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Prolonged length of stay associated with air leak following pulmonary resection has a negative impact on hospital margin

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Background: Protracted hospitalizations due to air leaks following lung resections are a significant source of morbidity and prolonged hospital length of stay (LOS), with potentially significant impact on hospital margins. This study aimed to evaluate the relationship between air leaks, LOS, and financial outcomes among discharges following lung resections.
Materials and methods: The Medicare Provider Analysis and Review file for fiscal year 2012 was utilized to identify inpatient hospital discharges that recorded International Classification of Diseases (ICD-9) procedure codes for lobectomy, segmentectomy, and lung volume reduction surgery (n=21,717). Discharges coded with postoperative air leaks (ICD-9-CM codes 512.2 and 512.84) were defined as the air leak diagnosis group (n=2,947), then subcategorized by LOS: 1) <7 days; 2) 7–10 days; and 3) ≥11 days. Median hospital charges, costs, payments, and payment-to-cost ratios were compared between non-air leak and air leak groups, and across LOS subcategories.
Results: For identified patients, hospital charges, costs, and payments were significantly greater among patients with air leak diagnoses compared to patients without ($P<0.001$). Hospital charges and costs increased substantially with prolonged LOS, but were not matched by a proportionate increase in hospital payments. Patients with LOS <7, 7–10, and ≥11 days had median hospital charges of US $57,129, $73,572, and $115,623, and costs of $17,594, $21,711, and $33,786, respectively. Hospital payment increases were substantially lower at $16,494, $16,307, and $19,337, respectively. The payment-to-cost ratio significantly lowered with each LOS increase ($P<0.001$). Higher inpatient hospital mortality was observed among the LOS ≥11 days subgroup compared with the LOS <11 days subgroup ($P<0.001$).
Conclusion: Patients who develop prolonged air leaks after lobectomy, segmentectomy, or lung volume reduction surgery have the best clinical and financial outcomes. Hospitals experience markedly lower payment-to-cost ratios as LOS increases. Interventions minimizing air leak or allowing outpatient management will improve financial performance and hospital margins for lung surgery.
Keywords: air leaks, length of stay, hospital financials

Introduction

Postoperative air leaks have been widely documented as one of the most common complications following pulmonary resection.[1–4] There are numerous causes of these air leaks, including trauma from lung manipulation, fissure dissection, or adhesiolysis; disruption of parenchyma at or adjacent to staple lines; barotrauma during positive pressure ventilation; or spontaneous air leak from underlying lung pathology. The majority of postoperative air leaks resolve on their own within a few days after surgery and do not prolong hospitalization time in patients.

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In some cases, however, air leaks persist and become prolonged, with a resulting delay in patient discharge and/or discharge with an indwelling chest tube for home management. Recent literature has defined prolonged air leaks as any air leak lasting longer than postoperative day (POD) 7.[2,5] Predictors of prolonged air leaks include low forced expiratory volume in 1 second (FEV1), preexisting lung disease, pleural adhesions, steroid use, previous chemo- and/or radiotherapy, malnutrition, and diabetes.[4]

Common clinical complications associated with prolonged air leaks include pain and decreased mobility from prolonged chest tube drainage, empyema, pneumonia, and pneumothorax.[4] Risk of morbidity and mortality in this particular patient population can be as high as 60% and is often the major limiting factor in delayed discharge from the hospital.[3–5] Because air leaks are associated with prolonged hospital stays, a more complicated postoperative course, and comorbidities, various intraoperative precautions are employed to avoid them.[4] Common techniques include the use of lung sealants, fibrin glue, sheets of synthetic material, and buttressing.[4,6] Despite these preventative measures, air leaks continue to occur and consume health care resources. While the overall prevalence of any postoperative air leak ranges from 48% to 75%, prolonged air leaks have shown to vary in incidence by surgery from 8% for segmental or wedge resections, 10% for lobectomy, up to 45% in patients undergoing lung volume reduction surgery (LVRS).[7]

The most common method for managing a postoperative air leak is through chest drainage with observation. This method relies on the visual assessment and interpretation of changes to bubbling in the drainage system by the physician or members of the team. More proactive techniques and procedures to stop air leaks include various bronchoscopic approaches such as endobronchial valve placement, pleurodesis, and at times reoperation.[7–9] The subjective nature of visual assessment, combined with varying degrees of confidence in time to chest tube removal, can have a significant impact on hospital length of stay (LOS).

