic (CT) scan at the level (Th V) of the descending aorta, demonstrating aortic invasion (arrow) of a centrally located tumor. (B) The CT scan of the level of six thoracic vertebra shows a tumor abutting the descending aorta (arrow).

adherent aorta was obtained by traction of the detached lung towards the thoracotomy (Figure 2).

When the aortic infiltration was locally confined to the adventitia and a plane of dissection within the aortic wall could easily be developed, a subadventitial dissection was conducted (Figure 3A). Otherwise, when invasion of the aortic media was evident or suspected, and more than approximately 30% of aortic circumference was involved by the tumor, tubular aortic resection was performed (Figure 3B).

Beginning at the site of the anticipated proximal anastomosis, the aorta was mobilised circumferentially. Intercostal arteries were exposed and clipped to the distal margins

of the aortic tumor adherence. At this point 100% oxygen, full heparinization and permissive moderate hypotension were started. Next the aorta was cross-clamped, divided and extracted en bloc with resected lung. The aorta was replaced with a primary patent prosthetic graft using a continuous 3-0 polypropylene suture for anastomotic repair. Finally the bronchus was covered with viable neighbouring tissue.

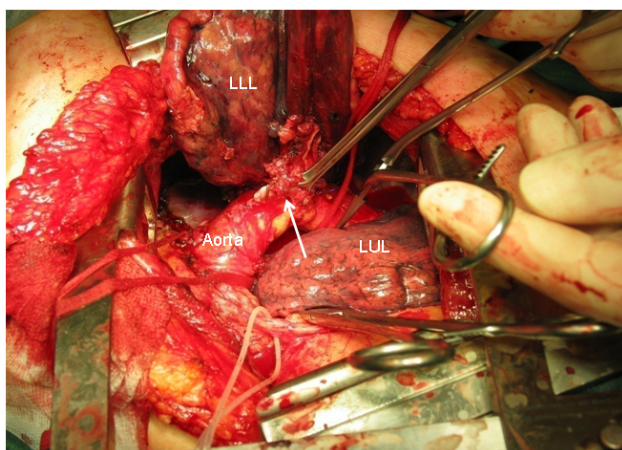


Figure 2: Operative findings showing localized tumor invasion of the aortic media (arrow).

The left lower lobe (LLL) is detached. The left upper lobe (LUL) is in situ and anastomosed by double sleeve (not shown).

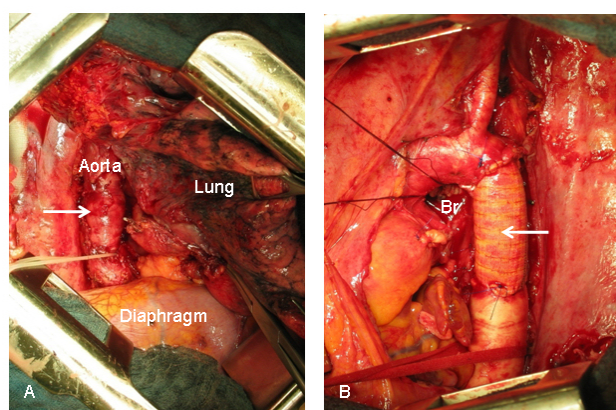


Figure 3: Operative view. (A) Tumor removed from the descending aorta by subadventitial dissection (arrow).

(B) Graft replacement of the descending aorta (arrow); lung removed. Bronchus (Br) cut and closed by manual sutures.

Statistical methods

The primary end point of the study was postoperative death from any cause following surgery or the last follow-up visit. Patient survival was analysed with the date of thoracotomy as the starting point using life-table estimates by the method of Kaplan-Meier. Differences between the curves when comparing the groups were tested for significance using log-rank statistics. A p-value of less than or equal to 0.05 was considered significant.

Results

The clinical and pathological characteristics of the 13 cases are depicted in Table 2.

