Original Article

The effectiveness of surgical treatment of lung cancer in Polish academic and nonacademic centers

Marcin Zbytniewski[1]^, Grzegorz M. Gryszko[1]^, Marcin M. Cackowski[1]^, Anna W. Sienkiewicz-Ulita[1], Katarzyna Woźnica[2], Michał Dziedzic[3], Tadeusz M. Orłowski[1], Dariusz A. Dziedzic[1]^; on behalf of the Polish Lung Cancer Study Group (PLCSG)

[1]Department of Thoracic Surgery, National Research Institute of Chest Diseases, Warsaw, Poland; [2]Faculty of Mathematics and Information Science, Warsaw University of Technology, Warsaw, Poland; [3]Faculty of Medicine, Medical University of Gdansk, Gdansk, Poland

Contributions: (I) Conception and design: M Zbytniewski; (II) Administrative support: TM Orłowski, DA Dziedzic; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: M Zbytniewski, GM Gryszko, MM Cackowski, AW Sienkiewicz-Ulita, M Dziedzic; (V) Data analysis and interpretation: K Woźnica; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Dariusz A. Dziedzic, MD, PhD, DSc. Department of Thoracic Surgery, National Research Institute of Chest Diseases, Plocka Street 26, 01-138 Warsaw, Poland. Email: drdariuszdziedzic@gmail.com.

Background: The theoretical advantage of academic hospitals over nonacademic are: more qualified surgeons, adequate diagnostic facilities and infrastructure, including intensive care units. The aim of the study was to compare the effectiveness of surgical lung cancer treatment in academic (ACA) and nonacademic (non-ACA) centers.

Methods: This was a retrospective analysis of data from 31,777 patients surgically-treated for lung cancer during the period from 2007 to 2020 in 9 ACA and 21 non-ACA centers. The analysis considered the clinical data of patients, the effectiveness of preoperative diagnostics, the type of procedures performed, the complications, the postoperative mortality and the long-term survival.

Results: The median number of anatomical lung resection procedures was 1,218 for ACA and 550 for non-ACA centers. In the ACA group, resection using the video-assisted thoracic surgery (VATS) technique was performed significantly more often than in the non-ACA group (23.6% *vs.* 14.2%, P<0.001). The pN feature analysis showed significantly lower proportions of pNX (9.2%) in the ACA group than those in the non-ACA group (17.1%) (P<0.001). The rates of postoperative complications in the ACA and non-ACA groups were 30.7% and 33.8%, respectively (P<0.001). There were no significant differences in 5-year survival between the ACA and non-ACA groups (56% and 56%, respectively) (P=0.2).

Conclusions: The present study showed that ACA centers are characterized by better preoperative diagnostics, a higher percentage of VATS lobectomies, a lower percentage of postoperative complications and a shorter hospitalization period than non-ACA centers, but there was no impact on 5-year survival.

Keywords: Lung cancer; thoracic surgery; academic centers

Submitted Oct 18, 2022. Accepted for publication Apr 12, 2023. Published online Aug 14, 2023.
doi: 10.21037/tlcr-22-752
View this article at: https://dx.doi.org/10.21037/tlcr-22-752

^ ORCID: Marcin Zbytniewski, 0000-0002-5507-8812; Grzegorz M. Gryszko, 0000-0002-4257-4470; Marcin M. Cackowski, 0000-0002-3183-6789; Dariusz A. Dziedzic, 0000-0002-3931-8636.

© Translational Lung Cancer Research. All rights reserved.

Introduction

Of all malignancies, lung cancer is one of the leading causes of mortality. Each year, approximately 1.2 million people die from lung cancer, and the 5-year survival does not exceed 20% (1). For years, the treatment of choice for early-stage non-small-cell lung carcinoma (NSCLC) has been surgery, which includes tumor and lymph node resection (2). Not only overall survival but also factors such as shorter hospitalization, fewer postoperative complications and lower mortality are related to treatment (3-8). It has been debated for years whether these factors are affected by the volume, type of the hospital or by the experience of the surgeon (3-5,8). However, cut off values, which divide centers into higher and lower levels, have varied between studies and are not always well explained (8). Additionally, some studies in which the majority of surgeries were performed outside the United States did not confirm the impact of hospital volume on the efficacy of surgery for lung cancer (3-7).

Approximately 22,000 Poles are diagnosed with lung cancer each year, and it is the main cause of death in both sexes. Most patients with resectable lung cancer undergo surgery in high volume, accredited thoracic surgery departments. In Poland, the impact of hospital volume or academic status on lung cancer surgery efficacy has not yet been examined (9).

Highlight box

Key findings

- Academic centres are associated with better diagnostics, higher rates of minimally invasive surgery, fewer complications and shorter hospitalization. However, this does not translate into survival.

What is known and what is new?

- The theoretical advantage of academic hospitals over nonacademic are: more qualified surgeons, adequate diagnostic facilities and infrastructure, including intensive care units. The most common division in the literature is between high-volume and low-volume hospitals. The division into high- and low-volume hospitals does not correspond to the division into academic and nonacademic groups, as our results show. Despite the differences in preoperative diagnostics and operative complications, the long-term results are comparable.

What is the implication, and what should change now?

- More research should be done in different countries with heterogeneous lung cancer treatment systems. The differences resulting from the analysis between centers can be offset by an appropriate training system and financial support.

Most studies have examined the impact of the number of surgeries performed on treatment outcomes (10-13). In our study, we investigated the effect of academic (ACA) and nonacademic (non-ACA) status of hospitals on complications, mortality and survival. To our knowledge, this is the first sizable study that discusses this matter in our region of Europe. We present this article in accordance with the STROBE reporting checklist (available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-752/rc).