Besides being a significant source of frustration to the patient and provider for medical reasons, protracted hospitalizations as a result of air leaks also impact hospital margins. While numerous studies demonstrated the cost of a prolonged air leak in terms of LOS and morbidity, few attempt to characterize the financial implications of air leak to hospitals. Prior to late 2012, specific International Classification of Diseases (ICD-9-CM) diagnosis codes for postoperative air leaks did not exist, which made it difficult to readily identify these cases retrospectively in claims data.[10] The implementation of specific air leak diagnosis codes on October 1, 2011 (also known as the start of US federal fiscal year 2012) allowed for an opportunity to measure the financial impact of air leaks for the first time using claims data. This study has two objectives as follows: first, to compare the hospital LOS, charges, costs, and payments among patients who underwent specific lung resections and were diagnosed with a postoperative air leak to those patients who were not diagnosed with an air leak; and second, to identify the impact of differences in total hospital charges, costs, and payments with varying degrees of prolonged LOS associated with air leak.

Materials and methods

Data sources

The Medicare Provider Analysis and Review (MedPAR) Hospital National Limited Data Set for federal fiscal year 2012 (October 1, 2011 through September 30, 2012), acquired from the Centers for Medicare and Medicaid Services (CMS), was utilized for this study.[11–13] This study only used pre-existing de-identified data; the MedPAR Limited Data Set lacks direct identifiers of beneficiaries, and is compliant with the Health Insurance Portability and Accountability Act (HIPAA Privacy Rule). As such, internal review board approval and patient consent was not required. MedPAR contains detailed charge and payment information for 100% of Medicare fee for service beneficiaries using Inpatient Prospective Payment System (IPPS) services. A total of 15,045,461 Medicare fee for service discharges were recorded in fiscal year 2012 (Figure 1). An inpatient "stay" record summarizes all services rendered to a beneficiary from the time of admission to a facility through discharge. Data fields pertaining to total hospital charges, LOS, age, race, sex, discharge status, and total payment amounts were utilized in the analysis.

Study population

Discharges were identified by one of the following primary ICD-9-CM procedure codes: LVRS (32.22), thoracoscopic lung segment resection (32.30), other lung segment resection (32.39), thoracoscopic lung lobectomy (32.41), and other lung lobectomy (32.49). There were 22,464 unique discharges with procedure codes relating to lung resection in fiscal year 2012 (Figure 1). Due to missing cost-to-charge ratios (CCRs) for some hospitals, charges could not be converted to cost.[12] Therefore, 747 (3%) discharges were excluded. The final sample included 21,717 discharges. Discharges with ICD-9-CM codes of 512.2 (postoperative air leak) and 512.84 (other air leaks) subsequent to the lung resection procedure codes were defined as air leak cases (n=2,947).

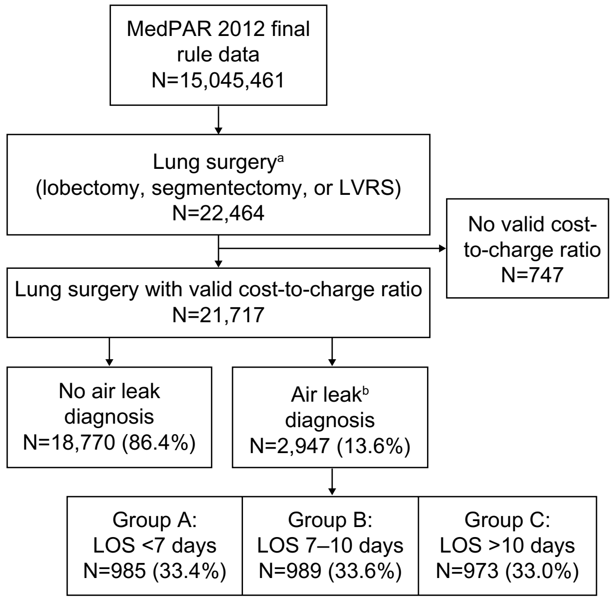

Figure 1 Medicare discharges from MedPAR data grouped by major lung surgery and air leak.