Most patients were male, with a mean age of 62 years (range 49 to 69 years). Surgical procedures included 9 pneumonectomies, 3 upper lobectomies, and one lower lobectomy together with aorta resection-reconstruction (case 1–8) or aortic subadventitial dissection (case 9–13). Ten patients underwent concurrent bifurcation

plasty (n=5), partial resection of the oesophagus muscle wall (n=4), and double sleeve (n=1). Histologically, the tumors consisted of adenocarcinoma (n=7), squamous cell carcinoma (n=4), and undifferentiated carcinoma (n=2). No important differences were noted concerning age, sex, histologic assessment, pathologic N status, or adjuvant therapy among aorta procedure related groups. Of the 13 patients, who were clinically diagnosed N0–1, 5 pathologically revealed N1 and 7 unsuspected N2 or N3 in one. The N2, N3 nodes were found fixed to the tumor, and were only discovered at the time of histologic examination of the operative specimen. The nodes were limited to a single node or station, and were related to 5, 8L, 8R stations. That highlights the clinical problem of preoperative differentiation between a centrally located tumor and immediate adjacent or clearly involved nodal disease which even intraoperatively – given that an en bloc resection is performed rather than a discontinuous resection – may be impossible; and finally explains that in this study accuracy of clinical N-factor only reached poor 38%. On the other hand, of the 13 patients who were diagnosed clinical T4, 11 had pathologic confirmation of T4 (histologic evidence of tumor within the aortic wall), 7 (64%) with invasion of the media. The accuracy of clinical T factor was 85%.

Resection was complete in 11 (85%) patients including patients with tubular aortic resection. Although resection was considered complete by intraoperative frozen section, in 2 (15%) of the dissection patients resection was ultimately incomplete since a lymphatic tumor cell propagation microscopically was found at the aortic resection margin. Radiation therapy was administered to all but one patient with N1 or N2/3 disease because of the suggestion that this decreases local tumor recurrence.

The operative characteristics of the 8 patients who underwent aortic resection and graft replacement are set out in Table 3.

Clamp times were 20 to 32 minutes (average, 24 minutes). The patients were extubated after an average of 1 day (range, 0 to 3 days). No perioperative complications due to aortic clamping were noted. In particular spinal cord injury as either paraplegia or paraparesis was not observed. No early deaths occurred. There were three major complications in 2 patients including postoperative bleeding (n=2) and late chylothorax (n=1), and were successfully treated by VATS (video-assisted thoracoscopic surgery). The other patients had no postoperative complications and recovered uneventfully. Average stay in the intensive care unit was 8 days (range 7 to 10 days) and in hospital was 27 days (range 23 to 32 days). The in hospital respective 90-days-mortality rate was 0%, and the morbidity rate was 23%.

Follow-up was completed for all patients in 8 to 125 months (average 36 months). Four patients died of systemic metastasis and 2 died of local recurrence within 35 months of the operation. In addition, one patient died of unknown reason 62 months after resection therapy. Six patients were alive after a median follow-up of 40 months (range 15–125 months) with two absolute 5-year

Table 2: Patients demographics

Nr.	Age, Sex	Resection	Histology	pTNM Staging	Resection Complete	Adjuvant Therapy	Follow-up (mo)	Recurrence	Status
1	70,F	lt. pneumonectomy/ resection	Ad	T4N1M0	yes	/	62	no	dead
2	52,M	lt. pneumonectomy/ resection	Ad	T3N2M0	yes	radio	125	no	alive
3	62,M	lt. pneumonectomy/ resection	Ad	T4N3M0	yes	radio	34	no	alive
4	59,M	lt. pneumonectomy/ resection	Ud	T4N1M0	yes	radio	15	no	alive
5	63,M	lt. pneumonectomy/ resection	Ad	T4N2M0	yes	radio	30	no	alive
6	68,M	lt. pneumonectomy/ resection	Sq	T4N1M0	yes	radio	28	systemic	dead
7	49,M	lt. upper lobectomy/ resection	Sq	T4N2M0	yes	radio	35	systemic	dead
8	62,M	lt. lower lobectomy/ resection	Sq	T4N1M0	yes	radio	54	no	alive
9	65,M	lt. upper lobectomy/ dissection	Ad	T3N2M0	no	radio	17	local	dead
10	67,M	lt. pneumonectomy/ dissection	Ad	T4N2M0	no	radio	8	local	dead
11	62,M	lt. upper lobectomy/ dissection	Ud	T4N1M0	yes	radio	21	systemic	dead
12	65,M	lt. pneumonectomy/ dissection	Sq	T4N2M0	yes	radio	24	systemic	dead
13	67,M	lt. pneumonectomy/ dissection	Ad	T4N2M0	yes	radio	17	no	alive