Methods

Ethical statement

This study was approved by the ethics committee of the National Research Institute of Chest Diseases, Warsaw, Poland (No. 96/2021). Patients signed an informed consent form to be included in the database. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Patients

The data were collected retrospectively from a database of the Polish Lung Cancer Study Group (PLCSG), which includes data from 30 thoracic surgery centers and contains information on every lung cancer surgery in Poland. Thoracic surgery centers are obliged to provide all information regarding patient data, advancement of the tumor, technique and extent of the surgery, complications and follow-up visits. All thoracic centers are required to collect data, which are transferred to the central register, stored and analyzed. A total of 31,777 patients who were surgically treated for NSCLC between 2007 and 2020 were included in the study. We divided the cohort based on the type of hospital. The ACA subgroup is defined as the highest referential center that participates in the training of specialists in the field of thoracic surgery or is dedicated to research activities. Additionally, ACA centers are often part of a university or medical school. Notably, the number of procedures performed each year does not correlate with the division into ACA and non-ACA subgroups. Based on these criteria, we identified 9 ACA centers with 16,345 patients and 21 non-ACA centers with 15,432 patients. The 8th edition of the TNM classification was used to define staging, whereas the lymph node stations were described using the International Association for the Study of Lung Cancer lymph node map (14,15).

© Translational Lung Cancer Research. All rights reserved.

Inclusion and exclusion criteria

The following patients were included in the study: operation between 2007 and 2020 with confirmed NSCLC who received radical surgery (R0) with at least 6 nodes retrieved according to the European Society of Thoracic Surgeons guidelines (2) and with complete data in the database. The following patients were excluded: non-radical resection (R1) or whose data were lost or who failed to complete follow-up.

Due to the small number of procedures or the lack of precise data on the scope of the procedure, we have excluded some specific surgical procedures (e.g., middle lobe, segment and wedge lobectomy).

Preoperative staging

Prior to the surgery, tumor staging in patients was assessed using the following tests: chest X-ray, computed tomography (CT) and magnetic resonance imaging. When the lymph nodes were enlarged more than 10 mm, the patients underwent more invasive procedures (such as endobronchial ultrasound with guided transbronchial needle aspiration (EBUS-TBNA), endoscopic ultrasound fine-needle aspiration, mediastinoscopy or mediastinotomy). Positron emission tomography-computed tomography (PET-CT) examination was not frequently performed in the first years of the study period (only 23% of patients from 2008–2010), but by the end of this period [2019–2020], the vast majority of patients (78%) had PET-CT before surgery.

Follow-up

The patients consulted with a surgeon within the first 3 weeks after surgery. Additionally, every 3–5 months for a period of 5 years, they reported for follow-up examinations, in which they had a chest X-ray, CT or PET-CT in justified cases. The pattern of failures were assessed using follow-up imaging studies and data obtained from procedures such as bronchoscopy, endobronchial ultrasound guided biopsy, endoscopic ultrasound fine-needle aspiration, transthoracic biopsy, mediastinoscopy, and mediastinotomy. Lymph node failure in the hilum or mediastinum was defined as a new or enlarging lymph node that showed excessive metabolism in PET-CT, or its short axis in CT was at least 10 mm.

Statistical analysis

In the data analysis, continuous variables were summarized using the mean and standard deviation as well as the median and range of values. Categorical variables were summarized using the frequency for each subgroup and the proportion of the considered population. Statistical significance of differences between the groups was determined using the Mann-Whitney *U*-test and Chi-squared test for continuous and categorical variables, respectively. Moreover, for every group and pathological N stage, the average number of lymph nodes involved and the examined lymph stations were reported. To assess the multivariable correlation between preoperative variables and the ACA and non-ACA groups, logistic regression was used. Survival curves were estimated with the Kaplan-Meier method, and the log-rank test was used to compare differences between groups. The Cox proportional hazards model was applied to univariable and multivariable analyses to determine the patients' risk of death. The selection of predictive variables was performed based on univariable models (P value <0.05). Based on these results, the following factors were determined to be important in the univariable analysis: sex, age, stage of lung cancer, pathological T stage, pathological N stage and surgical approach, resection type, histopathological recognition, mediastinoscopy, comorbidities [cardiac infarction, chronic obstructive pulmonary disease (COPD), coronary disease, circulatory system disorders and kidney disease], statistics for examination of N1 lymph station (number of examined nodes). All tests were two-sided, and a P value <0.05 was considered statistically significant. For pairwise comparisons of more than two groups, an FDR adjustment was applied. All analyses were performed using the survival and survminer packages in R software.

Results

Population characteristics

The study analyzed a cohort of 31,777 patients including 11,460 women (36.1%) and 20,317 men (63.9%). In the non-ACA group, a significantly higher percentage of patients had insulin-dependent diabetes (4.9% *vs.* 2.9%, P<0.001), nervous system disorders (1.4% *vs.* 0.4%, P<0.001) and hypertension (47.4% *vs.* 45.0%, P<0.001). However, in the ACA group, there was a significantly greater percentage of patients with COPD (26.4%

© Translational Lung Cancer Research. All rights reserved.

vs. 21.1%, P<0.001). The most frequently diagnosed histological type in both groups was adenocarcinoma [54.4% of patients in the ACA group, 52.2% of patients in the non-ACA group (P<0.001)]. In the ACA group, resection using the video-assisted thoracic surgery (VATS) was performed significantly more often than in the non-ACA group (23.6% *vs.* 14.2%, P<0.001). All clinical data is provided in *Table 1*.