Notes: [a]Lung surgery indicated by ICD-9-CM codes for lung volume reduction surgery (32.22), thorascopic lung segment resection (32.30), other lung segment resection (32.39), thorascopic lung lobectomy (32.41) and other lung lobectomy (32.49). [b]Air leak indicated by ICD-9-CM code (512.2 for postoperative air leak or 512.84 for another air leak).

Abbreviations: MedPAR, Medicare Provider Analysis and Review; LVRS, lung volume reduction surgery; LOS, length of stay; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

Definition of hospital charges, costs, and payments

Hospital charges represented the total amount of charges that hospitals reported to Medicare on claim forms. Actual hospital costs are not provided in the MedPAR data, so they were calculated using the IPPS Final Rule 2014 Standardizing File. This file was used to calculate provider-specific CCR by adding operating CCR and capital CCR.[12] For each discharge in MedPAR, total charges were multiplied by the provider-specific CCR to estimate total hospital cost. Discharges from providers without CCR information were excluded from the analysis.

Hospital payments reflect the total payment that hospitals received for the services performed. The hospital payments were taken from the Diagnosis-Related Group (DRG) Price Amount field, which is defined as the amount that would have been paid if no deductibles, coinsurance, primary payers, or outliers were involved (rounded to whole dollars). Some discharges have costs above a fixed-loss cost threshold amount (the dollar amount by which the costs of the case exceed payments, and qualify for outlier payments).[13] The DRG Outlier Approved Payment Amount field (the amount of payment approved due to an outlier situation over the DRG allowance for the stay) was added to the DRG Price Amount field to account for total payments. The payment-to-cost ratio was calculated by dividing the hospital payment by the hospital cost for each discharge examined.

Statistical analyses

Characteristics among discharges with and without air leaks were described, and chi-square tests were performed to test the difference in proportions between air leak diagnosis groups. Hospital LOS, cost, and payment were compared between air leak diagnosis groups by performing a Wilcoxon rank-sum test, since LOS and costs were not normally distributed. All analyses were performed using SAS software (version 9.3; SAS Institute Inc., Cary, NC, USA).

Discharges that presented with air leaks were grouped into three LOS subcategories: 1) $<$7 days; 2) 7–10 days; and 3) $\geq$11 days. The first cutoff at 7 days was used to distinguish discharges with and without a prolonged air leak. The second cutoff between 10 and 11 days was determined to correspond to approximately equivalent numbers of discharges to compare moderate and more profound prolonged LOS.

Distributions of characteristics between the three LOS groups were compared on a global basis using the chi-square test for homogeneity. If a significant difference was observed at α=0.05, then the groups were compared on a pairwise level using the same test with a Bonferroni-adjusted significance level of α=0.05/3=0.017. The quantitative outcomes in the three LOS subcategories were compared using the Kruskal–Wallis nonparametric one-way analysis of variance due to the heavy right skew in these data. Pairwise comparisons between LOS subcategories were determined by the Dunn's test, which controls the overall significance level at α=0.05.