lt.- left; Ad - adenocarcinoma; Ud - undifferentiated carcinoma; Sq - squamouscell carcinoma

Table 3: Operative characteristics of the 8 patients who underwent resection and reconstruction for T4 lung cancer

Patient number	Age (y), Sex	Lung Resection/ Aortic Replacement	Cross-Clamping Time (min)	ICU Stay (d)	Hospital Stay (d)	Postoperative Complications
1	70,F	lt. pneumonectomy/ tube graft	26	8	32	
2	52,M	lt. pneumonectomy/ tube graft	26	10	24	
3	62,M	lt. pneumonectomy/ tube graft	24	9	23	chylothorax, hemothorax
4	59,M	lt. pneumonectomy/ tube graft	23	8	32	hemothorax
5	63,M	lt. pneumonectomy/ tube graft	25	10	30	
6	68,M	lt. pneumonectomy/ tube graft	32	8	26	
7	49,M	lt. upper lobectomy/ tube graft	21	7	23	
8	62,M	lt. double sleeve lower lobectomy/tube graft	20	6	23	

lt.- left; ICU – intensive care unit.

survivors. The median survival time of the 13 patients was 28 months and the overall 5-year survival rate was 45%. The median survival time and 5-years survival rate were 48 months and 67%, respectively, for the 8 patients with aortic resection/reconstruction, and 17 months and

0%, respectively, for the 5 patients with aortic dissection ($p=0.001$, Figure 4) favoring aortic resection. The differences in survival between patients with complete or incomplete resection ($p=0.198$) failed to reach significance, due to the small numbers of patients in each group. On

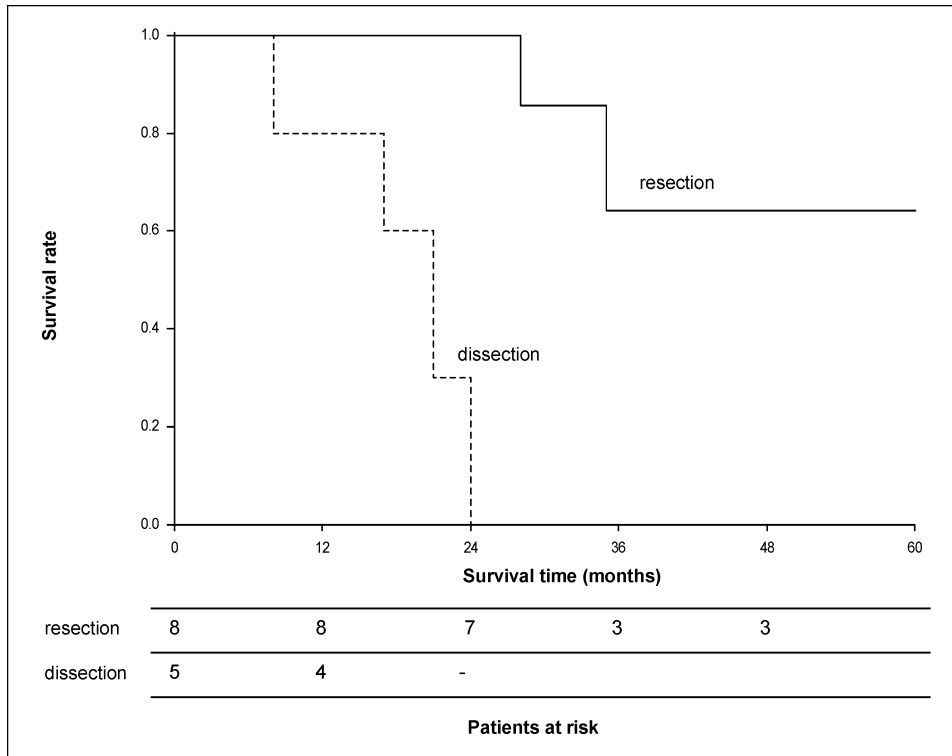


Figure 4: Survival of patients after aortic resection (n=8; solid line) and subadventitial dissection (n=5; dotted line) for T4 lung cancer with aortic involvement. There was a significant difference in the 5-year survival rate (p=0.001).