Hospital characteristics

The median number of anatomical lung resection procedures performed per year for lung cancer during the period 2007–2020 was 97.5 for ACA (mean 133.98) and 54.5 for non-ACA (mean 66.5) (*Table 2*, *Figure 1*). In 3 out of 9 ACA hospitals, the number of annual resections exceeded

Table 1 Patient characteristic

Variable	Academic (N=16,345)	Nonacademic (N=15,432)	Overall (N=31,777)	P value
Age (years)				<0.001
Mean (SD)	64.6 (7.86)	64.3 (7.78)	64.4 (7.82)	
Median [Min, Max]	65.0 [22.0, 96.0]	64.0 [27.0, 88.0]	65.0 [22.0, 96.0]	
Sex, n (%)				<0.001
Female	6,142 (37.6)	5,318 (34.5)	11,460 (36.1)	
Male	10,203 (62.4)	10,114 (65.5)	20,317 (63.9)	
Stage, n (%)				<0.001
IA1	281 (1.7)	352 (2.3)	633 (2.0)	
IA2	1,995 (12.2)	1,903 (12.3)	3,898 (12.3)	
IA3	1,777 (10.9)	1,833 (11.9)	3,610 (11.4)	
IB	3,635 (22.2)	3,486 (22.6)	7,121 (22.4)	
IIA	1,255 (7.7)	1,310 (8.5)	2,565 (8.1)	
IIB	3,686 (22.6)	3,040 (19.7)	6,726 (21.2)	
IIIA	3,054 (18.7)	2,809 (18.2)	5,863 (18.5)	
IIIB	662 (4.1)	699 (4.5)	1,361 (4.3)	
Smoking, n (%)	10,896 (66.7)	11,456 (74.2)	22,352 (70.3)	<0.001
Comorbidities, n (%)				
Diabetes I	473 (2.9)	760 (4.9)	1,233 (3.9)	<0.001
Cardiac infarction	1,030 (6.3)	1,026 (6.6)	2,056 (6.5)	0.22
Nervous diseases	58 (0.4)	209 (1.4)	267 (0.8)	<0.001
Heart failure	412 (2.5)	393 (2.5)	805 (2.5)	0.91
Kidney failure	197 (1.2)	150 (1.0)	347 (1.1)	0.05
COPD	4,308 (26.4)	3,258 (21.1)	7,566 (23.8)	<0.001
Hypertension	7,349 (45.0)	7,320 (47.4)	14,669 (46.2)	<0.001
Coronary disease	1,206 (7.4)	1,148 (7.4)	2,354 (7.4)	0.85
FEV1 (L), mean (SD)	1.46 (1.26)	1.80 (1.16)	1.63 (1.22)	<0.001
FVC (L), mean (SD)	2.02 (1.75)	2.50 (1.61)	2.26 (1.70)	<0.001
cT, n (%)				<0.001
0	12 (0.1)	8 (0.1)	20 (0.1)	
1	6,439 (39.4)	5,511 (35.7)	11,950 (37.6)	

Table 1 (*continued*)

© Translational Lung Cancer Research. All rights reserved.

Table 1 (*continued*)

Variable	Academic (N=16,345)	Nonacademic (N=15,432)	Overall (N=31,777)	P value
2	8,489 (51.9)	8,156 (52.9)	16,645 (52.4)	
3	1,183 (7.2)	1,312 (8.5)	2,495 (7.9)	
4	222 (1.4)	445 (2.9)	667 (2.1)	
cN, n (%)				<0.001
0	13,151 (80.5)	11,775 (76.3)	24,926 (78.4)	
1	2,108 (12.9)	1,920 (12.4)	4,028 (12.7)	
2	1,086 (6.6)	1,737 (11.3)	2,823 (8.9)	
pT, n (%)				<0.001
1a	307 (1.9)	390 (2.5)	697 (2.2)	
1b	2,328 (14.2)	2,186 (14.2)	4,514 (14.2)	
1c	2,279 (13.9)	2,253 (14.6)	4,532 (14.3)	
2a	5,097 (31.2)	4,716 (30.6)	9,813 (30.9)	
2b	1,978 (12.1)	1,920 (12.4)	3,898 (12.3)	
3	2,880 (17.6)	2,541 (16.5)	5,421 (17.1)	
4	1,476 (9.0)	1,426 (9.2)	2,902 (9.1)	
pN, n (%)				<0.001
0	10,343 (63.3)	9,280 (60.1)	19,623 (61.8)	
1	2,825 (17.3)	1,924 (12.5)	4,749 (14.9)	
2	1,676 (10.3)	1,593 (10.3)	3,269 (10.3)	
X	1,501 (9.2)	2,635 (17.1)	4,136 (13.0)	
PET-CT, n (%)	8,140 (49.8)	5,108 (33.1)	13,248 (41.7)	<0.001
EBUS-TBNA, n (%)	4,985 (30.5)	2,531 (16.4)	7,516 (23.7)	<0.001
Mediastinoscopy, n (%)	861 (5.3)	731 (4.7)	1,592 (5.0)	0.03
Chemotherapy/radiotherapy, n (%)	5,002 (30.6)	3,858 (25.0)	8,860 (27.9)	0.06
Extent of resection, n (%)				<0.001
Lower lobectomy	5,261 (32.2)	4,836 (31.3)	10,097 (31.8)	
Upper lobectomy	9,184 (56.2)	8,213 (53.2)	17,397 (54.7)	
Pneumonectomy	1,900 (11.6)	2,383 (15.4)	4,283 (13.5)	
Approach, n (%)				<0.001
Thoracotomy	12,482 (76.4)	13,244 (85.8)	25,726 (81.0)	
VATS	3,863 (23.6)	2,188 (14.2)	6,051 (19.0)	
Histopathology, n (%)				<0.001
Adenocarcinoma	8,891 (54.4)	8,048 (52.2)	16,939 (53.3)	
Squamous	7,454 (45.6)	7,384 (47.8)	14,838 (46.7)	

SD, standard deviation; COPD, chronic obstructive pulmonary disease; EBUS-TBNA, endobronchial ultrasound-guided transbronchial needle aspiration; FEV1, forced expiratory volume in one second; FVC, forced vital capacity; PET-CT, positron emission tomography-computed tomography; VATS, video-assisted thoracic surgery.

© Translational Lung Cancer Research. All rights reserved.

