

Results of the Austrian National Lung Cancer Audit

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ABSTRACT

OBJECTIVES: The Austrian Lung Cancer Audit (ALCA) is a pilot study to evaluate clinical and organizational factors related to lung cancer care across Austria.

MATERIALS AND METHODS: The ALCA is a prospective, observational, noninterventional cohort study conducted in 17 departments in Austria between September 2013 and March 2015. Participating departments were selected based on an annual case load of >50 patients with lung cancer.

RESULTS: The ALCA included 745 patients, representing 50.5% of all newly diagnosed cancer cases during that time period. In 75.8% of patients, diagnosis was based on histology, and in 24.2% on cytology; 83.1% had non-small-cell lung cancer, 16.9% small-cell lung cancer; and only 4.6% had to be classified as not otherwise specified cancers. The median time elapsed between first presentation at hospital and diagnosis was 8 days (interquartile range [IQR]: 4–15; range: 0–132); between diagnosis and start of treatment it was 15 days for chemotherapy (IQR: 9–27; range: 0–83), 21 days (IQR: 10–35; range: 0–69) for radiotherapy, and 24 days (IQR: 11–36; range: 0–138) for surgery, respectively. In 150 patients undergoing surgical treatment, only 3 (2.0%; n = 147, 3 missings) were seen with postoperative restaging indicating unjustified surgery. One-year follow-up data were available for 723 patients, indicating excellent 49.8% survival; however, a wide range of survival between departments (range: 37.8–66.7) was seen.

CONCLUSIONS: The ALCA conducted in high case load departments indicated management of lung cancer in accordance with international guidelines, and overall excellent 1-year survival.

KEYWORDS: Lung cancer, audit, quality of care, outcomes research

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Introduction

Lung cancer is the second most frequent cancer in Austria with a reported incidence of 4650 new cases in 2013.¹ Timely diagnosis including histological and/or cytological assessment including molecular profiling; accurate tumor, node, metastasis (TNM) staging; as well as treatment in accordance with guidelines is important to improve patients' quantity and quality of life. Over the last years, several lung cancer audits have been done, in particular, in the United Kingdom, highlighting important information about the delivery of care to patients. These audits have shown that the quality of care varies widely between hospitals and is frequently not in accordance with published guidelines. However, no such data exist for Austria.

Therefore, the Austrian Lung Cancer Group (ALCG) developed and directed the first Austrian Lung Cancer Audit (ALCA) to evaluate clinical and organizational factors related to lung cancer care across Austria. In particular, the audit aimed to describe hospital resources, patient characteristics, clinical interventions, patients' outcomes, and adherence to international guidelines for lung cancer care.

Materials and Methods

Study design

The ALCA was designed as a prospective, observational, noninterventional cohort study conducted between September 2013 and March 2015. A total of 17 respiratory and oncology departments with an annual case load of more than 50 patients participated. Over a 3- to 5-month period, all patients suspected with lung cancer and referred to one of the participating departments for diagnostic workup and treatment were enrolled. After 1 year of follow-up, survival and tumor recurrence was evaluated. The ALCA followed the Declaration of Helsinki. Patients were required to provide informed consent; the number of patients declining consent was not documented. At the time of the conduct of this audit, Austrian law did not require ethics committee approval for this type of study analyzing existing data from a database in an anonymized form.

The ALCG directed the audit, named a steering committee, and appointed a manager to organize and facilitate data collection at each site. After screening the recent literature, the steering committee initiated a Delphi process, identified and formulated key criteria for good quality of lung cancer care,²⁻⁵ and designed a web-based questionnaire to collect departmental and hospital resources, and patient data. Overall, patient demographics and lung cancer characteristics, resources available in participating departments, and parameters indicating quality of care were assessed, that is, methods used for lung cancer diagnosis, staging and treatment, time elapsed between diagnosis and start of treatment, and access to tumor boards and other variables.

Statistical analysis

All statistical analyses were performed with IBM SPSS Statistics 25, while only descriptive statistics were applied: mean, median, interquartile range (IQR), SD, range for continuous efforts, and frequency and percentage for categorical variables. Ranges between participating departments are presented for those variables that describe department-level quality indicators.

