Lung Cancer 135 (2019) 181–187

Contents lists available at ScienceDirect

Lung Cancer

journal homepage: www.elsevier.com/locate/lungcan

Impact of health care organization on surgical lung cancer care

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ARTICLE INFO

Keywords:
Non-small cell lung cancer
Lung cancer
Staging and surgery

ABSTRACT

Objectives: Organization and governance of national healthcare might play an important role in decision-making and outcomes in patients with lung cancer. Both Denmark and the Netherlands have a high level of healthcare but a different financial coverage, governance and level of centralization. By using both national databases we analyzed the consequences of these differences on patterns of care and outcomes with a focus on morbidity, mortality and clinical staging.

Materials and methods: General numbers on both healthcare systems were requested. All patients who had surgery for lung cancer from 2013 to 2016 were included. Mortality, morbidity and clinical staging were analyzed for patients with NSCLC without metastases, only one operation and no neo-adjuvant therapy.

Results: In 2016 annual budget as share of gross national product was 10.4% for both countries. In Denmark 4 hospitals performed lung surgery in 2016, compared to 43 hospitals in the Netherlands. We included 4030 Danish and 8286 Dutch patients. In the subgroup 30-day mortality was 1.5% in Denmark compared to 1.9% in the Netherlands. The percentage of patients with a complicated course was 24.4% and 34.8% respectively ($p < 0.05$). Accuracy between cTNM and pTNM was 53.0% in Denmark and 52.9% in the Netherlands.

Conclusion: Surgery for lung cancer is at a high level in both countries, reflected by low mortality-rates. Centralization has been implemented successfully in Denmark, which might explain the lower rate of patients with a complicated post-operative course, although different definitions preclude firm conclusions. In both countries correct clinical staging of lung cancer remains a challenge.

1. Introduction

Lung cancer is the most common cause of cancer related death worldwide. Accurate diagnosis and staging are crucial to direct the individual patient towards the optimal treatment. Ideally, all patients with lung cancer should be diagnosed, staged and treated in a uniform fashion. However, it is known that socio-economic status, gender, race and multidisciplinary tumor board discussion, are all factors that have the potential to influence the probability to receive a certain treatment [1–4]. In addition, to what extent the organization of national healthcare and governance might have an impact on daily practice and outcomes for patients with lung cancer, is currently unknown.

Although both Denmark and the Netherlands have high quality national healthcare systems according to the Euro Health Consumer Index (EHCI) [5], healthcare organization differs significantly on several aspects: (1) Financial coverage: in Denmark healthcare is financed from taxes for all inhabitants. In contrast, in the Netherlands, healthcare insurance is obligatory and inhabitants pay insurance costs to insurance companies. (2) Governance: in both countries, politicians govern the healthcare system. In the Netherlands, however, the hospitals (and doctors) are independent caregivers, where insurance companies can contract healthcare for their patients. (3) Centralization: one of the results of the difference in governance is that lung cancer care (including surgery) is rigorously centralized in Denmark (4 hospitals performing lung surgery in 2016), a process that has just started in the Netherlands (from 79 in 2005 to 42 hospitals performing lung surgery

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https://doi.org/10.1016/j.lungcan.2019.07.028
Received 7 June 2019; Received in revised form 25 July 2019; Accepted 28 July 2019

in 2018).

Both Denmark and the Netherlands have a national audit in which data regarding lung cancer is systematically collected [6,7]. To improve lung cancer care in Denmark, the Danish Lung Cancer Group (DLCG) was founded in 1991 and the Danish Lung Cancer Registry (DLCR) opened for registration in 2000 [6]. In the Netherlands, a database on lung cancer surgery was initiated in 2011 (Dutch Lung Surgery Audit (DLSA)). To cover and audit all aspects of lung cancer, the radiotherapists and the pulmonologists joined the audit in 2016 and 2017 respectively, and from then on the audit is called Dutch Lung Cancer Audit (DLCA, and DLCA-S for the surgical part of the database) [7,8].