Table 2 Number of procedures per year in academic and nonacademic centers

Year	Academic		Nonacademic	
	Mean	Median	Mean	Median
2007	111.1	92	62.1	55
2008	104.9	81	65.7	62.5
2009	108.3	72	61.5	57
2010	122.9	96	65.4	58
2011	128.3	86	64.7	47
2012	126.9	83	71.2	58.5
2013	123.9	69	70.6	53.5
2014	141.6	89.5	68.4	60
2015	161.1	109.5	72.2	49
2016	146.7	94	73.0	48.5
2017	158.7	124	70.9	50.5
2018	154.6	140	69.2	51
2019	162.1	124	60.5	43.5
2020	130.3	122.5	55.1	38.5
Overall	134.0	97.5	66.5	54.5

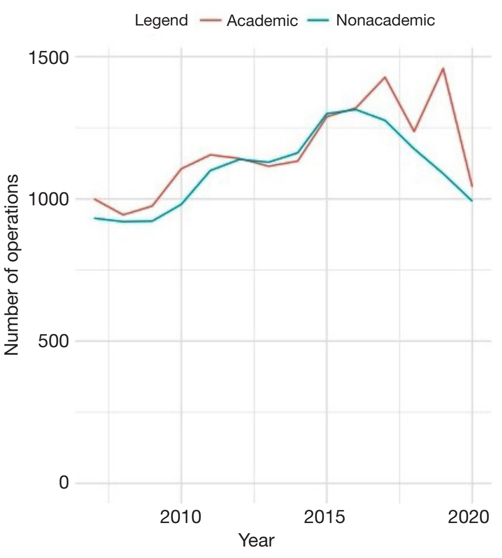

Figure 1 Number of operations per year in academic and nonacademic centers.

200 procedures during the period 2013–2019. In the non-ACA group, only 1 out of 21 hospitals, over 200 procedures were performed annually from 2015 to 2018.

Preoperative work-up and postoperative staging

In the ACA group, preoperative diagnostics included PET-CT and EBUS-TBNA in 49.8% and 30.5% of patients, respectively, and these values were significantly higher than those in the non-ACA group (33.1% and 16.4%, respectively, P<0.001). The pN feature analysis in the ACA group showed significantly lower proportions of pNx than those in the non-ACA group (9.2% *vs.* 17.1%, respectively, P<0.001).

According to results of logistic regression, patients with COPD, higher pT stage, higher pN stage, histology of squamous-cell cancer, higher number of N1 or N2 lymph nodes examined, or qualified for VATS; were more likely to

© Translational Lung Cancer Research. All rights reserved.

be operated in ACA (P<0.01). See Table S1.

Postoperative morbidity and mortality

The rates of postoperative complications in the ACA and non-ACA groups were 30.7% and 33.8%, respectively (P<0.001). Mortality during hospitalization for the ACA and non-ACA groups was 1.1% and 1.2%, respectively (P=0.62). In the non-ACA group, the mean number of days from surgery to discharge and the entire period of hospitalization was significantly higher than those in the ACA group (9.26 and 14.0 days *vs.* 7.94 and 12.8 days, respectively, P<0.001). Detailed data are presented in *Table 3*.

Overall survival

The median follow-up time for the entire group was 2,369 days. Overall, the 5-year survival was not significantly different (P=0.2) between the ACA (56%) and the non-ACA group (56%) (*Figure 2*). Regarding the type of surgery, significantly worse long-term results were found for pneumonectomy than for upper and lower lobectomies (41%, 60% and 56%, P<0.001, respectively). The survival rates for pN0, pN1 and pN2 in the ACA *vs.* non-ACA groups were 64% *vs.* 63% (P=0.02), 45% *vs.* 47% (P=0.08), and 33% *vs.* 31%, respectively (P=0.36). With regard to the pT feature, no significant differences were found between the groups at any stage except pT2a. All survival data are presented in *Table 4*. Detailed data on 5-year survival regarding clinical and pathological stage are presented in Table S2 and Figure S1.

Discussion

The indicators determining the results of the treatment are the percentage of postoperative complications, mortality and long-term survival depending on the stage of advancement (3-8). Theoretically, academic hospitals have an advantage over nonacademic hospitals in that they have a more highly qualified staff of surgeons and appropriate diagnostic facilities and infrastructure, including intensive care units. In the literature, the most common division is between high-volume and low-volume hospitals, but the appropriate number of treatments per year has not been established thus far (3-5). The division into high-volume and low-volume hospitals does not correspond to the division into ACA and non-ACA groups, as shown in our results. The study by Bernard *et al.* showed that a statistically significant threshold for the number of procedures is 70 resections per year, where the risk of death within 30 days decreases by 31% compared with centers performing <10 operations. Of these, 60% of university hospitals were classified as high volume (<70), whereas only 5.6% of nonacademic hospitals were included in this group (10). However, the work of Lüchtenborg *et al.* showed that in centers with a volume ≥150 resections per year, the risk of survival was significantly decreased compared with centers with <70 resections per year, particularly in the early postoperative period (11). Similar results were presented by Møller *et al.*, who found that mortality statistically significantly decreased in centers with >190 procedures per year compared with those performing 77–112 resections (12). A different view was presented by Schillemans *et al.*, which stated that the significant risk of death within 2 months of surgery increases by 13% with <10 resections, but showed no difference above 10 procedures. Similarly, 3-year survival with <10 treatments is significantly worse, whereas >10 treatments showed no significant improvement (13). In the meta-analysis by von Meyenfeldt *et al.* covering 19 studies, centers performing <5 and even <60 resections qualified as low-volume centers. The cut-off value for high-volume hospitals varied from >20 to >129.4 procedures per year (8). In this study, it was shown that survival is better in high-volume hospitals; however, it did not reach statistical significance.