Results

Characteristics of participating hospitals and departments

In total, 20 clinical departments participated in the ALCA; however, data from 3 departments were excluded due to lack of patient recruitment. In all, 17 departments, covering 8 out of 9 Austrian federal states, enrolled a total of 745 patients. During a median recruitment time of 130 days (range: 87-151, IQR: 116-146), a median of 44 patients per department (range: 11-84, IQR: 26-54) was included. Based on recruitment time and number of cases included, we estimated that the ALCA would have covered 2348 patients per year, indicating a 50.5% coverage of 4650 newly diagnosed lung cancer cases in Austria in 2013.¹

Hospitals, where the 17 participating departments were located, had the following characteristics: multidisciplinary tumor board (17 hospitals), thorax surgery (9 hospitals), radiotherapy (7 hospitals), and a palliative ward (11 hospitals).

All departments had access to in-house bronchoscopy, carrying out a reported median number of 408 procedures per year. Use of endobronchial ultrasound (94.1%, n=16) and interventional procedures such as laser (35.3%, n=6) and stenting (76.5%, n=13) were reported. In-house computed tomography (CT) was available in 16 (94.1%); magnetic resonance tomography (MRT) in 13 (76.5%), positron emission tomography (PET) in 7 (41.2%), and PET-CT in 5 (29.4%) hospitals, respectively (Table 1).

All pathology units serving these 17 departments reported using the 7th edition of the Union Internationale Contre le Cancer (UICC) criteria for pathological diagnosis of lung cancer.⁶ A total of 12 departments (70.6%) reported using standard operating procedure (SOP) for lung cancer care, and 11 departments (64.7%) reported participation in clinical trials of lung cancer.

Patient characteristics

A total of 745 patients with newly diagnosed lung cancer (60.5% male, n=451) with a mean (SD) age of 66.3 (9.9) years participated, the majority (75.7%, n=564) presenting with Eastern Cooperative Oncology Group (ECOG) performance status 0 or 1 (Table 2).

Patients with suspected lung cancer were either referred by lung specialists (34.2%, n=255), other hospitals (26.0%, n=194), general practitioners (19.5%, n=145), physicians from other specialties (13.2%, n=98), or were self-referrals (7.1%, n=53). The median time elapsed between first presentation at

the specialized department and diagnosis (Table 3; Figure S1) was 8.0 days (IQR: 4-15; range: 0-132), with the date of diagnosis defined as the pathology date.

Disease characteristics and pathologic assessment

Collection of diagnostic specimens was done using bronchoscopy in 655 (87.9%), CT-guided peripheral lung biopsy in 40

Table 1. In-house imaging and bronchoscopic facilities.

NO. (%)	ALL DEPARTMENTS N=17
Imaging	
CT	16 (94.1)
MRT	13 (76.5)
PET	7 (41.2)
PET-CT	5 (29.4)
PET and/or PET-CT	7 (41.2)
Bronchoscopic procedures	
Bronchoscopy	17 (100)
EBUS (including radial EBUS)	16 (94.1)
EUS	11 (64.7)
Laser	6 (35.3)
Stenting	13 (76.5)

Abbreviations: CT, computed tomography; EBUS, endobronchial ultrasound; EUS, endoscopic ultrasound; MRT, magnetic resonance tomography; PET, positron emission tomography.

Table 2. Baseline patient characteristics.

	ALL PATIENTS	MALES	FEMALES
Overall, No. (%)	745 (100)	451 (60.5)	294 (39.5)
Age, y			
Mean (SD)	66.3 (9.9)	66.8 (9.3)	65.5 (10.6)
(Range of %)	(33.8-91.3)	(35.2-91.3)	(33.8-89.4)
ECOG performance status before treatment, No. (%)			
0	283 (38.0)	179 (39.7)	104 (35.4)
1	281 (37.7)	164 (36.4)	117 (39.8)
2	107 (14.4)	62 (13.7)	45 (15.3)
3	58 (7.8)	37 (8.2)	21 (7.1)
4	14 (1.9)	7 (1.6)	7 (2.4)
5	2 (0.3)	2 (0.4)	0 (0.0)

Abbreviation: ECOG, Eastern Cooperative Oncology Group.

Range depicts range across centers.

ECOG performance status is defined as follows: 0=fully active, able to carry out all predisease performance without restriction; 1=restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature; 2=ambulatory and capable of all self-care but unable to carry out any work activities; up and about more than 50% of waking hours; 3=capable of only limited self-care; confined to bed or chair more than 50% of waking hours; 4=completely disabled; cannot carry out any self-care; totally confined to bed or chair; 5=dead.