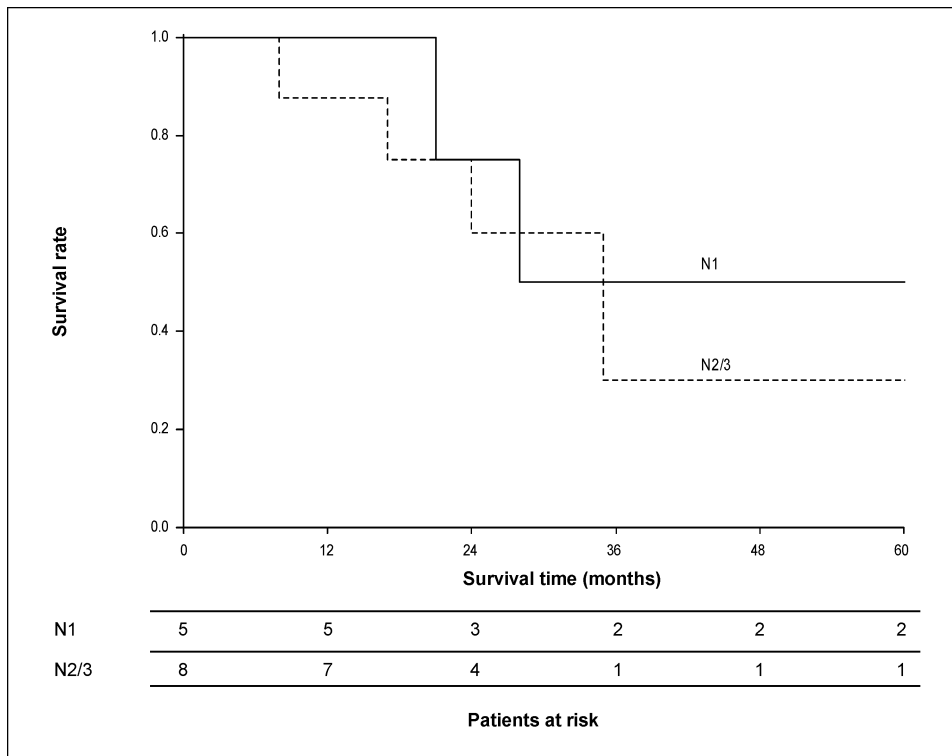


Figure 5: Survival of patients with T4 non small cell lung cancer invading the thoracic aorta, grouped by nodal status. The 5 year survival rate were 52% and 39% for N1 and N2/N3, respectively (p=0.998).

the basis of pathological N factor the overall 5-year survival rate was 52% for patients with pathological N1 and 39% for patients with pathological N2 or N3 (p=0.998, Figure 5), underlining the adverse implications N2 and N1 disease had on survival. Eighty percent of patients

with aortic dissections (Table 4) had either local recurrence or systemic recurrent disease.

By contrast, 25% of aortic resection patients had systemic relapse. Summarizing, N1-2 disease, recurrence, and

mode of resection had obvious implications on survival outcome.

Table 4: Recurrence

Procedure	Recurrence (n)	
	local	systemic
Tubular aortic resection	0	2/8
Subadventitial aortic dissection	2/5	2/5
Total	6/13	

p = 0.0129

Comment

Resection of the aorta in combination with resection of N2 lung cancer has been considered of unproven therapeutic value since the oncologic results of such surgery were disappointing [18]. According to a literature review (Table 1) approximately 100 patients underwent aortic resections with T4, mostly N2 primary lung cancer as were included in distinct therapeutic regimens (adjuvant chemo-/radiotherapy and induction chemotherapy). In these series the overall postoperative mortality ranged from 0 to 12.5%. However, pooling different types of aortic resections (resection/reconstruction and subadventitial dissection; bypass support, cross clamp), reveals non-homogeneous outcome and long-term survival.