In this study, the aim was to analyze the differences in healthcare organization and governance and the possible impact on daily practice and outcome, with a focus on morbidity, mortality and clinical staging.

2. Materials and methods

2.1. General data and patients

To compare both countries in general, variables such as lung cancer incidence, number of inhabitants, lung cancer resection rates and life expectancy were requested from the Danish and Dutch Cancer Registries, and from the Organisation for Economic Co-operation and Development (OECDstat).

All patients who had surgery for lung cancer from January 1st 2013, until December 31st 2016 were identified (Group I) and after comparing data definitions, predefined data were compared.

2.2. Outcomes

At first, general characteristics of all patients who had surgery for lung cancer from January 1st 2013, until December 31st 2016 were analyzed (Group I). After selection, a subgroup (Group II) was defined to enable proper comparison of patients from both countries, without possible bias from previous (neo-adjuvant) therapy or metastases. This group consisted of patients with primary surgery for NSCLC, without neo-adjuvant therapy and without metastases at time of diagnosis (see Fig. 1: Flowchart). For patients in Group II, outcomes were analyzed such as morbidity, mortality and risk adjusted mortality rates (RAMR), and the agreement between clinical stage (cTNM) and pathological stage (pTNM), as a measure of clinical staging accuracy in patients with NSCLC.

2.3. Statistical analysis

Descriptive statistics were used for all analysis. Chi-square tests were used to analyze dichotomous variables. To calculate the RAMR for both countries, the expected mortality per country was calculated using multivariable logistic regression analysis. Factors included in the regression model were sex, age, Eastern Cooperative Oncology Group (ECOG) performance status, histopathology, type of resection, type of entry in the thorax and year of surgery. Histopathology was removed from the definitive correction model because it was not significant in multivariable analysis. Statistical analysis was performed in SPSS version 25.

3. Results

In Table 1, the basic characteristics of lung cancer care in Denmark and the Netherlands in 2016 are presented. The number of inhabitants was approximately 3 times higher in the Netherlands and life expectancy at birth was comparable. Incidences of airway tract cancer were slightly higher in Denmark. In 2016, there were 4 hospitals performing lung surgery in Denmark (average number of resections per hospital per year: 252), compared to 43 hospitals in the Netherlands (average number of resections per hospital per year: 48). The annual budget for health care as a share of gross national product was exactly the same for both countries in 2016: 10.4%. Resection rates for NSCLC were comparable in both countries.