Results

Of the 21,717 discharges following lobectomy, segmentectomy, or LVRS identified in the 2012 MedPAR file, 2,947 (13.6%) were coded as having an air leak diagnosis following surgery (Table 1). Approximately 2% of discharges were deceased at time of discharge, regardless of air leak diagnosis (P=0.31). The distribution of age was similar between air leak and non-air leak diagnosis groups (P=0.13). Males (55%) were significantly more likely than females to have an air leak diagnosis ($P<0.001$). Lobectomy was the most common surgery (18,484 [85.11%]), followed by segmentectomy (3,148 [14.50%]), then LVRS (85 [0.39%]) (Table 1). The proportion of discharges that had an air leak diagnosis was highest in the post-LVRS discharge group, for which the proportion with air leak diagnosis was over double that of

Table 1 Medicare discharges undergoing major lung surgery with and without air leak diagnosis during hospital stay: patient demographics

Characteristic	N (Col%)			*P*-value[b]
	No air leak	Air leak[c]	Total discharges	
Number of cases[a]	18,770 (86.4%)	2,947 (13.6%)	21,717 (100%)	N/A
Status at discharge				
Alive	18,391 (98.0%)	2,879 (97.7%)	21,270 (97.9%)	0.31
Deceased	379 (2.0%)	68 (2.3%)	447 (2.1%)	
Age distribution				
<65 years	1,849 (9.9%)	255 (8.7%)	2,104 (9.7%)	0.13
65–69 years	4,659 (24.8%)	747 (25.3%)	5,406 (24.9%)	
70–74 years	5,183 (27.6%)	835 (28.3%)	6,018 (27.7%)	
75–79 years	4,105 (21.9%)	615 (20.9%)	4,720 (21.7%)	
80+ years	2,974 (15.8%)	495 (16.8%)	3,469 (16.0%)	
Sex				
Male	9,190 (49.0%)	1,610 (54.6%)	10,800 (49.7%)	<0.001
Female	9,580 (51.0%)	1,337 (45.4%)	10,917 (50.3%)	
Race				
Asian	260 (1.4%)	19 (0.6%)	279 (1.3%)	<0.001
White	16,424 (87.5%)	2,668 (90.5%)	19,092 (87.9%)	
Black	1,497 (8.0%)	178 (6.0%)	1,675 (7.7%)	
Hispanic	183 (1.0%)	15 (0.5%)	198 (0.9%)	
Native American	59 (0.3%)	10 (0.3%)	69 (0.3%)	
Other/unknown	347 (1.8%)	57 (1.9%)	404 (1.9%)	
Surgery type[a]				
LVRS	52 (61.2%)	33 (38.8%)	85 (100%)	<0.001
Lobectomy	15,854 (85.8%)	2,630 (14.2%)	18,484 (100%)	
Segmentectomy	2,864 (91.0%)	284 (9.0%)	3,148 (100%)	

Notes: [a]Percentage of row, not column; [b]*P*-values determined by chi-square test for homogeneity; [c]air leaks defined as ICD-9-CM codes 512.2 and 512.84.
Abbreviations: LVRS, lung volume reduction surgery; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; Col, column; N/A, not applicable.

Table 2 Medicare discharges undergoing major lung surgery with and without air leak diagnosis: total length of stay and hospital financials

Characteristic	Mean ± SD (Median)		*P*-value[a]
	No air leak	Air leak[b]	
Number of cases	18,770	2,947	N/A
Length of stay (LOS) in days	7.3±6.4 (6)	10±7.0 (8)	<0.001
Total hospital charges	$88,840±$87,381 ($66,553)	$98,809±$84,131 ($77,319)	<0.001
Total hospital costs	$23,698±$20,492 ($18,852)	$27,229±$17,818 ($22,641)	<0.001
Total hospital payments	$16,977±$19,182 ($14,843)	$18,976±$18,557 ($16,948)	<0.001
Ratio of payments to costs	0.777±0.609 (0.763)	0.750±0.528 (0.750)	0.16

Notes: [a]*P*-values determined by Wilcoxon rank-sum test on continuous variables; [b]air leaks defined as ICD-9-CM codes 512.2 and 512.84. Currency USD.
Abbreviations: SD, standard deviation; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; N/A, not applicable.

the post-lobectomy discharges, and over quadruple that of the post-segmentectomy discharges.

As expected, the median LOS was significantly greater among the air leak diagnosis group compared to the non-air leak diagnosis group (8 days vs 6 days, respectively; $P<0.001$, Table 2). Hospital charges, costs, and payments significantly increased among discharges with postoperative air leaks (all $P<0.001$) (Table 2).