The involvement of the aorta influences the type of resection. Aortic invasion can be suspected when the tumor is in apposition to the aorta and the fat plane is lost between the aorta and the tumor [19]. The invasion may be limited to the adventitia, but more commonly the media will also be invaded. When present resection requires cross-clamping to remove the infiltrated wall. On technical aspects using a CPB or a shunt prosthesis may facilitate resection [12], [16], and in case of aortic arch involvement will maintain perfusion of the upper and lower part of the body during cross-clamping in order to prevent spinal cord ischemia and renal failure [12]. However, former results of surgery for descending thoracic aortic aneurysm repair [20], [21] provided support for our thesis that clamp and sew aortic resection with T4 lung cancer and limited invasion to the descending aorta is feasible with a low incidence of complications. Since spinal cord injury is the single most devastating complication, its occurrence is particularly likely in repair of the peridiaphragmatic aorta [22]. From this area spinal cord vessels mostly arise in particular the artery of Adamkiewicz between Th 8 and L 1 in up to 91% [23], [24]. Consequently we restricted aortic resection to the above Th 8 spine area. Average 5 intercostal arteries were sacrificed less than are judged critical for cord perfusion [22]. Due to our operative strategy which encloses lung resection *at first step* followed by aortic resection-reconstruction, we were able to minimize aortic occlusion time to or less than 30

minutes; thus reducing the risk of spinal cord injury and other critical complications [20], [21], [25].

Nodal disease compromises long-term outcome [9], [10], [12], [13], [15] and limits survival by tumor relapse. Therefore it has been claimed that operative indication should be restricted to patients who were diagnosed clinical N0/1 [10]. Whereas chemotherapy, most likely in its neoadjuvant form has been administered to patients with clinical N2 disease [15] and, was proposed [17] or demanded [12] for pathological N2. Mediastinal lymphadenopathy was diagnosed as clinical N2, when the lymph node had a short diameter of greater than 1.0 cm on the CT image [15], or was confirmed pathological N2 by performing mediastinoscopy [10], [17]. Scarce information is available regarding clear up of immediate adjacent or clearly tumor involved nodes in particular of paraaortic, subaortic, and periesophageal nodes. These nodes represent regional disease (adjacent nodal metastases) of a centrally tumor with aortic invasion. The high numbers of unsuspected (nonimaged) N2 nodes in this study and unsettled (imaged) N2 disease in others is a glaring problem and may have been the result of an incomplete or inadequate pretherapy staging of the mediastinum. Another explanation is that because the series extend over long periods, modern diagnostic techniques (videoendoscopy; PET modalities; EBUS and EUS-FNA) were not available or were applied only exclusively at that time. Today, there is a strong demand for improved application of staging modalities, as is critical for selecting patients that may most benefit from an operation. However, we must be aware that the quality of staging frequently is limited for cases in which: (1) direct video-endoscopic access to subcarinal node, and para-/subaortic or periesophageal node might be prohibited by extension of the tumor itself; (2) identification of regional disease (adjacent mediastinal nodal metastasis) using PET scan modalities can be confounded by the intense hypermetabolic activity of a centrally located tumor [26]; (3) the routine use of EBUS or EUS-FNA without suspicious targets on PET and CT scans for N2 is unsafe [5]; and finally, (4) surgical exploration as a staging tool to select patients with potentially resectable, clinically staged T4 N0-1 lung cancer may lead to a risky and unfavorable discontinuous dissection of lung and aorta tumor structures, disregarding that in our opinion the surgeon should be able to evaluate the possibility of a radical resection before thoracotomy.