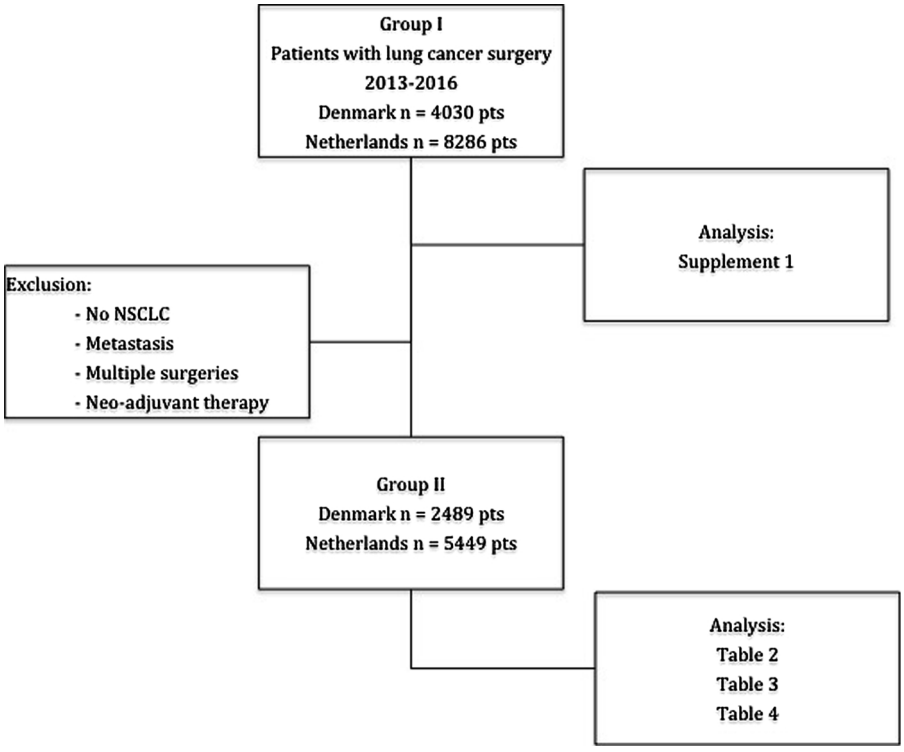

Fig. 1. Flowchart of study population and analyses.

Table 1
Basic characteristics of lung cancer care in Denmark and the Netherlands in 2016.

	Denmark	Netherlands
Number of inhabitants [9,10]	5,707,251	16,979,120
Life expectancy female at birth	82.8 years	83.2 years
Life expectancy male at birth	79.0 years	80.0 years
Annual budget for health care as share of gross national product [11]	10.4%	10.4%
Number of practicing physicians in (head count, **2015**)	20,902	59,073
Number of hospitals performing lung surgery [12,13]	4	43
Average volume per hospital per year* (median (min-max))	252 (144–324)	48 (25–109)
Incidence airway tract cancer (lung + trachea + mesothelioma + thymus)/100.000 [14,15]	90	79
Incidence lung cancer overall/100.000 [14,15]	82	75
Incidence NSCLC/100.000 [12,15]	68	55
Resection rate NSCLC [12,13]	23.2%	22.8%

Abbreviation: NSCLC – Non-Small Cell Lung Cancer.
* Calculated over 2013–2016.

3.1. Outcomes Group I

Between January 1st 2013 and December 31st 2016, a total of 4030 patients with resected lung cancer were registered in the Danish DLCR and 8286 patients in the Dutch DLCA-S (Supplement 1). The mean age at time of surgery differed slightly between Denmark (68 years) and the Netherlands (65.6 years), however age-distribution was different ($p < 0.05$). In Denmark 54.2% of patients were younger than 70 years compared with 62.5% in the Netherlands. Most surgically treated patients had clinical stage IA (40.2% in Denmark and 35.8% in the Netherlands). Primary surgery in patients with clinical N2 disease was uncommon: 3.6% in Denmark and 4.9% in the Netherlands. Neo-adjuvant treatment was used in 4.6% of patients in Denmark and 6.8% of patients in the Netherlands ($p < 0.05$). Surgery was predominantly performed by thoracoscopic approach in both countries: 64.7% in Denmark and 56.7% in the Netherlands ($p < 0.05$). In the Netherlands, however, in 10.9% of patients a thoracoscopy was converted to an open procedure (conversion rate in Denmark is unknown; converted procedures are recorded as thoracotomy). When analyzing type of resection, lobectomy was performed in 71.5% in Denmark and 74.8% in the Netherlands. In Denmark, 17.0% of patients had a wedge resection compared to 8.5% in the Netherlands, and 10.9% of the Danish patients had two or more surgical procedures compared to 2.4% in the Netherlands ($p < 0.05$).

3.2. Outcomes Group II

Table 2 presents the characteristics of Group II. In Denmark, 2489 patients were registered who met these criteria, in the Netherlands 5449 patients. In this selected group, clinical stage IA NSCLC remained the most frequent indication for surgery (42.5% versus 39.8% for Denmark and the Netherlands, respectively). Primary surgery for stage IIIA and IIIB comprised 7.8% of all surgical patients in Denmark, compared with 9.1% in the Netherlands. In Denmark 63.8% of patients were operated by thoracoscopic approach, 59.1% of patients in the Netherlands was operated this way ($p < 0.05$). However, in 11.9% of patients operations were started thoracoscopically in the Netherlands but were then converted to an open procedure (converted procedures recorded as thoracotomy in Denmark). Lobectomy remained the preferred procedure in this subgroup: 81.2% of the Danish and 81.4% of the Dutch patients underwent lobectomy. Wedge resection was the performed procedure in 8.1% of patients in Denmark and in 3.2% of patients in the Netherlands.