The data cited above still do not answer the question of what impact teaching facilities (TF) have on the results of surgical treatment of lung cancer. In a study by Cheung *et al.*, the results of treatment in centers with TF and nonteaching facilities (NTF) were analyzed. In the TF centers, a higher percentage of patients were treated for arterial hypertension, congestive heart failure, cardiac arrhythmias, rheumatoid arthritis, and chronic pulmonary disorders (16). In the current study, in the non-ACA group corresponding to NTF, a higher percentage of patients had insulin-dependent diabetes, nervous system disorders and arterial hypertension. However, the ACA group showed a higher percentage of COPD patients. Similarly, differences in nicotine consumption were shown with a predominance in the non-ACA group.

As in the previously cited study, more patients were operated on in ACA centers with locally advanced lung cancer, but the rate of pneumonectomy was lower than that in non-ACA centers (11.6% *vs.* 15.4%, P<0.001). In the study by Cheung *et al.*, the rates of pneumonectomy in TF and NTF were 10.9% and 14.1%, respectively

© Translational Lung Cancer Research. All rights reserved.

Table 3 Complication rates and length of stay in academic and nonacademic hospitals

Complication	Academic (n=16,345)	Nonacademic (n=15,432)	P value
Any, n (%)	5,022 (30.7)	5,209 (33.8)	<0.001
In hospital mortality, n (%)	178 (1.1)	178 (1.2)	0.62
Hemorrhage requiring reoperation, n (%)	140 (0.9)	180 (1.2)	0.007
Hemothorax requiring reoperation, n (%)	237 (1.5)	145 (0.9)	<0.001
Perioperative blood transfusion, n (%)	1,110 (6.8)	1,913 (12.4)	<0.001
Atrial arrhythmia requiring treatment, n (%)	1,057 (6.5)	870 (5.6)	0.002
Ventricular arrhythmia requiring treatment, n (%)	130 (0.8)	67 (0.4)	<0.001
Atelectasis requiring suction, n (%)	654 (4.0)	542 (3.5)	0.02
Late bronchial fistula (>6 days), n (%)	85 (0.5)	51 (0.3)	0.012
Residual air space, n (%)	506 (3.1)	320 (2.1)	<0.001
Wound infection, n (%)	57 (0.3)	124 (0.8)	<0.001
Pleural empyema without fistula, n (%)	49 (0.3)	36 (0.2)	0.3
Prolonged air leak, n (%)	1,377 (8.4)	1,166 (7.6)	0.005
Tracheostomy, n (%)	80 (0.5)	66 (0.4)	0.47
Acute coronary syndrome, n (%)	35 (0.2)	51 (0.3)	0.06
Other respiratory complications, n (%)	199 (1.2)	309 (2.0)	<0.001
Urinary tract infection, n (%)	15 (0.1)	35 (0.2)	0.004
Other cardiovascular complication, n (%)	103 (0.6)	157 (1.0)	<0.001
Chylothorax, n (%)	31 (0.2)	18 (0.1)	0.13
Recurrent laryngeal nerve palsy, n (%)	24 (0.1)	53 (0.3)	<0.001
Drain removal postoperative day			0.003
Mean (SD)	3.68 (2.44)	3.84 (2.87)	
Median [Min, Max]	3.00 [0, 26.0]	3.00 [0, 27.0]	
Length of hospital stay (days)			<0.001
Mean (SD)	12.8 (11.3)	14.0 (15.0)	
Median [Min, Max]	11.0 [0, 311]	11.0 [0, 337]	
Discharge postoperative day			<0.001
Mean (SD)	7.94 (8.22)	9.26 (9.58)	
Median [Min, Max]	6.00 [0, 310]	7.00 [0, 302]	

SD, standard deviation.

(P<0.001) (16). However, in the work of Sioris *et al.*, in both groups, the rate of pneumonectomy was similar, although it occurred at an unexpectedly high level (27.7% *vs.* 27.2%) (7). In the present study, a significantly higher percentage of patients treated at ACA centers underwent VATS surgery. There were statistically significant differences with a predominance in the percentage of patients who underwent PET-CT and EBUS-TBNA in the ACA group. The demonstrated differences undoubtedly influenced the higher percentage of pNx in the non-ACA group.

The present study showed a significantly higher

© Translational Lung Cancer Research. All rights reserved.

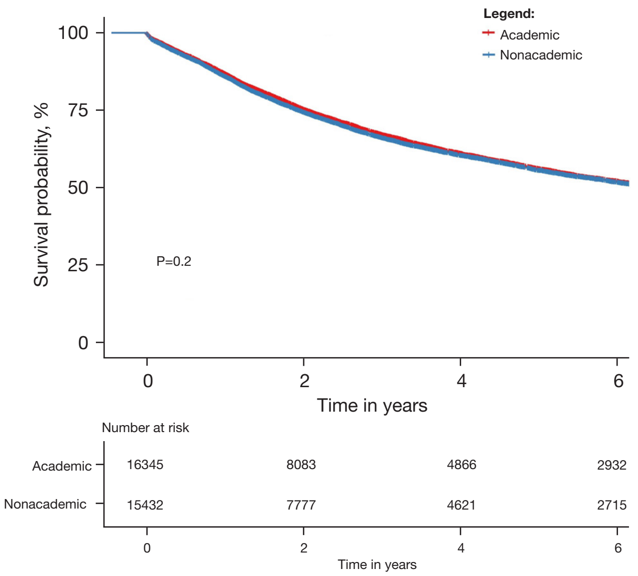

Figure 2 Impact of the type of hospital on overall survival.