(5.4%), ultrasound guided lymph node biopsy in 21 (2.8%), and various other techniques (eg, thoracotomy or mediastinoscopy) in 29 patients (3.9%), respectively.

Prior to the bronchoscopy, 90.4% (n = 592 of 655 patients) underwent a CT scan. The CT scans were either performed in-house in 348 patients (46.7%; range: 8.7-90.9) or externally in 524 patients (70.3%; range: 37.8-92.9). When probing the quality of out-of-hospital CT scans, deficits were reported for the scans of 57 patients (10.9% of 524 patients; range: 0.0-86.7), e.g. no use of contrast agent, nonconsideration of liver, layer thickness >3 mm, or scans were more than 6 months old. PET/PET-CT scans were conducted in 55.7% of patients (n = 415; range: 17.4-95.7; Table S2) and brain MRT scans in 44.9% (n = 335). Following staging procedures, 16.2% of patients (n = 121) had TNM stage I, 7.8% (n = 58) had TNM stage II, 27.8% (n = 207) had TNM stage III, and 48.2% (n = 359) had TNM stage IV (Table 4) disease.

The primary lung cancer was located in the upper lobes in 45.5% of patients (n = 339), in the lower lobes in 26.7% (n = 199), in the middle lobe in 5.2% (n = 39), and in one of the main bronchi in 11.9% (n = 89). The specific tumor subtype was determined by histology in 75.8% of patients (n = 565; range: 27.8-100), and by cytology in the remaining 24.2% (n = 180; range: 0.0-72.2). Overall, 83.1% of patients were diagnosed with non-small-cell lung cancer (NSCLC; n = 619) and 16.9% (n = 126) with small-cell lung cancer (SCLC), and only in 4.6% (n = 34) of patients the exact cancer subtype could not be otherwise specified (NOS; Table S1).

Of 376 patients with adeno- or adenosquamous lung cancer, 77.1% (n = 290) were tested for epidermal growth factor

Table 3. Time intervals of interest, overall, and by cancer type and treatment intent.

KEY TIME PERIODS, D	OVERALL N=745	SCLC N=126	NSCLC N=619
First presentation at specialized clinic to diagnosis			
Mean (SD)	13.0 (16.7)	9.9 (14.2)	13.7 (17.1)
Median (Q1, Q3)	8.0 (4, 15)	7.0 (4, 12)	8.0 (4, 16)
(Range)	(0-132)	(0-132)	(0-127)
Diagnosis to first therapy ^a			
Chemotherapy	N=424	N=103	N=321
Mean (SD)	19.6 (15.1)	12.0 (10.6)	22.1 (15.5)
Median (Q1, Q3)	15.0 (9, 27)	9.0 (5, 15)	17.0 (11, 30)
(Range)	(0-83)	(0-74)	(0-83)
Radiotherapy	N=78	N=4	N=74
Mean (SD)	23.3 (16.9)	6.0 (4.0)	24.3 (16.8)
Median (Q1, Q3)	21.0 (10, 35)	8.0 (2, 8)	21.5 (13, 36)
(Range)	(0-69)	(0-8)	(0-69)
Surgery	N=150	N=2	N=148
Mean (SD)	26.7 (22.9)	26.5 (37.5)	26.7 (22.8)
Median (Q1, Q3)	24.5 (11, 36)	26.5 (-)	24.5 (10, 35)
(Range)	(0-138)	(0-53)	(0-138)

Abbreviations: NSCLC, non-small-cell lung cancer; SCLC, small-cell lung cancer. Range depicts range across hospitals.

^aPatient numbers are based on the patients who received chemotherapy (N=424), radiotherapy (N=78), or surgery (N=150) as first treatment.

receptor mutation, with 10.3% (n = 30) testing positive; 176 of these 290 patients were in stage IIIB/IV (60.7%). Anaplastic lymphoma kinase rearrangement was tested in 62.5% (n = 235) of adeno- or adenosquamous carcinoma and found positive in 3.8% (n = 9); 137 of these 235 patients were in stage IIIB/IV (58.3%).