Given that even a "thorough" staging will not ultimately predict mediastinal N2 disease distinct multimodality treatment regimens disclosed a way out this dilemma: patients with a T4 NSCLC infiltrating the aorta, and with CT matched lymphadenopathy as clinical N2 disease showed after induction chemotherapy a marked reduction of lymphadenopathy and no metastasis on postoperative histologic examination. That indicated a possible downstaging in 7 out of 10 patients after therapy, and was associated with 5-year survivals of 70% for patients with N0 and 16.7%, respectively, for patients with persistent N2 or N3 disease [15]; alternatively, patients with T1-4

NSCLC and with integrated PET/CT microscopic unsuspected N2 disease who underwent complete resection, and were followed by adjuvant therapy (chemotherapy and radiotherapy), had 5-year survivals of 35% to 40% [5] which is at least threefold better than the average number oncologists quote for N2 disease. Although the studies are hardly comparable for several aspects, nevertheless the results obtained let us firmly believe that for a given heterogeneity of N2 disease patients may profit from a certain multimodality treatment concept and that there is a place of primary surgery for accurate staged limited N2 disease. However, as there is not at all clear that preoperative chemotherapy is actually better than postoperative chemotherapy further studies are needed. As affecting our current practice and based on our results we suggest the following treatment algorithm. Patients with a T4 tumor infiltrating the aorta, as confirmed by CT imaging, should routinely undergo PET-CT and mediastinoscopy, and further examinations, such as EUS-FNA or EBUS for suspicious targets identified by both CT scan and PET-CT. Patients who are N2 positive will get induction chemotherapy. Those N2 negatives will get a radical lung and aortic *en bloc* resection and systematic lymph node dissection. Patients with unsuspected N2 disease will have adjuvant chemotherapy, and in case of extracapsular or multistation N2 disease radiotherapy is added. Outcome is adversely affected by incomplete resection and recurrence [9], [12]. There is strong evidence that complete resection can have more favorable results [15], [17]. Two of our initial patients (case 9, 10) who underwent subadventitial aortic dissections had local tumor recurrences about 5 and 10 months after the operation. We suspected that local recurrence was due to lymphatic tumor cell propagation beyond the aortic adventitia. Furthermore we speculated that aortic dissection, even when proven a complete resection by intraoperative frozen section, fails to reach one fundamental of radical cancer surgery, i.e. resect at a distance of the tumor. That is why such a "shaving" procedure reflects a borderline potentially endolesional resection in patients with even minimal aortic involvement and, from a surgical point of view, risks a marginal, discontinuous and incomplete resection. In contrast to that radical *en bloc* resection of the tumor and invaded aorta has the uppermost potential for work out complete resection. Another 4 patients had systemic tumor relapse as a result of N1/2 disease. No patient with incomplete resection and local recurrence, systemic relapse, or had aortic subadventitial dissection survived more than 3 years. The most important results of this study derived long-term survival analysis. The N2 and N1 disease had obvious adverse implications on survival. Actually, single station N2 disease was found to have a much better prognosis than can be expected for more extended N2 disease. Consequently, it comes down to patient selection for which most accurate staging, at least with PET-CT and mediastinoscopy is a precondition. Not surprisingly, patients' survivals after complete aortic resection-reconstruction were found to be 67% at 5 years, with 2 patients surviving more than 5 years, which was

significantly better than that of aortic dissection patients ($p=0.001$), and is identical with a 70% 5-year survival of patients with preoperative chemotherapy reported by Ohta and colleagues [15].

In conclusion our results indicate that primary surgery is justified in selected patients with single station N2 non-small cell lung cancer and invasion of the descending aorta. There are clearly many legitimate ways to carry out such a complex operation. However, clamp-and-sew is an effective means of repair of the descending aorta with a calculated risk of spinal cord dysfunction. The data suggest that aortic resection-reconstruction is associated with better outcome than subadventitial dissection. Further studies should address the appropriate surgical technique and medical therapy whether preoperative chemotherapy ultimately improves outcome and survival, or is postoperative chemotherapy preferred.

Notes

Acknowledgements

The authors are thankful to Dr. Ludwig Lampl (Clinic Cardiovascular and Thoracic Surgery, Augsburg, Germany) for valuable assistance.