The demographics and status at discharge are presented for the three LOS subcategories in the air leak diagnosis group (n=2,947) in Table 3. Age and race were not different among these LOS subcategories ($P=0.62$ and $P=0.71$, respectively). However, males were significantly more likely to endure a LOS ≥11 days ($P<0.001$). There was no difference in sex proportions between LOS group <7 days and LOS group 7–10 days (51.7% vs 52.9% male, respectively). Mortality was significantly increased among postoperative patients with air leak diagnoses in LOS group ≥11 days compared with LOS group <11 ($P<0.001$) days. Four percent of discharges that experienced an air leak and had a LOS ≥11 days were deceased, compared to 1.6% and 1.3% among LOS group <7 days and LOS group 7–10 days, respectively.

Hospital charges, costs, payments, and payment-to-cost ratio across the three air leak LOS subcategories are presented in Table 4. As expected, hospital charges and costs increased substantially with prolonged LOS, but

Table 3 Medicare discharges undergoing major lung surgery with air leak diagnosis during hospital stay: comparison of patient demographics by length of stay (LOS) group

Characteristic	N (Col%)[a]				*P*-value[b]	Pairwise test[c]		
	Group A LOS <7	Group B LOS 7–10	Group C LOS ≥11	Total discharges		A vs B	B vs C	A vs C
Number of cases	985 (33.4%)[d]	989 (33.6%)[d]	973 (33.0%)[d]	2,947	N/A	N/A		
Status at discharge								
Alive	969 (98.4%)	976 (98.7%)	934 (96.0%)	2,879 (97.7%)	<0.001	0.57	0.0002	0.001
Deceased	16 (1.6%)	13 (1.3%)	39 (4.0%)	68 (2.3%)				
Age distribution								
<65 years	85 (8.6%)	79 (8.0%)	91 (9.4%)	255 (8.7%)				
65–69 years	253 (25.7%)	255 (25.8%)	239 (24.6%)	747 (25.3%)	0.62	N/A		
70–74 years	278 (28.2%)	278 (28.1%)	279 (28.7%)	835 (28.3%)				
75–79 years	188 (19.1%)	214 (21.6%)	213 (21.9%)	615 (20.9%)				
80+ years	181 (18.4%)	163 (16.5%)	151 (15.5%)	495 (16.8%)				
Sex								
Male	509 (51.7%)	523 (52.9%)	578 (59.4%)	1,610 (54.6%)	0.001	0.59	0.004	0.0006
Female	476 (48.3%)	466 (47.1%)	395 (40.6%)	1,337 (45.4%)				
Race								
Asian	6 (0.6%)	10 (1.0%)	3 (0.3%)	19 (0.6%)	0.71	N/A		
White	887 (90.1%)	893 (90.3%)	888 (91.3%)	2,668 (90.5%)				
Black	61 (6.2%)	58 (5.9%)	59 (6.1%)	178 (6.0%)				
Hispanic	8 (0.8%)	4 (0.4%)	3 (0.3%)	15 (0.5%)				
Native American	4 (0.4%)	3 (0.3%)	3 (0.3%)	10 (0.3%)				
Other/unknown	19 (1.9%)	21 (2.1%)	17 (1.7%)	57 (1.9%)				

Notes: [a]air leak defined by ICD-9-CM 512.2 and 512.84; [b]*P*-values were calculated by chi-square test for homogeneity on categorical variables; [c]subanalysis determined by chi-square pairwise test if the global chi-square test proved to be significantly different; [d]Percentage of row, not column.
Abbreviations: ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; N/A, not applicable; Col, column.