In Table 3 the recorded morbidity and mortality of Group II is presented: in Denmark the percentage of patients with a complicated course after surgery was 24.4%, the 30-day mortality was 1.5% and the risk adjusted mortality 1.7% (95%-CI: 1.3–2.4%). For the Netherlands, these numbers were 34.8%, 1.9% and 1.8% (95%-CI: 1.4–2.2%), respectively ((risk adjusted) mortality: not significant, complicated course: $p < 0.05$).

Table 4 presents the clinical and pathological TNM for Group II. Accuracy of staging is highest in early stage lung cancer: in Denmark, this was 59.2% for stage IA and 56.5% for stage IB, in the Netherlands 65.9% and 49.8%, for stage IA and IB, respectively. Overall accuracy of the clinical staging process was 53.0% in Denmark and 52.9% in the Netherlands.

4. Discussion

Clinical auditing was designed to assess quality of medical care and to benchmark treatment outcome. It can be used to analyze variation in patterns of care and outcomes. Benchmarking can be used as a feedback tool for hospitals or individual caregivers to provide insight in ways to improve quality of care [16–19]. This analysis is the first using two national registries (DLCR and DLCA-S) to compare patterns of care and outcomes for lung cancer patients treated with surgery. Both countries are located in Western Europe and have access to high quality health care, but have a different national healthcare organization in terms of financial coverage, governance and level of centralization. Where lung cancer surgery is highly centralized in Denmark, centralization in the Netherlands is an ongoing process. Despite the differences in financial coverage and governance, it is remarkable that the annual budget for health care as share of gross national product is exactly the same in both countries. Several findings from this analysis deserve a closer look.

4.1. Centralization

In Denmark, lung surgical operations were performed in 4 hospitals during the entire inclusion period. In the Netherlands, there were 43 hospitals performing lung surgical operations in 2016 (last year of inclusion period). This leads to a considerable variety in number of procedures per hospital per year: an average of 252 procedures per hospital per year in Denmark, compared to 48 in the Netherlands during the analyzed period. Several studies report improved outcomes in high volume centers compared to low volume centers, however, the cut-off value for volume currently is an ongoing subject of debate [20–24]. It is hard to conclude from our data whether differences in outcomes, as discussed in the following paragraphs, are in more or lesser extent attributable to the different level of centralization.

4.2. Characteristics group I

A relative lower number of patients operated for NSCLC were included in the Dutch registration when compared with Denmark. There are several possible explanations for this finding. First, registration of pulmonary procedures was voluntary at the beginning of the analyzed period in the Netherlands. However, it became obligatory for all institutes performing lung surgery in 2015, resulting in an increased

Table 2
Operations on patients with NSCLC, no metastasis, one operation and no neo-adjuvant therapy 2013–2016 (Group II).