Overall, 55.5% of lung cancer cases (n = 413) were discussed in interdisciplinary tumor boards (Table 4), with the highest stage patients (TNM stage IV, n = 359) having the lowest probability of being presented (n = 148, 41.2% of patients with TNM stage IV). Furthermore, participation in tumor boards differed between departments, as the percentage of patients among all TNM stages presented ranged from 16.7% to 100%.

Therapies received

Of 745 patients, 505 patients (67.8%) were scheduled to receive chemotherapy and 424 (56.9%) received chemotherapy as first-line treatment, 50 had surgery followed by chemotherapy (33.3% of first-line surgery), and 31 had radiotherapy followed by chemotherapy (39.7% of first-line radiotherapy).

A total of 159 patients (21.3%) underwent surgery, of whom 150 received surgery as first treatment and 9 received surgery after neo-adjuvant chemotherapy.

A total of 169 patients (22.7%) received radiotherapy, of whom 78 as their first treatment (10.5% of all patients and 46.2% of patients receiving radiotherapy), 86 had radiotherapy in combination with first-line chemotherapy (concomitant or sequential), and 5 had surgery prior to radiotherapy.

Therapies and procedures received in first-line are discussed below.

Chemotherapy in first-line. Overall, 424 (56.9%) received chemotherapy as first treatment. A PET or PET-CT was available in 53.3% (n = 226; range: 38.5% to 100%; Table S2). Overall, most patients (94.8%, n = 402) received combination chemotherapy; 5.2% (n = 22) received single-agent chemotherapy. Tables S3 and S4 show an overview of prescribed chemotherapy treatments in first-line. The median time from diagnosis to initiation of first-line chemotherapy was 15 days (range: 0-83; Table 3). Overall, 52.1% of patients (n = 221) received all or part of their first-line chemotherapy on an outpatient basis. In 72.4% of patients (n = 307; range: 0.0-100), treatment response was assessed after 2 cycles. Participation in a clinical lung cancer trial was documented for 6.6% (n = 28) of first-line chemotherapy patients (range: 0.0-32.8).

In patients completing their first-line of chemotherapy, who subsequently went on to second-line chemotherapy (41.0%,

Table 4. Clinical TNM staging and consultation of interdisciplinary tumor board by stage.

NO. (%) (RANGE OF %)	ALL PATIENTS N=745	TUMOR BOARD ^a N=413
All stages	745 (100) (NA)	413 (55.5) (16.7-100)
IA	69 (9.3) (2.0-24.3)	52 (75.4) (0.0-100)
IB	52 (7.0) (2.2-18.2)	37 (71.2) (0.0-100)
IIA	30 (4.0) (0.0-14.3)	20 (66.7) (0.0-100)
IIB	28 (3.8) (0.0-15.8)	22 (78.6) (0.0-100)
IIIA	121 (16.2) (5.3-29.1)	81 (66.9) (0.0-100)
IIIB	86 (11.5) (0.0-15.7)	53 (61.6) (0.0-100)
IV	359 (48.2) (27.0-66.7)	148 (41.2) (0.0-100)

Abbreviations: TNM, tumor, node, metastasis; NA, not applicable. Range depicts range across centers.
^aProportions of patients presented to the interdisciplinary tumor board are based on the number of patients diagnosed with the respective TNM stage. The overall proportion of patients presented to an interdisciplinary tumor board is based on 745 patients overall.

n = 174), the median interval between end of first-line and start of second-line treatment was 121.0 days (IQR: 40-193; range: 0-411; range of medians between hospitals: 67.4-172.0).

Surgery in first-line. Of 150 first-line surgery patients, preoperative FEV₁ (the volume that has been exhaled at the end of the first second of forced expiration) was available in 80.7% (n = 121; range of hospitals: 0%-100%) with a mean (SD) value of FEV₁% (% predicted [pred]) of 76.2% (17.1). Preoperative D_{LCO} (diffusion capacity in % pred) was measured in 53.3% (n = 80; range of hospitals: 0%-100%) with a mean (SD) value of 71.8% (17.1). Magnetic resonance tomography of the brain was completed in 40.7% (n = 61; range: 0.0-100), and a PET/PET-CT scan in 86.0% (n = 129; range: 38.5-100; Table S2). Almost all (n = 52/53, 98.1%) surgical patients treated in hospitals with in-house nuclear medicine facilities underwent

PET/PET-CT, whereas only 79.4% (n = 77/97) underwent this procedure when it was not available at the hospital.