Table 4 5-year overall survival rates [95% CI] of the patients

Subgroup	Academic (%)	Nonacademic (%)	P value
pN descriptor			
pN0	64 [63–65]	63 [62–64]	0.02
pN1	45 [43–47]	47 [44–50]	0.08
pN2	33 [31–36]	31 [28–34]	0.36
pNx	53 [50–56]	54 [51–56]	0.72
pT descriptor			
pT1a	75 [68–83]	75 [68–83]	0.58
pT1b	72 [69–74]	72 [69–74]	0.9
pT1c	63 [60–66]	64 [62–67]	0.59
pT2a	59 [57–61]	56 [54–58]	0.048
pT2b	51 [48–54]	53 [50–56]	0.81
pT3	47 [45–50]	45 [43–48]	0.1
pT4	36 [33–40]	39 [36–42]	0.5

CI, confidence interval.

complication rate in the non-ACA group than in the ACA group, but without significant differences in mortality. However, in the ACA group, a reduction in hospitalization time and postoperative stay was found. In the study by Meguid *et al.*, the percentage of fatal complications during hospitalization was significantly higher in teaching hospitals than in nonteaching hospitals (9.9% *vs.* 8.1%, respectively, P<0.001) and was highest in the group of patients who underwent pneumonectomy (7.6% *vs.* 9.5%, P=0.025) with the rate of pneumonectomy being lower than in the present study (9.9% and 8.1%) (17).

In the meta-analysis by Attaar *et al.* the main reasons for prolonged air leak are decreased spirometric values and smoking (18). Patients operated on in ACA centers had statistically more pronounced prolonged air leak than in non-ACA centers. Moreover, lower spirometric values were noted in ACA compared to non-ACA group, and the number of COPD patients was greater in the ACA group. On the other hand, the number of smokers was statistically higher in the case of patients operated on in nonacademic centers.

Long-term survival is undoubtedly the key parameter for assessing the influence of the type of center on the quality of surgical treatment of lung cancer. In a study by Bach *et al.*, significantly higher 5-year survival was found in teaching hospitals (42% *vs.* 34%, P<0.001) (19). Similar conclusions have been reached in most studies devoted to this topic (8,10). Most studies show a rather strong correlation between long-term survival and the volume of operations performed in a given center (13). However, in our study, 5-year survival was not significantly different in ACA and non-ACA centers, despite significant differences in postoperative staging between the groups.

Despite the differences in perioperative care in both types of centers, the long-term results were similar. There are undoubtedly visible shortcomings in preoperative diagnostics in non-ACA centers, manifested as limited access to PET-CT and EBUS-TBNA. There are also visible shortcomings in the training of surgeons, resulting in a much lower rate of VATS surgery. This, in turn, translates into a higher percentage of postoperative complications and longer hospitalizations.

The present work has several important limitations. First, it is a retrospective study based on data from the PLCSG surveys, which entails the possibility of errors in the analyzed data. The study also did not consider the volume in individual centers, and as we showed, the division into ACA and non-ACA centers did not correspond to the division into high-volume and low-volume hospitals. Moreover, the analysis conducted in our study is based on the Polish system of organizing chest surgery centers, in which lung cancer surgery is performed only by specialists in the field of thoracic surgery. Therefore, the conclusions resulting from this analysis cannot be generalized to

© Translational Lung Cancer Research. All rights reserved.

organizational systems in other countries, although a high degree of similarity is certainly visible.

Conclusions

In summary, the present study showed that ACA centers are characterized by better preoperative diagnostics, a higher rate of VATS, a lower percentage of postoperative complications and a shorter hospitalization than non-ACA centers. However, there were no statistically significant differences in 5-year survival.

Acknowledgments

Principal investigators of institutions participating in this study include Piotr Gabryel (Poznan University of Medical Sciences, Poznan, Poland), Piotr Rudzinski (National Research Institute of Chest Diseases, Warsaw, Poland), Robert Wlodarczyk (National Cancer Center, Warsaw, Poland), Wojciech Laudanski (Bialystok University of Medical Sciences, Bialystok, Poland), Tomasz Marjanski (Medical University of Gdansk, Gdansk, Poland), Krzysztof Buczynski (Lublin University of Medical Science, Lublin, Poland), Konrad Pawelczyk (Lower Silesia Center of Lung Diseases, Wroclaw, Poland), Roman Lewandowski (Zabrze Medical University of Silesia, Katowice, Poland), Marcin Wawrzycki (Lodz University of Medical Science, Lodz, Poland), Andrzej Bala (Department of Thoracic Surgery, Bydgoszcz, Poland), Krzysztof Brulinski (Center of Pulmonology and Thoracic Surgery, Bystra Slaska, Poland), Arkadiusz Gebski (Department of Thoracic Surgery, Czerwona Gora, Poland), Piotr Talar (Krakow University of Medical Sciences, Krakow, Poland), Mariusz Lochowski (Department of Thoracic Surgery, Lodz, Poland), Janusz Golota (Olsztyn University of Medical Science, Olsztyn, Poland), Anna Zel (Center of Lung Diseases, Otwock, Poland), Dariusz Preis (Department of Thoracic Surgery, Prabuty, Poland), Kazimierz Wojtun, Janusz Rybka, Adam Lis, Grzegorz Kobak (Center of Lung Diseases, Rzeszow, Poland), Michal Bielewicz (Szczecin University of Medical Sciences, Szczecin, Poland), Pawel Pryszczek (Department of Thoracic Surgery, Zielona Gora, Poland), Michal Wilkojc (Department of Thoracic Surgery, Zakopane, Poland), Mariusz Bella (Bydgoszcz University of Medical Sciences, Bydgoszcz, Poland), Mariusz Chabowski (Military Clinical Hospital with Polyclinic, Wroclaw, Poland), and Joanna Nogaj (Kielce University of Medical Science, Kielce, Poland).

Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-752/rc

Data Sharing Statement: Available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-752/dss

Peer Review File: Available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-752/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-752/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee of the National Research Institute of Chest Diseases, Warsaw, Poland (No. 96/2021), and patients signed an informed consent form to be included in the database.