		Denmark (n)	Denmark (%)	Netherlands (n)	Netherlands (%)	p-value (χ^2)
Total		2489	100.0%	5449	100.0%	
Year of surgery						< 0.05
	2013	486	19.5%	1179	21.6%	
	2014	593	23.8%	1118	20.5%	
	2015	668	26.8%	1551	28.5%	
	2016	742	29.8%	1601	29.4%	
Gender						< 0.05
	Female	1207	48.5%	2414	44.3%	
	Male	1282	51.5%	3035	55.7%	
Age in categories						< 0.05
	< =59	380	15.3%	1088	20.0%	
	60–69 year	886	35.6%	2109	38.7%	
	70–79 year	985	39.6%	1922	35.3%	
	> =80 year	238	9.6%	330	6.1%	
ECOG score						< 0.05
	ecog 0	1505	60.5%	2813	51.6%	
	ecog 1	621	24.9%	1331	24.4%	
	ecog 2+	122	4.8%	176	3.2%	
	unknown/missing	241	9.7%	1129	20.7%	
Clinical TNM stage*						< 0.05
	Stage IA	1057	42.5%	2168	39.8%	
	Stage IB	630	25.3%	1205	22.1%	
	Stage IIA	295	11.9%	877	16.1%	
	Stage IIB	312	12.5%	699	12.8%	
	Stage IIIA	180	7.2%	471	8.6%	
	Stage IIIB	15	0.6%	29	0.5%	
Clinical T stage						0.91
	T1a-b (+T0-is)	1131	45.4%	2435	44.7%	
	T2a-b	932	37.4%	2054	37.7%	
	T3	359	14.4%	813	14.9%	
	T4	67	2.7%	147	2.7%	
Clinical N stage						< 0.05
	N0	2185	87.8%	4487	82.3%	
	N1	238	9.6%	782	14.4%	
	N2	56	2.2%	164	3.0%	
	N3	10	0.4%	16	0.3%	
Histopathology						< 0.05
	Adenocarcinoma	1459	58.6%	3204	58.8%	
	Squamous cell carcinoma	720	28.9%	1979	36.3%	
	Different NSCLC	310	12.5%	266	4.9%	
Type of entry thorax						< 0.05**
	Thoracotomy	901	36.2%	1462	26.8%	
	VATS/RATS	1588	63.8%	3223	59.1%	
	Conversion**	–	–	649	11.9%	
	Unknown/missing	0	0.0%	115	2.2%	
Type of resection						< 0.05
	Wedge resection	201	8.1%	174	3.2%	
	Segmentectomy	62	2.5%	101	1.9%	
	Lobectomy	2024	81.2%	4437	81.4%	
	Bilobectomy	101	4.1%	322	5.9%	
	Pneumonectomy	101	4.1%	415	7.6%	

Abbreviations: ECOG – Eastern Cooperative Oncology Group Performance Score; NSCLC – Non-Small Cell Lung Cancer; VATS – Video-Assisted Thoracoscopic Surgery; RATS – Robotic-Assisted Thoracoscopic Surgery.

* According to TNM-7.

** In the Danish data the conversion rate is unknow, conversion of a VATS/RATS was registered as thoracotomy. For calculating the p-value, conversions in the Dutch data are counted in the group thoracotomy.

number of registered resections in the DLCA-S (from 1870 in the year 2013 to 2349 in 2016). Secondly, the slightly lower incidence of lung cancer in the Netherlands might be part of the explanation why there were not a 3-fold of patients registered in the DLCA-S compared to the DLCR. Another possible explanations is that patients in the Netherlands presented in higher clinical stages, not amenable for surgery. Finally, radiotherapy might have been the preferred choice of treatment in (elderly) patients instead of surgery. These possible explanations warrant further research by analyzing radiotherapy and pulmonology data.

When looking at age, in Denmark 54.2% of patients were younger than 70 years, compared to 62.5% of patients in the Netherlands. The distribution between age categories differed significantly between the two countries, probably explained by the higher centralization rate in Denmark, resulting in more resections for patients with higher ages [25]. In addition, the use of radiotherapy instead of surgery in higher aged patients might also contribute to this finding.

4.3. Resection type

In Denmark, 17% of patients were treated primarily with a wedge resection, predominantly for diagnostic purposes or metastasectomies, which appeared to be primary lung cancer on final pathological examination. In some of these patients, the wedge resection was followed by a completion lobectomy, explaining the high number of patients that had multiple surgeries in the Danish database. However, even after exclusion of these patients, still 8.1% of patients was treated by wedge

Table 3
Mortality and morbidity for Group II.

	Denmark (n)	Denmark (%)	Netherlands (n)	Netherlands (%)	p-value (χ^2)
Total	2489	100.0%	5449	100.0%	
Mortality (30 days)	38	1.5%	102	1.9%	0.28
Complicated course (30 days)*	608	24.4%	1894	34.8%	< 0.05
Bleeding with reoperation	29	1.2%	65	1.2%	0.92
Prolonged air leakage**	229	9.2%	456	8.4%	0.22
Pneumonia	132	5.3%	603	11.1%	< 0.05
Wound infection	6	0.2%	39	0.7%	< 0.05
Empyema	22	0.9%	90	1.7%	< 0.05
Bronchopleural fistula	2	0.1%	18	0.3%	< 0.05
Atelectasis	24	1.0%	143	2.6%	< 0.05
Myocardial ischemia/infarction	6	0.2%	23	0.4%	0.21
Atrial fibrillation	91	3.7%	266	4.9%	< 0.05
Pulmonary embolism	5	0.2%	42	0.8%	< 0.05

* Patients can have multiple complications.
** Prolonged air leakage Denmark = more than 7 days, NL = more than 5 days.