Anatomical lung resection with curative intent was achieved in 82.0% (n = 123), 91.1% (n = 112) underwent lobectomy, and 8.9% (n = 11) underwent pneumonectomy. Nonradical first-line surgery was done in 13.3% (n = 20) and palliative surgery in 4.7% (n = 7) of patients. The median time from diagnosis to surgery as first treatment was 24.5 days (range: 0-138, IQR: 11-36; Table 3). Postoperative histological assessment indicated complete resection (R0) in 84.0% (n = 126), and incomplete resection (R1 and R2) in 5.4% (n = 8). Resection margins could not be assessed (RX) in 10.7% (n = 16). Of 150 patients, 50 undergoing surgery (33.3%, range: 0.0-68.8) subsequently received adjuvant chemotherapy.

To evaluate quality of preoperative staging, postoperative pathological stage was compared with preoperative stage (Figure 1). Of 150 patients, 70.0% (n = 105) were categorized preoperatively as having TNM stage IA or IB or IIA disease (ie, N0). Of these, preoperative staging was confirmed postoperatively in 68.6% (n = 72); 6.7% (n = 7) were downstaged, and 22.9% (n = 24) were upstaged. Two postoperative stage classifications (2.8%) were missing for this group. The number of patients receiving surgery as first-line therapy in whom postoperative restaging did not justify surgery was very low (2.0%; n = 3; highlighted in Figure 1).

Radiotherapy. Altogether, 169 of 745 patients (22.7%) received radiotherapy. Concomitant or sequential combination chemoradiotherapy was reported for 115 patients (68.0%), 5 patients (3.0%) had surgery prior to radiotherapy, and 47 patients (27.8%) underwent radiotherapy only. Of patients receiving radiotherapy as first-line therapy, 43.6% (n = 34/78) had a prior PET/PET-CT. The FEV₁% pred was measured in 112 patients (66.3%) before radiotherapy and was found to be between 20% and 117%, with a mean (SD) of 63.7%. In 96 patients (56.8%), only the primary tumor was targeted by irradiation, whereas in 45 patients (23.0%), additional irradiation of mediastinal and/or

Pre-operative staging		Post-operative staging							
		IA	IB	IIA	IIB	IIIA	IIIB	IV	No staging
IA	(n=52)	38	7	3	2	1	0	0	1
IB	N=35	4	22	6	0	2	0	0	1
IIA	(n=18)	3	0	12	1	1	0	1	0
IIB	(n=16)	1	0	3	8	2	0	1	1
IIIA	(n=22)	3	0	3	2	13	1	0	0
IIIB	(n=1)	0	0	1	0	0	0	0	0
IV	(n=6)	0	0	0	1	0	0	5	0

Figure 1. Matching of pre- and postoperative staging in 150 patients receiving surgery. Patients highlighted in bold frame should not have been operated.

hilar lymph nodes was performed; 78 patients (46.2%) underwent irradiation of various metastases (categories not mutually exclusive). Esophagitis was described in 29 patients (17.2%; 18 patients with grade 1 and 11 patients with grade 2).

The duration of radiotherapy was between 1 and 77 days, with a mean of 20.8 days. The mean (SD) time from diagnosis to initiation of radiotherapy as first treatment (radiation therapy only or concomitantly with chemotherapy, $n=78$) was 23.3 days (16.9; range: 0-69; median: 21.0; Table 3).

One-year survival and tumor recurrence. First treatment with curative intent was done in 38.4% ($n=286$) of patients. At 12 months follow-up, 211 patients (74.5%) were reported tumor free. One-year survival data were available for 723 patients (97.0%) with 22 patients (3.0%) lost to follow-up. Overall, the mean overall 1-year survival across all participating departments was 49.8% ($n=360$, range: 37.8%-66.7%). Figure S2 shows the distribution of 1-year survival rates across all participating centers. One-year survival of all patients was 35.8% ($n=43$) in patients with SCLC and 53.2% ($n=325$) NSCLC.