Open Access Statement: This is an Open Access article distributed in accordance with the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 International License (CC BY-NC-ND 4.0), which permits the non-commercial replication and distribution of the article with the strict proviso that no changes or edits are made and the original work is properly cited (including links to both the formal publication through the relevant DOI and the license). See: https://creativecommons.org/licenses/by-nc-nd/4.0/.

References

1. Cronin KA, Lake AJ, Scott S, et al. Annual Report to the Nation on the Status of Cancer, part I: National cancer statistics. Cancer 2018;124:2785-800.
2. Lardinois D, De Leyn P, Van Schil P, et al. ESTS guidelines for intraoperative lymph node staging in non-small cell lung cancer. Eur J Cardiothorac Surg

© Translational Lung Cancer Research. All rights reserved.

2006;30:787-92.
3. Freixinet JL, Julià-Serdà G, Rodríguez PM, et al. Hospital volume: operative morbidity, mortality and survival in thoracotomy for lung cancer. A Spanish multicenter study of 2994 cases. Eur J Cardiothorac Surg 2006;29:20-5.
4. Kozower BD, Stukenborg GJ. The relationship between hospital lung cancer resection volume and patient mortality risk. Ann Surg 2011;254:1032-7.
5. Lien YC, Huang MT, Lin HC. Association between surgeon and hospital volume and in-hospital fatalities after lung cancer resections: the experience of an Asian country. Ann Thorac Surg 2007;83:1837-43.
6. Otake H, Yasunaga H, Horiguchi H, et al. Impact of hospital volume on chest tube duration, length of stay, and mortality after lobectomy. Ann Thorac Surg 2011;92:1069-74.
7. Sioris T, Sihvo E, Sankila R, et al. Effect of surgical volume and hospital type on outcome in non-small cell lung cancer surgery: a Finnish population-based study. Lung Cancer 2008;59:119-25.
8. von Meyenfeldt EM, Gooiker GA, van Gijn W, et al. The relationship between volume or surgeon specialty and outcome in the surgical treatment of lung cancer: a systematic review and meta-analysis. J Thorac Oncol 2012;7:1170-8.
9. Adamek M, Biernat W, Chorostowska-Wynimko J, et al. Lung Cancer in Poland. J Thorac Oncol 2020;15:1271-6.
10. Bernard A, Cottenet J, Mariet AS, et al. Is an activity volume threshold really realistic for lung cancer resection? J Thorac Dis 2018;10:5685-94.
11. Lüchtenborg M, Riaz SP, Coupland VH, et al. High procedure volume is strongly associated with improved survival after lung cancer surgery. J Clin Oncol 2013;31:3141-6.
12. Møller H, Riaz SP, Holmberg L, et al. High lung cancer surgical procedure volume is associated with shorter length of stay and lower risks of re-admission and death: National cohort analysis in England. Eur J Cancer 2016;64:32-43.
13. Schillemans V, Vrijens F, De Gendt C, et al. Association between surgical volume and post-operative mortality and survival after surgical resection in lung cancer in Belgium: A population-based study. Eur J Surg Oncol 2019;45:2443-50.
14. Asamura H, Chansky K, Crowley J, et al. The International Association for the Study of Lung Cancer Lung Cancer Staging Project: Proposals for the Revision of the N Descriptors in the Forthcoming 8th Edition of the TNM Classification for Lung Cancer. J Thorac Oncol 2015;10:1675-84.
15. Brierley J, Gospodarowicz MK, Wittekind CH. TNM classification of malignant tumours 2017. ISBN 978-83-65797-37-7.
16. Cheung MC, Hamilton K, Sherman R, et al. Impact of teaching facility status and high-volume centers on outcomes for lung cancer resection: an examination of 13,469 surgical patients. Ann Surg Oncol 2009;16:3-13.
17. Meguid RA, Brooke BS, Chang DC, et al. Are surgical outcomes for lung cancer resections improved at teaching hospitals? Ann Thorac Surg 2008;85:1015-24; discussion 1024-5.
18. Attaar A, Tam V, Nason KS. Risk Factors for Prolonged Air Leak After Pulmonary Resection: A Systematic Review and Meta-analysis. Ann Surg 2020;271:834-44.
19. Bach PB, Cramer LD, Schrag D, et al. The influence of hospital volume on survival after resection for lung cancer. N Engl J Med 2001;345:181-8.

Cite this article as: Zbytniewski M, Gryszko GM, Cackowski MM, Sienkiewicz-Ulita AW, Woźnica K, Dziedzic M, Orłowski TM, Dziedzic DA; on behalf of the Polish Lung Cancer Study Group (PLCSG). The effectiveness of surgical treatment of lung cancer in Polish academic and nonacademic centers. Transl Lung Cancer Res 2023;12(8):1717-1727. doi: 10.21037/tlcr-22-752

© Translational Lung Cancer Research. All rights reserved.

Supplementary

Table S1 Results of logistic regression

Variable	Value	Lower confidence	Upper confidence	P value
(Intercept)	−1.59	−1.82	−1.35	<0.01
Age	0.00	0.00	0.00	0.41
Sex	−0.06	−0.11	−0.01	0.02
Stage	−0.11	−0.13	−0.08	<0.01
Smoking	−0.35	−0.40	−0.30	<0.01
Diabetes type 1	−0.56	−0.69	−0.43	<0.01
Cardiac infarction	0.00	−0.10	0.10	0.99
Neurological diseases	−1.31	−1.63	−1.01	<0.01
Heart failure	−0.05	−0.20	0.11	0.54
Kidney failure	0.16	−0.07	0.40	0.17
Chronic obstructive pulmonary disease	0.34	0.28	0.39	<0.01
Hypertension	−0.14	−0.19	−0.09	<0.01
Coronary disease	−0.05	−0.14	0.05	0.31
pT	0.15	0.12	0.17	<0.01
pN	0.27	0.24	0.30	<0.01
Upper lobectomy	−0.04	−0.09	0.02	0.17
Pneumonectomy	0.01	−0.07	0.10	0.75
Video-assisted thoracic surgery	0.70	0.63	0.76	<0.01
Squamous cell carcinoma	0.08	0.03	0.13	<0.01
Mediastinoscopy	−0.10	−0.21	0.02	0.09
Sum of N1 examined nodes	0.89	0.85	0.92	<0.01
Sum of N2 examined nodes	−0.07	−0.08	−0.05	<0.01