Conflicts of interest

None declared.

References

1. Burt ME, Pomerantz AH, Bains MS, McCormack PM, Kaiser LR, Hilaris BS, Martini N. Results of surgical treatment of stage III lung cancer invading the mediastinum. *Surg Clin North Am.* 1987;67(5):987-1000.
2. Martini N, Yellin A, Ginsberg RJ, Bains MS, Burt ME, McCormack PM, Rusch VW. Management of non-small cell lung cancer with direct mediastinal involvement. *Ann Thorac Surg.* 1994;58(5):1447-51.
3. Dartevelle PG, Herbert Sloan Lecture. Extended operations for the treatment of lung cancer. *Ann Thorac Surg.* 1997; 63(1):12-9.
4. Rice TW, Blackstone EH. Radical resections for T4 lung cancer. *Surg Clin North Am.* 2002;82(3):573-87. DOI: 10.1016/S0039-6109(02)00017-8
5. Cerfolio RJ, Bryant AS. Survival of patients with unsuspected N2 (stage IIIA) nonsmall-cell lung cancer. *Ann Thorac Surg.* 2008;86(2):362-6. DOI: 10.1016/j.athoracsur.2008.04.042
6. Rush VW. Aggressive surgery for lung cancer. *Thorac Surg Clin.* 2004;14(2):XI. DOI: 10.1016/S1547-4127(04)00014-3
7. Nakahara K, Ohno K, Mastumura A, Hirose H, Mastuda H, Nakano S, Shirakura R, Kawashima Y. Extended operation for lung cancer invading the aortic arch and superior vena cava. *J Thorac Cardiovasc Surg.* 1989;97:428-33.
8. Horita K, Itho T, Ueno T. Radical operation using cardiopulmonary bypass for lung cancer invading the aortic wall. *Thorac Cardiovasc Surg.* 1993;41(2):130-2. DOI: 10.1055/s-2007-1013839