An ad hoc analysis of 1-year survival was conducted to explore possible differences in outcomes in departments with or without onsite PET/PET-CT facilities. Overall, 257 patients (34.5%) were treated at a department with onsite PET/PET-CT scanners; the remaining patients ($n=488$, 65.5%) were not. Of the 723 patients included in the 1-year survival follow-up analysis, 247 patients (34.2%) were treated at a department with onsite PET/PET-CT scanners, and their 1-year overall survival rate was 60.7% ($n=150$). In patients treated at a department without onsite PET/PET-CT ($n=476$, 65.8%), the 1-year overall survival rate was 54.4% ($n=259$). The difference between these groups was not statistically significant (χ^2 test $P=.114$). Kaplan-Meier cumulative survival curve comparing departments with and without onsite PET/PET-CT scanners is shown in Figure S3 of the supplemental material.

Discussion

The ALCA was conducted by the ALCG in 17 Austrian respiratory or oncology departments experienced in lung cancer care. Projected to the full year, the ALCA had a catchment of more than 50% of all lung cancer cases diagnosed during the study year. We assume that the findings are thus representative of the quality of lung cancer care in Austria. Pathological diagnosis and preoperative radiographic staging is of high quality in that the number of NOS tumors and the number of patients receiving unjustified surgery were very low. The time from first presentation to diagnosis and the time from diagnosis to start of therapy were short, well below time limits recommended by international guidelines. However, the number of lung cancer cases presented to interdisciplinary tumor boards was rather low, and lower than recommended. One-year overall survival was better than reported previously but showed a 2-fold difference between departments.

According to EUROCARE-5, Austria is among the countries with the highest lung cancer survival rates in Europe.⁷

Aside from factors deeply ingrained in a country's society, such as socioeconomic factors and general health, results from such international comparisons can serve as an indicator for the quality of cancer services provided. Continuous efforts to measure and improve quality of cancer care have resulted in increased survival between repeated observations of the EUROCARE project.⁸ Especially, the United Kingdom has invested a lot of effort in improving standards of care for lung cancer. The British Royal College of Physicians (RCP) conducts a lung cancer audit every year. The RCP has set forth recommendations against which they continuously audit, analyze, and report quality of care and improvement of outcomes.⁵ Some of these recommendations were also used as a benchmark for the ALCA.

Overall, the ALCA shows that awareness for appropriate quality standards is high, with all hospitals stating to follow international standards for pathological diagnosis of lung cancer (UICC criteria),⁶ and 70.6% of hospitals reporting the use of specific oncologic SOPs.

Hospital infrastructure and diagnostic standards

It is reassuring that diagnostic imaging and pathological services are available for all hospitals. Hence, ascertainment of tumor morphology and tumor stage was correct in almost all lung cancer cases. The RCP recommends that patient assessment at diagnosis should include performance status, TNM staging in $\geq 90\%$, and pathological confirmation of malignancy in $\geq 80\%$ of patients. The RCP guidelines define that a diagnosis of "NSCLC not otherwise specified (NOS)" should be made in less than 15% of cases. Within the framework of the ALCA performance status and histological/cytological determination of lung cancer morphology was available for all almost patients. Only 4.6% of tumors were classified as NOS, and NOS classification was found only in patients where morphology was done using cytology.

The RCP also recommended that in patients, eligible for surgery with stage I or II disease and performance status 0 or 1, lung function (FEV_1 , FEV_1 % pred) should be measured in more than 75%. In the ALCA, preoperative spirometry was performed in 80.7% of patients, and this benchmark has clearly been met across all hospitals participating in the ALCA.

According to European Society of Medical Oncology (ESMO) guidelines, bronchoscopy is recommended to obtain pathological diagnosis of centrally located, nonmetastatic NSCLC in stages I to III,³ and a contrast-enhanced CT scan of the chest and upper abdomen should be done in patients with metastatic NSCLC.² For SCLC, biopsies are recommended to be obtained by bronchoscopy.⁴

