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Evaluating lung cancer care in the Netherlands: staging, treatment and surgical quality assurance

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CHAPTER 8

Variation in incidence, prevention and treatment of persistent air leak after lung cancer surgery in The Netherlands

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ABSTRACT

Objectives

Persistent air leak (PAL; >5 days after surgery) is the most common complication after pulmonary resection and associated with prolonged hospital stay and increased morbidity. Literature is contradictory about the prevention and treatment of PAL. Variation is therefore hypothesized. The aim of this study is to understand the variation in the incidence, preventive management and treatment of PAL.

Methods

Data from the Dutch Lung Cancer Audit for Surgery were combined with results of an online survey among Dutch thoracic surgeons. The national incidence of PAL and case-mix corrected between-hospital variation were calculated in patients who underwent an oncological (bi)lobectomy or segmentectomy between January 2012 and December 2018. By multivariable logistic regression, factors associated with PAL were assessed. A survey was designed to assess variation in (preventive) management and analysed using descriptive statistics. Hospital-level associations between management strategies and PAL were assessed by univariable linear regression.

Results

Of 12 382 included patients, 9.0% had PAL, with a between-hospital range of 2.6-19.3%. Factors associated with PAL were male sex, poor lung function, low body mass index, high American Society of Anesthesiologists (ASA) score, pulmonary comorbidity, upper lobe resection, (bi)lobectomy (vs segmentectomy), right-sided tumour and robotic-assisted thoracic surgery. Perioperative (preventive) management of PAL differed widely between hospitals. When using water seal compared to suction drainage, the average incidence of PAL decreased 2.9%.

Conclusions

In the Netherlands, incidence and perioperative (preventive) management of PAL vary widely. Using water seal instead of suction drainage and increasing awareness are potential measures to reduce this variation.

INTRODUCTION

Persistent or prolonged air leak (PAL) is one of the most common complications after pulmonary resection, with incidence rates reported between 8 and 26%. (1-8) PAL is associated with prolonged length of hospital stay and increased morbidity, including pneumonia and intensive care unit admission. (4, 9-11) Studies regarding management of air leakage, and PAL in particular, are mostly inconclusive and some show even contradictive results. (12-14) This lack of convincing evidence can lead to management based on preferences of treating physicians or treatment teams, and large variation in clinical practice. This has been shown by Lang et al. in the UK, in applying suction to chest drains. (15) In the Netherlands, a national guideline on chest drain management is available; however, most recommendations are based on low levels of evidence. (16) A more recent guideline by the *Society for Translational Medicine* emphasizes the small sample sizes in randomized controlled trials and therefore argues that conclusions should be further tested in larger trials. (17) Besides a clinical review by Burt and Shrager, there are no guidelines regarding (preventive) management of PAL. (13) Therefore, variation between hospitals in incidence and management of PAL is suspected. The nationwide Dutch Lung Cancer Audit for Surgery (DLCA-S) was started in 2012 to monitor and improve quality of care by registering processes and outcomes of lung surgery and can be used to test this hypothesis of between-hospital variation. (18,19) Using DLCA-S data combined with results from an online survey among Dutch thoracic surgeons, this study aims to assess:

1. the incidence of PAL (%) in the Netherlands and risk factors associated with PAL;
2. between-hospital variation in the incidence of PAL;
3. between-hospital variation in (preventive) management of PAL; and
4. associations between (preventive) management strategies and incidence of PAL on a hospital level.