Table 4
Comparison between clinical stage and pathological stage for Group II.

Denmark		pStage						Total	% correct
		Stage IA	Stage IB	Stage IIA	Stage IIB	Stage IIIA	Stage IIIB		
cStage	Stage IA	626	271	72	43	45	0	1057	59.2%
	Stage IB	81	356	87	51	54	1	630	56.5%
	Stage IIA	19	54	109	36	76	1	295	36.9%
	Stage IIB	18	41	48	137	65	3	312	43.9%
	Stage IIIA	18	17	16	35	90	4	180	50.0%
	Stage IIIB	3	2	5	2	2	1	15	6.7%
Total		765	741	337	304	332	10	2489	53.0%

Netherlands		pStage						Total	% correct
		Stage IA	Stage IB	Stage IIA	Stage IIB	Stage IIIA	Stage IIIB		
cStage	Stage IA	1429	419	151	48	118	3	2168	65.9%
	Stage IB	160	600	223	91	128	3	1205	49.8%
	Stage IIA	92	158	326	142	153	6	877	37.2%
	Stage IIB	55	64	116	292	170	2	699	41.8%
	Stage IIIA	36	38	63	91	231	12	471	49.0%
	Stage IIIB	4	3	6	7	6	3	29	10.3%
Total		1776	1282	885	671	806	29	5449	52.9%

Abbreviations: cStage – clinical stage. pStage – pathological stage.

resection for NSCLC (Group II) in Denmark. It would be interesting to know patient characteristics and long-term survival of these patients, as a wedge resection is considered an inferior treatment when compared to anatomical parenchymal resections [26,27].

4.4. Characteristics Group II

When analyzing Group II in more detail, clinical stage IA NSCLC was the most frequent indication for surgery and video-assisted thoracic surgery (VATS) was the preferred surgical approach in both countries. Although minimally invasive surgery does not improve survival compared to open procedures, its benefits are shorter length of stay, less postoperative pain and a better quality of life in the first year after surgery [28–32].

4.5. Morbidity and mortality Group II

In Denmark, 24.4% of the patients had a complicated post-operative course compared to 34.8% in the Netherlands ($p < 0.05$). Regarding the type of complications, pneumonia, wound infection, empyema, fistula, atelectases, atrial fibrillation and pulmonary embolism were recorded more frequently in the Netherlands than in Denmark ($p < 0.05$). Although data definitions were compared, it is difficult to interpret these data because details regarding definitions of complications are lacking. For example, it is unclear whether the definitions and diagnosis of pneumonia or wound infection are the same in Denmark and the Netherlands. One clear difference in definition is prolonged air leakage: in Denmark this is defined as persistent air leakage longer than 7 days post-operatively, where in the Netherlands this is 5 days. A cardiopulmonary morbidity rate of 18.7% was found by Brunelli et al analyzing the European Society of Thoracic Surgeons (ESTS) database, and although this group published the data definitions of the Society of Thoracic Surgeons (STS) and ESTS database extensively in an earlier publication, it is still very difficult to compare their reported morbidity rates with these found from our analysis due to the lack of well-defined data definitions [33,34].

Although there was an absolute difference in 30-day mortality of 0.4% in favor of Denmark compared with the Netherlands ($p = 0.28$), risk adjusted mortality rates narrowed this difference (1.7 versus 1.8% respectively, not significant). Both mortality rates compare favorable with those reported in the literature. In a large retrospective ESTS analysis of 47,960 patients who underwent an anatomic lung resection from 2007 to 2015, the 30-day mortality was 2.7% [34]. When interpreting these data, however, one should realize that the nature of the data from both our dataset as well as the one used by the ESTS (e.g. retrospective analysis, voluntary participation (ESTS), not all hospitals

(beginning of the DLCA-S)/countries (ESTS) participating), is subject to bias and true numbers may differ.