In the ALCA, 87.9% of patients underwent bronchoscopy, with 90.4% having a CT prior to bronchoscopy. The RCP recommends that of patients undergoing bronchoscopy, $\geq 95\%$ should have a CT scan prior to the procedure,⁵ a criterion which was nearly met in the ALCA. Alarmingly, 38.5% of CT

scans conducted in external facilities showed quality deficits and therefore had to be repeated. The RCP recommends that $\geq 90\%$ of patients should receive a PET-CT scan prior to surgery or radical radiotherapy. In the ALCA, 86.0% of patients receiving surgery, 43.6% of patients receiving radiotherapy, and 53.3% of patients receiving chemotherapy had a prior PET/PET-CT. Thus, the recommended number for PET-CTs was not reached overall. The low number of PET/PET-CT scans performed is most likely due to the lack of availability of such a device, as only 41.2% of hospitals had an in-house PET or PET-CT. The number of patients receiving a PET/PET-CT was much greater, if such device was available in-house. When surgical patients were treated in hospitals, where a PET-CT was available, 98.1% had a preoperative PET, whereas when patients were treated in hospitals, where no PET-CT was available in-house, only 4.8% had a preoperative PET-CT. The range between federal states in the percentage of patients receiving a PET/PET-CT was 35.3% to 97.6%, with lower numbers in the eastern parts of Austria. A study from England also showed a wide variation between hospitals in the proportion of patients receiving a PET-CT scan (range: 13%-64%).⁹

In-house access to MRT (76.5% of hospitals) was more readily available and preoperative MRT (40.7% of patients) was conducted in a substantial proportion of surgery patients according to the ALCA.

The accuracy of the initial staging results was assessed in patients undergoing surgery, where tumor staging was conducted prior and again after surgery and results were compared. Ideally, pre- and postoperative staging results should closely match and postoperative stage should never be higher than preoperative assessment. Of patients categorized preoperatively as having stage IA or IB or IIA cancer, staging was confirmed postoperatively in 68.6%. Postoperative stage was even lower in 6.7% and was higher in 22.9% of patients. A Dutch lung cancer audit investigated the quality of clinical staging in patients with stage I NSCLC.¹⁰ Results from preoperative, clinical TNM staging using PET-CT were compared with pathological staging based on resected tissue. The Dutch audit reported 59.9% concordance rate between clinical and pathological staging. However, 22.9% of patients needed to be upstaged from stage I to stage II or higher, changing the treatment approach to adjuvant chemotherapy.¹⁰ In a study from England, the rate of histological confirmation in patients with lung cancer with performance status 0 to 2 was assessed and a wide variation of 61% to 100% confirmation rate was found.⁹

Treatment standards

Treatment decisions should be taken within a multidisciplinary tumor board.² In the ALCA, only 55.5% of cases were taken to a tumor board, although a tumor board was available at all hospitals. However, the number of cases discussed by an interdisciplinary panel of experts was higher in patients with early-stage disease. There was a wide range between participating departments with

the proportion of cases discussed (16.7%-100%). A national lung cancer organization audit conducted in the United Kingdom has identified a wide variation in time dedicated to each case per tumor board session and overall case load per team per year, and the authors suggested that high specialist workloads may negatively impact diagnostic time and subsequent treatment rates.¹¹

According to guidelines, patients with earlier stage NSCLC should primarily undergo surgical tumor resection with curative intent, followed by adjuvant chemotherapy or radiotherapy, if indicated.³ Locally advanced and metastatic NSCLC should preferably be treated with nonsurgical systemic therapy, provided that the performance status is 0 to 1.^{2,3} In the present audit, this recommendation was followed with 76.1% of patients with NSCLC not undergoing surgery. For patients with SCLC, concomitant chemo-radiotherapy or surgery plus adjuvant chemotherapy is recommended for most patients treated with curative treatment intent.⁴ In the present audit, 81.7% of patients with SCLC received chemotherapy, 3.2% received radiotherapy, and 1.6% underwent surgery as first treatment line; 13.5% did not receive any treatment. The SCLC is characterized by its rapid growth and rapid start of treatment is important.⁴

The RCP recommends that in patients with SCLC chemotherapy treatment should be started within 2 weeks of pathological diagnosis.⁵ In the ALCA, patients with SCLC started chemotherapy after a median of 9 days after diagnosis, radiotherapy after 8 days, and surgery after 26.5 days. For NSCLC, the RCP does not make a recommendation for a maximum time between diagnosis and start of treatment.⁵ In the present audit, chemotherapy was started in patients with NSCLC after a median of 17 days, radiotherapy after 21.5 days, and surgery was conducted after 24.5 days.