MATERIALS AND METHODS

This study combines results from an online survey conducted among Dutch thoracic surgeons with data from the nationwide DLCA-S database. Approval of the Privacy Review Board of DLCA-S was obtained (8 August 2018; DLCAS201704) and consent of patients has been waived, in accordance with the Dutch Personal Data Protection Act. Surgeons gave their explicit approval for the use of their data by completing the survey. In the DLCA-S, PAL is defined as 'air leak > 5 days after surgery', not originating

from a bronchopleural fistula. This definition, which is in line with recent literature and international database definitions, was also used in the survey. (20)

Analysis of national data of the Netherlands

Data source

The DLCA-S was started in 2012 and participation was mandatory from the beginning for general lung surgeons trained and certified in noncardiac thoracic surgery, and from 2015 onwards also for cardio-thoracic surgeons. It covers all lung surgical procedures in the Netherlands. (18)

Patient selection

From 2012-2018 all patients with a (bi)lobectomy or segmentectomy for (suspected) lung cancer and a known age, gender, survival status 30 days after surgery and resection type were selected from the DLCA-S. In case of missing data on PAL or when it was unknown whether complications had occurred, patients were excluded. Hospitals with > 5% missing data on PAL, calculated before excluding these patients, were excluded from hospital-level analyses.

Statistical analysis

The overall incidence of PAL was calculated. Baseline characteristics of patients with and without PAL were compared using chi-squared tests. Univariable and multivariable logistic regression analyses were performed to identify factors associated with PAL. Variables with a univariable p-value < 0.10 were included in the multivariable logistic regression model. The variance inflation factor was calculated for all variables included in the multivariable model to test for multicollinearity.

Hospital incidence of PAL was adjusted for differences in case-mix between hospitals. Adjustment for case-mix was performed by calculating the probability of PAL for every patient with a logistic regression model. Factors included in this model, using backward selection, were: sex, age, lung function (forced expiratory volume 1 second (FEV₁)% and diffusing capacity for carbon monoxide (DLCO)% combined), body mass index (BMI), American Society of Anesthesiologists (ASA) score, Charlson comorbidity index (CCI), pulmonary comorbidity (mostly chronic obstructive pulmonary disease (COPD), but any other pulmonary comorbidity was included), lobe, side of the tumor, histological type and type of resection. To check the discrimination of the model we calculated the C-statistic (area under the curve). For every hospital, the expected percentage of patients with PAL was calculated using the probabilities of the individual patients. Per hospital the observed percentage of patients with PAL divided by the expected percentage was presented in a

funnel plot with 95% and 99.8% confidence limits to visualize hospital outcome and to identify positive and negative outliers.

Online survey among Dutch thoracic surgeons

To gain insight in differences in routine peri-operative care for patients undergoing lung resection, drain management and management in case of PAL, three semi-structured interviews were held with two lung surgeons (K.J.H. and W.H.S.) and 1 cardiothoracic surgeon (A.F.V.). Based on their feedback, an online survey was developed (*Supplementary Material, Appendix S1*) using Google Forms. (21) With the help of the professional associations involved in the DLCA-S, this survey was sent to all surgeons in the Netherlands performing oncological lung resections (n=138). Descriptive statistics were used for the analysis of survey results. Results were analyzed on a surgeon level and, if suitable, also on a hospital level. Emphasized was that water seal in digital drainage systems often consists of a slight negative pressure (e.g. -8 cm in Thopaz systems). We asked respondents to also consider this as a water seal.

Combining of survey results and DLCA-S data

For each hospital, the true PAL rate calculated from the DLCA-S database was set against the PAL incidence rate estimated by thoracic surgeons in the online survey, to test how well aware surgeons are about their complication rates.

To assess hospital level associations between (preventive) management strategies and the incidence of PAL, a hospital level dataset with actual PAL incidence rates and case-mix adjusted PAL rates was created from the DLCA-S database. Local management strategies to reduce the PAL-rate for each hospital were added manually based on survey results. Factors included were peroperative use of sealants; chest drain device; drain device setting directly postoperative and type of ward the patient is admitted to postoperatively. Data were considered missing in case surgeons from the same hospital entered conflicting answers. After checking whether the hospital PAL rate was normally distributed, univariable linear regression was used to test for associations, with hospital PAL rate as the dependent variable and management strategies as independent variables. This was done for case-mix unadjusted and adjusted data. Even though almost all hospitals in the Netherlands participated in the survey, the number of hospitals would be too limited to have enough power to perform a multivariable analysis.