© Translational Lung Cancer Research. All rights reserved.
https://dx.doi.org/10.21037/tlcr-22-752

Table S2 5-year overall survival rates [95% CI] of the patients

Subgroup	Academic (%)	Nonacademic (%)	P value
Clinical stage descriptor			
IA	66 [65–68]	69 [67–71]	0.13
IB	54 [53–56]	53 [51–54]	0.1
IIA	57 [52–64]	61 [55–68]	0.05
IIB	47 [44–49]	48 [45–50]	0.63
IIIA	47 [44–50]	45 [43–48]	0.41
IIIB	46 [39–54]	51 [45–58]	0.28
IV	37 [23–58]	51 [41–64]	0.32
Pathological stage descriptor			
IA1	79 [72–87]	77 [70–85]	0.76
IA2	75 [72–78]	74 [71–77]	0.68
IA3	67 [64–70]	69 [67–72]	0.71
IB	66 [64–68]	63 [61–65]	0.03
IIA	58 [55–62]	59 [56–62]	0.21
IIB	52 [50–54]	50 [48–52]	0.16
IIIA	37 [35–40]	39 [37–41]	0.22
IIIB	27 [23–32]	26 [22–30]	0.3

CI, confidence interval.

© Translational Lung Cancer Research. All rights reserved.
https://dx.doi.org/10.21037/tlcr-22-752

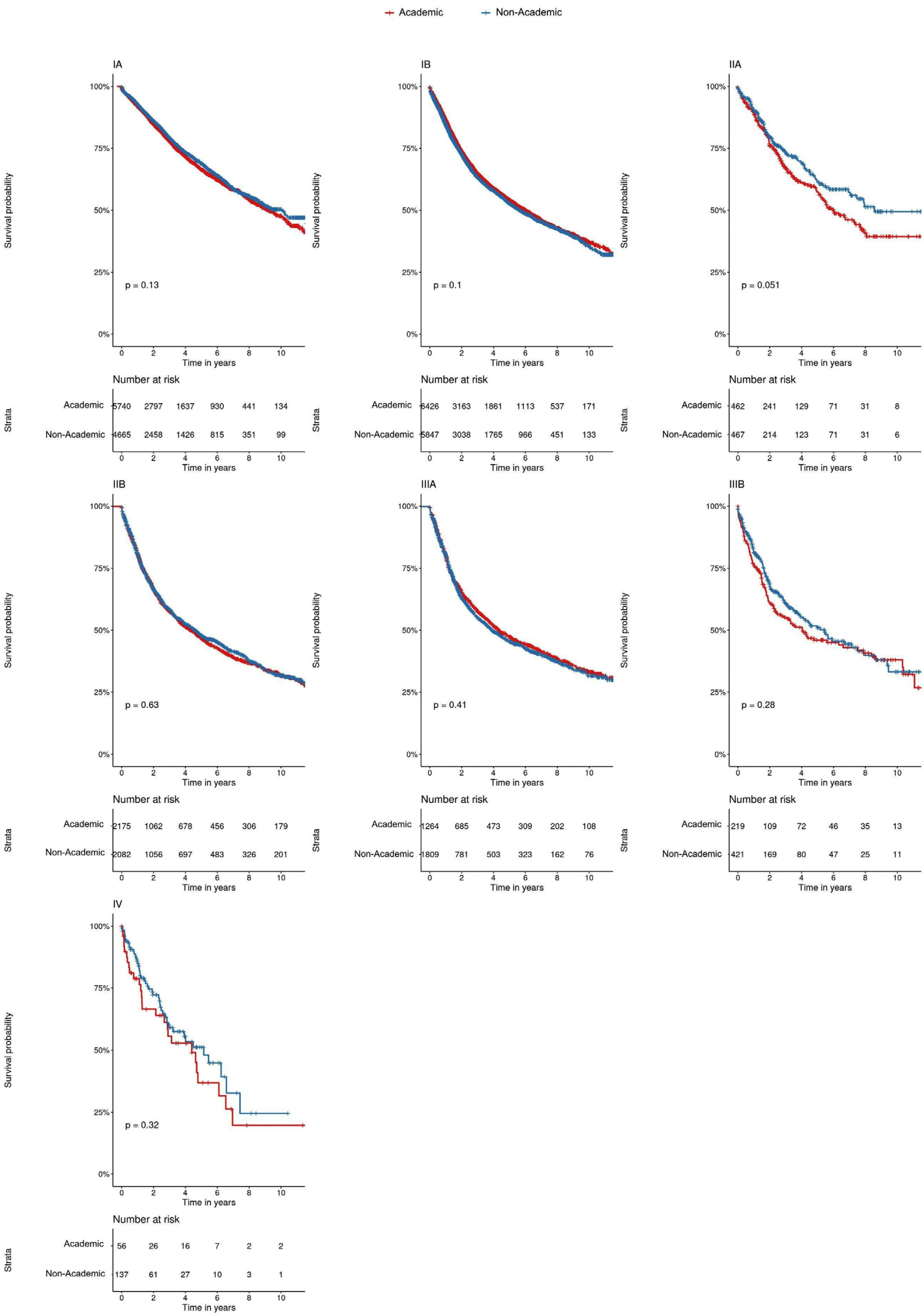

Figure S1 5-year survival rates (95% CI) of the patients regarding clinical stage.

© Translational Lung Cancer Research. All rights reserved.