In surgical patients, the R classification—besides its prognostic significance—is regarded as a measure of treatment quality¹²; residual tumor at the resection margin (=R1/R2) should be avoided. In the ALCA, R1/R2 classification was found in 5.3% of patients. In a retrospective study that evaluated the probability of survival in 596 patients who had undergone resection for NSCLC with curative intent, R1 residual disease was found in 4.4% of patients and R2 in 2%.¹³ A chart review of 4026 patients revealed 5.4% of patients with R1, in whom 5-year survival rates were lower than in patients with R0 (20% versus 46%, $P < 10^{-6}$).¹⁴ The findings of the present audit suggest a similar proportion of R1/2 findings compared with other reports.

Outcomes

Overall, in the ALCA, the mean 1-year survival rate was 49.8%, exceeding previous reports from other countries. For the years 2009 to 2013, the Austrian Statistical Agency reported a 1-year survival rate of 49.1%.¹⁵ In the United Kingdom, the 1-year survival in patient with lung cancer was reported to be 32.1%.¹⁶ In a Spanish cohort study in patients with NSCLC, a 45.5%

1-year survival for the observation period of 2003 to 2005 was found. A French study of lung cancer survival found a 1-year survival rate of 43.6% in 2010.¹⁷

Overall, differences between departments in the routine clinical approach to diagnostic workup and treatment of lung cancer were observed, together with a wide range in outcomes.

It is possible that organizational factors such as onsite PET/PET-CT scan or surgery or board discussions were associated with differences in outcomes. An ad hoc analysis of the impact of onsite PET/PET-CT scans on 1-year survival did not show a statistically significant difference. Regarding surgery, there are only a limited number of specialized thoracic surgery departments in Austria and all patients are referred to these specialized centers. No difference in outcomes is expected between these departments. It is well known that multidisciplinary tumor board discussions led to improved clinical outcomes.¹⁸ Differences in outcomes by regularity of multidisciplinary board discussions were not systematically assessed in the present audit and will be considered in the follow-up audit.

In the United Kingdom, there have been substantial efforts to reduce such differences and improve outcomes following the disappointing findings of the EURO CARE studies. Efforts included a longitudinal lung cancer audit program, organizational audits and reciprocal peer review, and other quality improvement initiatives.^{5,9,11,19,20} We identified 3 main learnings from the ALCA that should be implemented:

1. There was substantial inhomogeneity between evaluated departments. Departments were notified about their results and suggestions for improvement were provided.
2. Shortages in infrastructure and hospital resources regarding PET/PET-CT were identified in some regions. These need to be resolved to optimize initial diagnosis and staging.
3. The number of cases presented to interdisciplinary tumor boards should be increased.
4. To assess changes in quality over time will only be possible in the future, when the lessons from the present audit have been implemented.

Limitations

This national lung cancer audit has some limitations. It focused on medium to large hospitals experienced in treating substantial numbers of patients with lung cancer and a high likelihood of routine use of SOPs, adequate in-house diagnostic facilities, and access to a local multidisciplinary team of experts. Such departments will be more likely to offer higher quality of care due to a higher level of experience and clinical routine than smaller centers that were not covered by this audit. In addition, this audit focused exclusively on the hospitals' core competencies such as hospital infrastructure and routine clinical practice of cancer care, leaving aside

other factors influencing cancer diagnosis and outcomes, including existence of centralized services (eg, national guidelines or screening programs), free movement of patients between primary care providers, and speed of and barriers to referral between primary and secondary care.²¹ Only patients referred to the participating centers for diagnostic workup and treatment were captured. This may have introduced a selection bias by excluding all patients who were discovered as having lung cancer by their primary care center but not referred to the specialist center for further investigation due to other, more burdensome comorbidities or performance status or personal preference, for example very elderly or sick patients. Comorbidities, an important factor impacting survival, were not collected in this audit and should be included in follow-up audits.

Conclusions

The ALCA was a pilot study. Overall, it can be concluded that the methodology used allowed to draw a representative picture of the quality of lung cancer care in Austria. Although the quality of care in Austria was found to be very high, we were able to identify areas of improvement; in particular, we followed up on the divergent practice between departments. Periodic repetition of such an audit is warranted to monitor changes in clinical practice. Extension of future audits to smaller departments may broaden our understanding of the overall quality of care and improve patient pathways to optimize outcomes.

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Data Sharing

All authors had access to the source data. Qualified researchers may request data from the corresponding author upon reasonable request.

Supplemental Material

Supplemental material for this article is available online.

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