RESULTS

Incidence of persistent air leak, risk factors and between-hospital variation

Of the 12 489 included patients, 107 (0.9%) had missing data on PAL and were excluded. Of the remaining 12 382 patients, 1111 had PAL resulting in a nationwide incidence rate of 9.0%. The baseline patient and tumor characteristics of patients with and without PAL are listed in *Supplementary Material, Table S1*.

In multivariable logistic regression, male sex, poor lung function with a FEV₁ or DLCO <80% (versus both >80%), BMI below 18.5 kg/m² (versus 18.5-25.0, being overweighted was protective), high ASA-score, pulmonary comorbidity, upper lobe resection, (bi)lobectomy (versus segmentectomy), right-sided tumor and robot-assisted thoracoscopic surgery (RATS; versus video-assisted thoracoscopic surgery (VATS)) were found to be significantly associated with PAL (*Table 1*). All these factors were included in the case-mix model supplemented with age, excluding surgical approach, which concerns a treatment choice. The case-mix adjusted hospital incidence of PAL ranged from 2.6% to 19.3%. Case-mix unadjusted and adjusted PAL rates are respectively shown in *Figure 1a and b*, which shows significant differences between hospitals. The C-statistic (95% confidence interval) of the model was 0.67 (0.66-0.69).

TABLE 1. Probability for persistent air leak, results of univariable and multivariable analyses.

Variables	Probability for PAL ^a		Univariable logistic regression		Multivariable logistic regression	
	n	OR [95% CI]	P value	n	aOR [95% CI]	P value
Total	12,382			12,382		
Age (years)			0.187			
<60	2842	1				
60-69	4724	1.20 [1.01-1.42]				
70-79	4161	1.16 [0.98-1.38]				
>79	655	1.10 [0.81-1.49]				
Sex			<0.001			<0.001
Male	6620	1		6620	1	
Female	5762	0.62 [0.55-0.71]		5762	0.61 [0.53-0.69]	0.812
Charlson Comorbidity Index			<0.001			
0	4188	1		4188	1	
1	3374	1.48 [1.26-1.74]		3374	1.00 [0.84-1.21]	
2+	4820	1.36 [1.17-1.58]	0.835	4820	0.96 [0.81-1.14]	
Cardiac comorbidity						
No	9218	1				
Yes	3164	0.99 [0.86-1.14]				
Pulmonary comorbidity			<0.001			<0.001
No	8020	1		8020	1	
Yes	4362	1.81 [1.60-2.05]	0.165	4362	1.61 [1.39-1.86]	
ECOG score ^b						
0-1	9828	1				
II+	465	1.33 [0.99-1.78]				
Unknown / missing	2089	1.03 [0.88-1.22]				
ASA score^c			<0.001			0.010
I-II	8097	1		8097	1	
III+	3591	1.41 [1.23-1.61]		3591	1.23 [1.07-1.42]	
Unknown / missing	694	1.01 [0.76-1.34]		694	1.24 [0.91-1.67]	
Lung function^d			<0.001			<0.001
FEV ₁ and DLCO% >80%	4008	1		4008	1	
FEV ₁ or DLCO% <80%	7601	1.95 [1.68-2.27]		7601	1.63 [1.39-1.91]	
Both unknown / missing	773	1.16 [0.85-1.58]		773	1.23 [0.89-1.70]	
BMI (kg/m²)			<0.001			<0.001
<18.5	109	2.25 [1.43-3.56]		109	2.24 [1.40-3.58]	