are not matched by a proportionate increase in hospital payments, resulting in progressively lower hospital margin with increasing LOS (Figures 2 and 3). Patients with LOS <7, LOS 7–10, and LOS ≥11 days had median hospital charges of US $57,129, $73,572, and $115,623, respectively. Based on reported charges for each discharge, median hospital costs in these LOS subcategories were estimated at $17,594, $21,711, and $33,786, respectively, by applying provider-specific CCRs calculated using the IPPS Final Rule 2014 Standardizing File. However, increases in hospital payments were lower per group at $16,494, $16,307, and $19,337, respectively. The increasing gap between hospital cost and payment is represented by the declining ratio of payment to cost in each LOS subcategory: 1) 0.912

Table 4 Medicare discharges undergoing major lung surgery with air leak diagnosis during hospital stay: comparison of hospital financials by length of stay (LOS) group

Characteristic	Mean ± SD (Median)			*P*-value[a]	Pairwise test[b]		
	Group A LOS <7	Group B LOS 7–10	Group C LOS ≥11		A vs B	B vs C	A vs C
Number of cases[c]	985	989	973	N/A	N/A	N/A	N/A
Length of stay (LOS) in days	4.7±1.2 (5)	8.3±1.1 (8)	17.1±7.9 (15)	<0.001	<0.001	<0.001	<0.001
Total hospital charges	$64,682±$31,906 ($57,129)	$82,954±$42,658 ($73,572)	$149,475±$120,693 ($115,623)	<0.001	<0.001	<0.001	<0.001
Total hospital costs	$18,402±$6,299 ($17,594)	$23,231±$8,083 ($21,711)	$40,227±$24,316 ($33,786)	<0.001	<0.001	<0.001	<0.001
Total hospital payments	$15,501±$9,523 ($16,494)	$16,222±$10,986 ($16,307)	$25,294±$27,737 ($19,337)	<0.001	0.53	<0.001	<0.001
Ratio of payments to costs	0.899±0.592 (0.912)	0.726±0.483 (0.758)	0.623±0.462 (0.634)	<0.001	<0.001	<0.001	<0.001

Notes: [a]*P*-values were calculated by Kruskal–Wallis test on continuous variables; [b]pairwise test determined by Dunn's test; [c]air leak defined by ICD-9-CM 512.2 and 512.8. Currency USD.
Abbreviations: SD, standard deviation; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; N/A, not applicable.

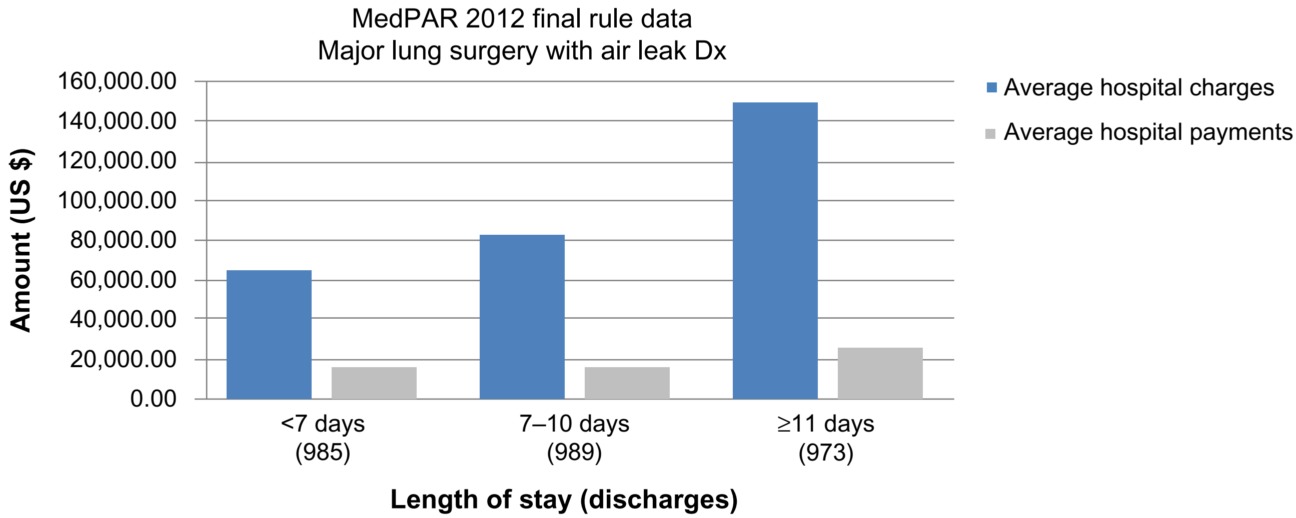

Figure 2 Comparison of hospital charges and payments by LOS group.
Abbreviations: MedPAR, Medicare Provider Analysis and Review; Dx, diagnosis; LOS, length of stay.