4.6. Accuracy of clinical staging Group II

The calculated overall staging accuracy of surgically treated NSCLC was 53.0% in Denmark and 52.9% in the Netherlands, with staging of early stages being more accurate. Although these numbers can be considered very low, other authors have previously reported numbers of this range [35–37]. In Denmark, an accuracy of 91.3% has been reported previously [6]. The algorithm that was used to calculate this impressive percentage assumed accordance was reached when there was no change of treatment for the patient. A change of treatment was made in those patients in whom a resectable tumor turned out to be T4 pathologically, when unforeseen N2 or N3 nodes were discovered or when unexpected metastases were proven in the pathological TNM. The problem with this algorithm is that it assumes that there is no difference in treatment between a T1a or T3, or a N0 or N1. This used to be true when only surgical treatment could be used as treatment in resectable NSCLC. Currently there are many emerging therapies, from stereotactic ablative body radiotherapy (SABR) in operable stage I disease, chemoradiotherapy as induction therapy in locally advanced NSCLC, to new developments in using immunotherapy as neo-adjuvant therapy. It is therefore of utmost importance to obtain a correct clinical stage before any treatment starts We do believe that difficulty in clinical staging will be an important limitation in current ongoing studies that evaluate neo-adjuvant therapy. From a Dutch cohort, it was already shown that in surgically treated clinical stage I disease, more than 22% of patients was upstaged to a pathological stage II or higher [38].

4.7. Limitations

The most important limitation is that comparing two national databases means comparing two sets with different definitions of endpoints. Databases are developed and designed for benchmarking purposes, and to compare hospitals or caregivers within a country. When comparing two countries, it is very important that data definitions correspond, which is unclear in some of the parameters in this study because of lack of definition. Another important limitation is that it is not clear what impact governance and centralization have on lung cancer care: survival data are lacking, so the effect of centralization could not be extracted from this dataset. This merits further research, particularly since recent studies from the UK and Germany report on shorter length of stay and lower risk of re-admission and death in high volume centers [21,22,24]. It is interesting to evaluate the different patterns of care in both countries, but differences in datasets hamper drawing firm conclusions on who perform best, and what recommendations would improve health care. Finally, the way data is gathered in the databases can cause unreliable results: in Denmark data registration is linked to the financial administration, assuming hospitals have a correct financial system and thus registered data are correct. In the Netherlands physicians are responsible for data registration and do it themselves or have supporting staff that register the data. Data-verification in the Netherlands is done by an external organization [7,39]. Both ways of data collection have their own flaws and might cause bias.

4.8. Future perspectives

Due to different data definitions used in both audits, it is very difficult to draw conclusions from the presented data. To compare healthcare and outcome between countries, to identify positive and negative outliers, and learn from each other how to improve outcomes in surgical lung cancer care, we recommend applying comparable data definitions for outcomes and complications or even synchronize registries throughout Europe (and if possible the world).

5. Conclusion

In this study we compared surgical lung cancer care in two western European countries with a high level of healthcare by using their respective national databases. Surgery for lung cancer is of good quality in both Denmark and the Netherlands, which is demonstrated by low mortality numbers. Centralization has been implemented successfully in Denmark, which might explain the lower rates of patients with a complicated course, although different definitions of endpoints in the databases preclude firm conclusions. In both Denmark and the Netherlands correct clinical staging of lung cancer remains a challenge. Implementation of uniform definitions of clinical endpoints on an international level is a prerequisite for comparing datasets. Relating organization and governance of national healthcare systems to clinically relevant endpoints may very well deliver the necessary tools to improve surgical lung cancer care on a global scale.

Declaration of Competing Interest

The authors have declared no conflicts of interest.

Acknowledgement

No acknowledgement or research support.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.lungcan.2019.07.028.

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