TABLE 1. Continuous

18.5 - 25	1724	1	0.59 [0.47-0.75]	1724	1	0.60 [0.47-0.76]	
25 - 30	1488		0.35 [0.24-0.51]	1488		0.36 [0.25-0.52]	
>30	690		0.64 [0.54-0.75]	690		0.69 [0.58-0.82]	
Unknown / missing	8371			8371			
Pathological stage ^e							0.206
Stage 0	228		1.00 [0.63-1.60]				
Stage I	6115	1					
Stage II	3070		1.16 [1.00-1.34]				
Stage III	1633		1.00 [0.82-1.21]				
Stage IV	305		0.89 [0.58-1.36]				
Unknown / missing	1031		0.86 [0.67-1.10]				
Pathological T-stage ^e							0.207
pT1a(mi)-b-c (and To Tis)	4869	1					
pT2a-b	4269		1.01 [0.87-1.16]				
pT3	1847		1.21 [1.01-1.45]				
pT4	527		1.12 [0.83-1.53]				
Unknown / missing	870		0.93 [0.72-1.21]				
Tumor side							<0.001
Left	4958	1		4958	1		0.002
Right	7245		1.25 [1.10-1.42]	7245		1.22 [1.07-1.42]	
Unknown / missing	179		0.33 [0.14-0.81]	179		0.38 [0.14-1.00]	
Histological type							0.467
Benign	471		0.87 [0.62-1.24]	471		0.84 [0.59-1.20]	
Adenocarcinoma	6762	1		6762	1		
Squamous cell carcinoma	3345		1.26 [1.10-1.45]	3345		1.09 [0.94-1.26]	
Different NSCLC	1220		0.84 [0.67-1.06]	1220		0.92 [0.73-1.16]	
SCLC	146		0.86 [0.46-1.60]	146		0.83 [0.44-1.55]	
Other / unknown / missing	438		0.83 [0.58-1.21]	438		0.86 [0.69-1.25]	
Type of resection							0.009
Bilobectomy	810		1.36 [1.09-1.70]	810		1.23 [0.97-1.56]	
Lobectomy	11,177	1		11,177	1		
Segmentectomy (anatomical)	395		0.52 [0.32-0.82]	395		0.54 [0.34-0.87]	
Lobe^f							<0.001
Lower lobe	3742	1					
Middle lobe	634		0.43 [0.28-0.69]				
Upper lobe	6987		1.54 [1.33-1.78]				
Upper and middle lobe	336		1.36 [0.92-2.01]				

Lower and middle lobe	452	2.13 [1.58-2.86]			
Unknown / missing	231	1.20 [0.74-1.95]			
Surgical approach					<0.001
Thoracotomy	3170	0.99 [0.85-1.15]	3170	0.89 [0.76-1.04]	
VATS	6800	1	6800	1	
RATS	304	2.14 [1.56-2.92]	304	2.06 [1.48-2.88]	
UVATS	511	1.20 [0.89-1.62]	511	1.11 [0.81-1.53]	
Conversion to thoracotomy	1265	1.19 [0.98-1.46]	1265	1.03 [0.83-1.26]	
Unknown / missing	332	0.79 [0.51-1.22]	332	0.99 [0.61-1.60]	
Induction therapy					0.359
No / Unknown / missing	11,545	1			
Chemoradiotherapy	526	0.78 [0.56-1.10]			
Other	311	0.99 [0.67-1.47]			0.357
Year of surgery					
2012	1155	1			
2013	1497	0.96 [0.72-1.27]			
2014	1427	1.05 [0.80-1.39]			
2015	1901	1.10 [0.85-1.43]			
2016	1970	1.07 [0.82-1.39]			
2017	2153	1.22 [0.95-1.57]			
2018	2279	1.19 [0.93-1.53]			

^aPAL: air leak >5 days after surgery.

^bECOG score: Eastern Cooperative Oncology Group performance score.