9. Tsuchiya R, Asamura H, Kondo H, Goya T, Naruke T. Extended resection of the left atrium, great vessels, or both for lung cancer. *Ann Thorac Surg.* 1994;57(4):960-5.
10. Fukuse T, Wada H, Hitomi S. Extended operation for non-small cell lung cancer invading great vessels and left atrium. *Eur J Cardiothorac Surg.* 1997;11(4):664-9. DOI: 10.1016/S1010-7940(96)01140-2
11. Okubo K, Yagi K, Yokomise H, Inui K, Wada H, Hitomi S. Extensive resection with selective cerebral perfusion for a lung cancer invading the aortic arch. *Eur J Cardiothorac Surg.* 1996;10(5):389-91. DOI: 10.1016/S1010-7940(96)80101-1
12. Klepetko W, Wisser W, Birsan T, Mares P, Taghavi S, Kupilik N, Wolner E. T4 lung tumors with infiltration of the thoracic aorta: is an operation reasonable? *Ann Thorac Surg.* 1999;67(2):340-4. DOI: 10.1016/S0003-4975(98)01244-2
13. Bernard A, Bouchot O, Hagry O, Favre JP. Risk analysis and long-term survival in patients undergoing resection of T4 lung cancer. *Eur J Cardiothorac Surg.* 2001;20(2):344-9. DOI: 10.1016/S1010-7940(01)00788-6
14. Spaggiari L, D' Aiuto M, Veronesi G, Pelosi G, de Pas T, Catalano G, de Braud F. Extended pneumonectomy with partial resection of the left atrium, without cardiopulmonary bypass, for lung cancer. *Ann Thorac Surg.* 2005;79(1):234-40. DOI: 10.1016/j.athoracsur.2004.06.100
15. Ohta M, Hirabayashi H, Shiono H, Minami M, Maeda H, Takano H, Miyoshi S, Matsuda H. Surgical resection for lung cancer with infiltration of the thoracic aorta. *J Thorac Cardiovasc Surg.* 2005;129(4):804-8. DOI: 10.1016/j.jtcvs.2004.05.010
16. de Perrot M, Fadel E, Mussot S, de Palma A, Chapelier A, Dartevelle P. Resection of locally advanced (T4) non-small cell lung cancer with cardiopulmonary bypass. *Ann Thorac Surg.* 2005;79(5):1691-6. DOI: 10.1016/j.athoracsur.2004.10.028
17. Shiraishi T, Shirakusa T, Miyoshi T, Yamamoto S, Hiratsuka M, Iwasaki A, Kawahara K. Extended resection of T4 lung cancer with invasion of the aorta: is it justified? *Thorac Cardiovasc Surg.* 2005;53(6):375-9. DOI: 10.1055/s-2005-865678
18. Ponn RB, LoCicero J, Daly BDT. Surgical treatment of non-small cell lung cancer. In: Shields TW, LoCicero J, Ponn RB, Rusch VW, editors. *General thoracic surgery.* 6th ed. Philadelphia, Pennsylvania: Lippincott Williams & Wilkins, 2004. p.1548-87. Volume 2
19. Patterson GA. Extended pulmonary resections. In: Pearson FG, Cooper JD, Deslauriers J, et al, editors. *Thoracic surgery.* 2nd ed. New York, NY: Churchill Livingstone, 2002. p. 1045-61.
20. Biglioli P, Spirito R, Porqueddu M, Agrifoglio M, Pompilio G, Parolari A, Dainese L, Sisillo E. Quick, simple clamping technique in descending thoracic aortic aneurysm repair. *Ann Thorac Surg.* 1999;67(4):1038-44. DOI: 10.1016/S0003-4975(99)00146-0
21. Coselli JS, Plestis KA, La Francesca S, Cohen S. Results of contemporary surgical treatment of descending thoracic aortic aneurysms: experience in 198 patients. *Ann Vasc Surg.* 1996;10(2):131-7. DOI: 10.1007/BF02000756
22. Griep RB, Ergin MA, Galla JD, Lansman S, Khan N, Quintana C, McCollough J, Bodian C. Looking for the artery of Adamkiewicz: a quest to minimize paraplegia after operations for aneurysms of the descending aorta and thoracoabdominal aorta. *J Thorac Cardiovasc Surg.* 1996;112(5):1202-13. DOI: 10.1016/S0022-5223(96)70133-2
23. Koshino T, Murakami G, Morishita K, Mawatari T, Abe T. Does the Adamkiewicz artery originate from the larger segmental arteries? *J Thorac Cardiovasc Surg.* 1999;117(5):898-905. DOI: 10.1016/S0022-5223(99)70369-7
24. Morishita K, Fujisawa Y, Murakami G, Fujisawa Y, Kawaharada N, Fukada J, Saito T, Abe T. Anatomical study of blood supply to the spinal cord. *Ann Thorac Surg.* 2003;76(6):1967-71. DOI: 10.1016/S0003-4975(03)01254-2
25. Livesay JJ, Cooley DA, Ventemiglia RA, Montero CG, Warrian RK, Brown DM, Duncan JM. Surgical experience in descending thoracic aneurysmectomy with and without adjuncts to avoid ischemia. *Ann Thorac Surg.* 1985;39(0):37-46.
26. Lanuti N, Mathisen DJ. Carinal resection. *Thorac Surg Clin.* 2004;14(2):199-209. DOI: 10.1016/S1547-4127(04)00011-8

Corresponding author:

Dr. Peter Wex, MD
87764 Maria-Thann, Germany
epswmt@t-online.de

Please cite as

Wex P, Graeter T, Zaraca F, Haas V, Decker S, Bugdayev H, Ebner H. Surgical resection and survival of patients with unsuspected single node positive lung cancer (NSCLC) invading the descending aorta. *GMS Thorac Surg Sci.* 2009;6:Doc02.

This article is freely available from

<http://www.egms.de/en/journals/tss/2009-6/tss000016.shtml>

Published: 2009-07-14

Copyright

©2009 Wex et al. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by-nc-nd/3.0/deed.en>). You are free: to Share – to copy, distribute and transmit the work, provided the original author and source are credited.