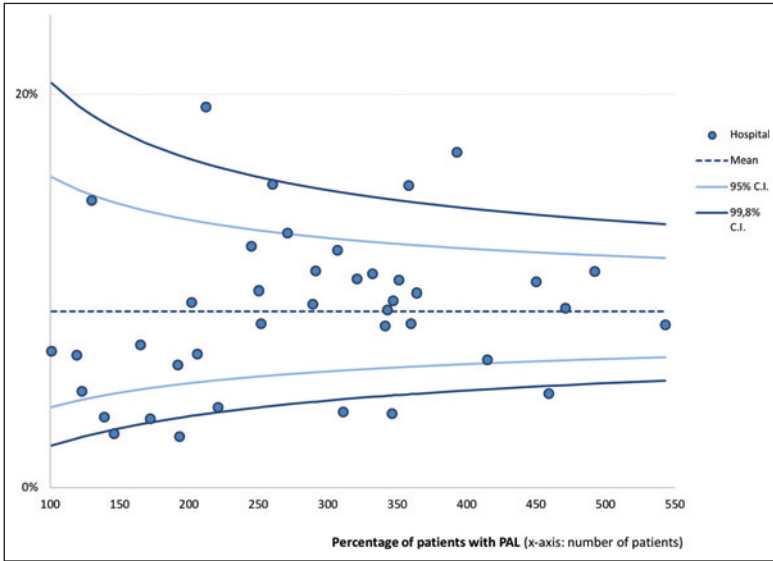
^cASA score: American Society of Anesthesiologists physical status classification system.

^dLung function: combined measure of DLCO and FEV₁.

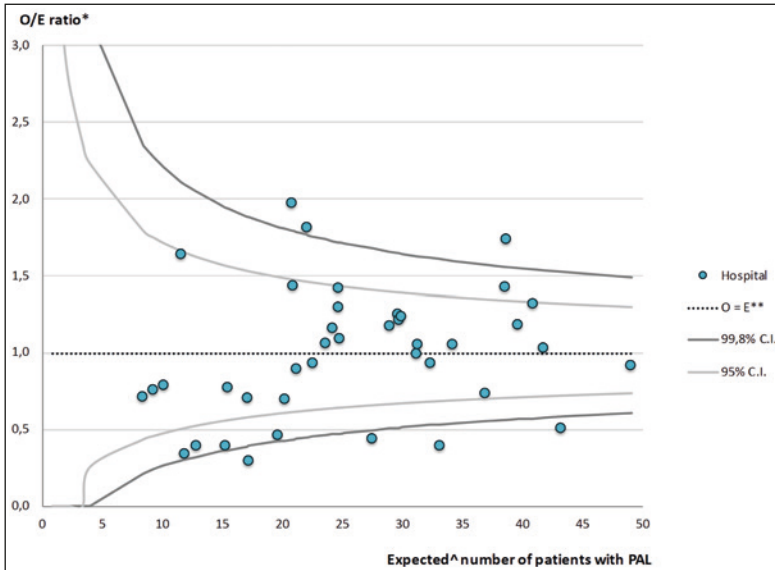
^ePathological (T-)stage: TNM 7th edition till 2016, TNM 8th edition from 2017.

^fAlthough 'Lobe' was a significantly associated with PAL in univariable analysis, there was too much overlap with the variable 'Type of resection', to put both variables in the multivariable model. Although not presented here, lobe continued to be significantly associated with PAL in multivariable analysis.

aOR: adjusted odds ratio; BMI: body mass index; CI: confidence interval; DLCO: diffusing capacity of the lungs for carbon monoxide; FEV₁: forced expiratory volume in 1 s; NSCLC: non-small-cell lung cancer; OR: odds ratio; PAL: persistent air leak; RATS: robotic-assisted thoracoscopic surgery; SCLC: small-cell lung cancer; TNM: tumour, node and metastasis; UVATS: uniportal video-assisted thoracoscopic surgery; VATS: video-assisted thoracoscopic surgery.



A



B

FIGURE 1. Funnel plot of between-hospital variation in persistent air leak (2012–2018): (A) unadjusted and (B) adjusted for case-mix. *O/E ratio: observed number of PAL divided by expected^ number of PAL. **O = E: the observed number equals the expected^ number of patients with PAL. ^Expected based on population characteristics in the hospital. CI: confidence interval; PAL: persistent air leak.

Variation in management of persistent air leak

The online survey was completed by 68 surgeons (49.3% of those addressed) from 38 out of 43 hospitals performing lung surgery in the Netherlands. The results are summarized in *Supplementary Material, Appendix S1*. The majority of hospitals used protocols for postoperative drain management (97.4%), but only 60.5% of hospitals had described specific management in case of PAL in a protocol. Almost half of the surgeons (47.1%) estimated the occurrence of postoperative PAL in their hospital to be 5-10%, against 23.5% who estimated PAL < 5% and 29.4% > 10%.

The use of intraoperative preventive measures varied between hospitals. Of the surgeons, 17.6% (n=12) used sealants routinely regardless of patients' conditions or type of resection, 13.2% (n=9) never used them and 69.1% (n=47) only used sealants when deemed indicated. Also, wide variation in postoperative management was seen. Of the hospitals, 60.5% (n=23) used digital drainage systems and 13.2% (n=5) used analogue systems only. The remaining 26.3% (n=10) used both systems. Setting of the drain device directly postoperative was suction in 47.4% (n=18) of the hospitals and water seal in 47.4% (n=18) of the hospitals (5.2% conflicting answers, suggesting no uniform policy). In case of reintervention for PAL, 45.6% (n=31) of the surgeons routinely performed computed tomography (CT) scan of the thoracic cavity before proceeding to reintervention, 47.1% (n=32) did this only when they considered it to be contributing.

Estimation of own results and associations between (preventive) management strategies and the incidence of persistent air leak

The percentages of PAL per hospital as registered in the DLCA-S were compared with the estimated percentages from the online survey (*Figure 2*). Eighteen hospitals (45%) had an estimated percentage of PAL concordant with their actual PAL rate. Surgeons from 12 hospitals (30%) underestimated the incidence of PAL in their hospitals. Most of these hospitals had a PAL incidence above the national average of 9.0%.

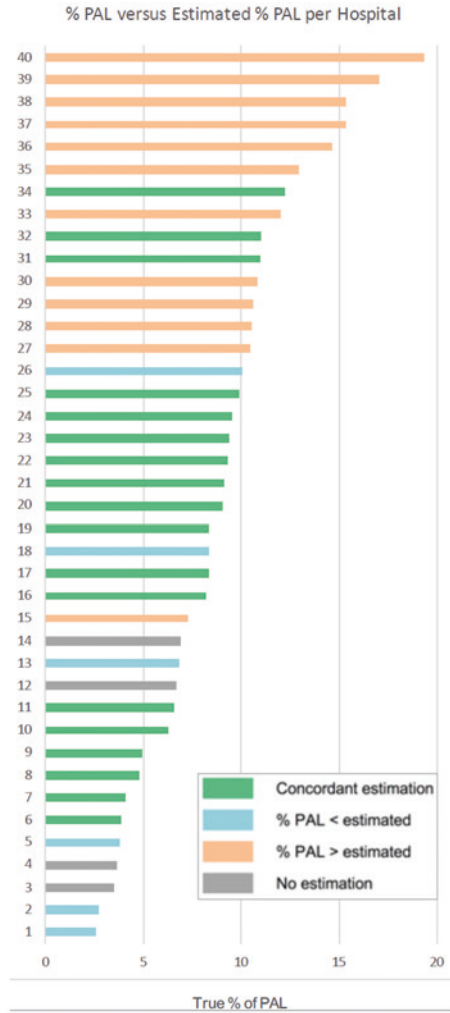


FIGURE 2. True percentage of persistent air leak, derived from the Dutch Lung Cancer Audit for Surgery, versus estimated percentage of persistent air leak, derived from the survey, per hospital. PAL: persistent air leak.

For 36 hospitals both data on incidence of PAL, derived from the DLCA-S, and data on post-operative management were available. In univariable analyses on these data, the postoperative drain device setting immediately after surgery was the only factor significantly associated with PAL (Table 2). Hospitals applying water seal, compared to those applying suction immediately after closing the thoracic cavity, had 2.9% less PAL (case-mix adjusted).

TABLE 2. Predicted effect of hospital management strategies on the incidence of persistent air leak (PAL, %) on hospital level by linear regression using (A) the true percentages of PAL per hospital and (B) the case-mix corrected percentages of PAL.

Probability for PAL Variables	A. Univariable linear regression			B. Univariable linear regression – case-mix corrected % of PAL	
	n	B (%) [95% CI]	p value	B (%) [95% CI]	p value
Total	36				
Postoperative ward	34		0.295		0.322
Respiratory	21	Ref.		Ref.	
Surgery	13	-1.47 [-4.27 to 1.34]		-1.32 [-3.97 to 1.35]	
Use of sealants	35		0.247		0.251
On indication	23	Ref.		Ref.	
Always	6	-2.00 [-5.65 to 1.65]		-1.85 [-5.32 to 1.62]	
Never	6	-2.68 [-6.32 to 0.97]		-2.56 [-6.03 to 0.91]	
Chest drain device	35		0.134		0.116
Digital	21	Ref.		Ref.	
Analogue	5	-3.55 [-7.44 to 0.33]		-3.69 [-7.37 to -0.01]	
Both	9	0.65 [-2.46 to 3.76]		0.21 [-2.73 to 3.15]	
Drain device setting	33		0.015		0.023
Suction	17	Ref.		Ref.	
Water seal	16	-3.27 [-5.88 to -0.67]		-2.92 [-5.42 to -0.43]	

CI: confidence interval; PAL: persistent air leak. Significant if $p < 0.05$.

DISCUSSION

From 2012 to 2018, in the Netherlands, a PAL incidence rate of 9.0% was found with a considerable between-hospital variation. This national cohort study shows that male sex, poor lung function, low BMI, high ASA-score, pulmonary comorbidity, upper lobe resection, (bi)lobectomy (versus segmentectomy), right-sided tumor, and RATS are independent predictors of PAL. In addition to the variation in PAL rate, awareness

and (preventive) management strategies varied considerably between hospitals. On a hospital-level, postoperative water seal versus suction, immediately after surgery, was associated with 2.9% less PAL.

The incidence of PAL of 9.0% is in line with previous research. In 2016 Pompili et al. reported, in a cohort of >5000 VATS lobectomies from the ESTS database, an incidence of 9.9% PAL. (4) A single-center, consecutive cohort study in lobectomies, by Brunelli et al., found an incidence of 13% PAL. (5) And, in a selection of lobectomies of patients in the STS database, Paul et al. found 8.7% PAL after thoracotomy and 7.6% after VATS. (7) Although our overall results are similar to previous studies, the variation in PAL incidence between Dutch hospitals, ranging from 2.6% to 19.3%, suggests that there is still room for improvement.

We analyzed several previously identified risk factors associated with PAL. Male gender, FEV₁ <80%, and BMI <18.5kg/m² were found to be associated with PAL by Pompili et al. and were included in a risk score predicting post-operative PAL. (5) Earlier, Brunelli found pleural adhesions (not in our data) and upper lobe resection as predictors of PAL and made a different risk score. (3) And in a review on PAL, Singhal et al. additionally described DLCO <80%, bilobectomy, lobectomy vs. sublobar resections, and steroid use as risk factors. (22) Right-sided resections have been suggested to be a risk factor but, till now, never been found significantly associated with PAL. RATS was also identified as a risk factor for PAL. In RATS the choice for a dissection through the fissure may play a role in causing an air leak, in contrast to a hilum first approach. But this finding should be regarded with care, since learning curve may have played a role in the higher PAL rate for this relatively new technique. On the other hand, focus on the results of RATS, as a new technique, could have resulted in better registration of complications. Finally, few hospitals use this technique in the Netherlands, making it vulnerable to a hospital effect.

Despite all these previous efforts, risk models never have been successfully implemented into (Dutch) practice. Therefore, we focused on variation in real-life practice and the ability to draw lessons from treatment patterns leading to better outcomes. The survey, completed by more than half of all Dutch thoracic surgeons, showed a large variation in daily practice, suggesting management is based on local preferences and experience, rather than on evidence. Aerostatics or seals, for example, are for some surgeons part of their surgical routine, while others never use them, or, most of them, when deemed useful. Another striking result was the lack of consensus about the postoperative drain device setting, which was 50/50 for suction vs. water seal.

To take advantage of these differences, we related these management factors on a hospital-level to the incidence of PAL. Despite the low numbers, limited by the number of Dutch hospitals, a correlation between drain device setting and PAL was found. When using water seal compared to suction drainage, the average incidence of PAL will decrease by 2.9%. This is in line with earlier suggestions from literature, summarized by Cerfolio and Bryant (23) and supported by the 2018 results of Holbek et al., who compared water seal vs. suction on a patient level in 228 consecutive VATS lobectomies. They concluded an advantage of 9.9% less PAL for patients receiving 'water seal' immediately after surgery. (24) Reproducing this effect on a hospital-level in our study reinforces the recommendation for postoperative water seal drainage in patients after an oncological lung resection. When applying water seal instead of suction, fear for more complications could arise, such as atelectasis or pneumonia. However, Holbeck et al. didn't find significant differences in any complications in their randomized trial. (24)

Finally, we found that in hospitals with high PAL incidence, surgeons weren't aware of this and underestimated their PAL complications. As every improvement starts with awareness of the problem, benchmarked feedback to the treating surgeon on their PAL rate is very important. The DLCA-S is a key instrument in achieving this, by including PAL rates in the Codman Dashboard, which shows the surgeons (trends in) their outcomes. (19)

Strengths and limitations

The main strengths of this study are the national design, covering all hospitals performing lung surgery in the Netherlands, and the conducted survey, which allowed us to combine patient-level data on PAL with hospital management strategies after an oncological lung resection. Also, the decrease in PAL using water seal compared to suction is still manifest and clinically relevant after case-mix correction, which increases the reliability of our results.

The main risk of using self-reported registry data in case of complications is under-reporting by hospitals. However, previous validation of the DLCA-S database showed only 3.3% missing or incorrectly registered complications. (25) By excluding hospitals with >5% missing data on PAL from hospital-level analysis, we minimized the effect of a potential registration bias.

Analyzing data on a hospital-level may lead to the phenomenon of 'ecological fallacy', i.e. the false assumption that inferences made at hospital-level would apply to individual patients. (26) Because we didn't have the data on individual drain device settings, we weren't able to check this in our study population. However, the same relation between

postoperative water seal and less PAL was reported previously in a randomized controlled trial, which endorses our results and suggests no interference by ecological fallacy. (24)

CONCLUSION

This study showed that, between 2012-2018, the nationwide incidence of PAL after oncological lung resection in The Netherlands was 9.0%. However, there was a significant between-hospital variation, and variation in management strategies by hospitals regarding postoperative (persistent) air leakage. Hospitals applying water seal had 2.9% less PAL compared to hospitals using suction drainage. With an equal number of Dutch hospitals applying postoperative water seal drainage and suction drainage, an opportunity for improvement is revealed. Underestimation of PAL rates of 30% by hospitals with a high PAL incidence highlights the importance of awareness for quality improvement. Therefore, benchmarked feedback on PAL rates will be implemented in the Codman Dashboard of the nationwide quality registry.

SUPPLEMENTARY MATERIAL

Supplementary material is available at EJCTS online.

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