for LOS <7 days; 2) 0.758 for LOS 7–10 days; and 3) 0.634 for LOS >10 days (0.634 vs 0.912; $P<0.001$) (Figure 4).

Discussion

While many papers reporting on complications following lung resection address the negative impact air leaks have on LOS, comorbidity, and costs, there have been few papers quantifying the financial burden of prolonged hospitalization for the postoperative air leak patient population, and none that we are aware of that address the impact of air leak-associated prolonged LOS on hospital financial performance.[1–5,14] With health care entering an era emphasizing stricter adherence to best practices and more coordinated efforts to control costs, it seems timely to evaluate the relationship between hospital LOS and financial outcomes in the postoperative air leak population. As a result, we can evaluate how to better manage postoperative air leaks and reduce the financial impact to hospitals.

Despite preventative measures, air leaks still range in incidence from 8% for segmental resections to up to 45% for LVRS.[7] A postoperative air leak is usually managed conservatively with a watch-and-see approach that includes chest tube drainage, or discharging a patient with a Heimlich valve. While there are articles published on timing for safe removal of a chest tube, there is still a wide range of confidence levels

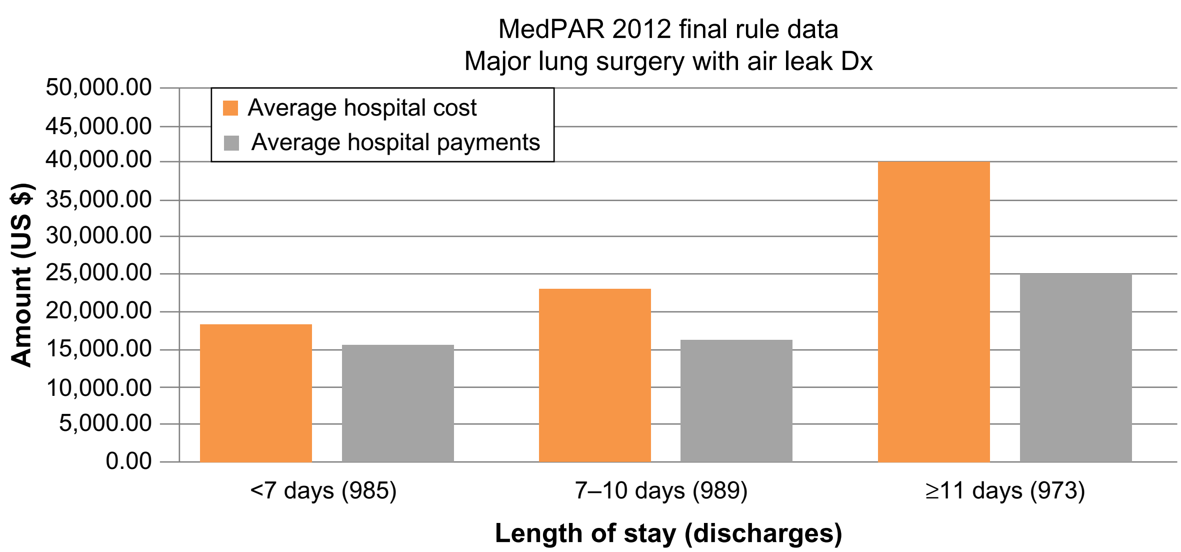

Figure 3 Comparison of hospital costs and payments by LOS group.
Abbreviations: MedPAR, Medicare Provider Analysis and Review; Dx, diagnosis; LOS, length of stay.

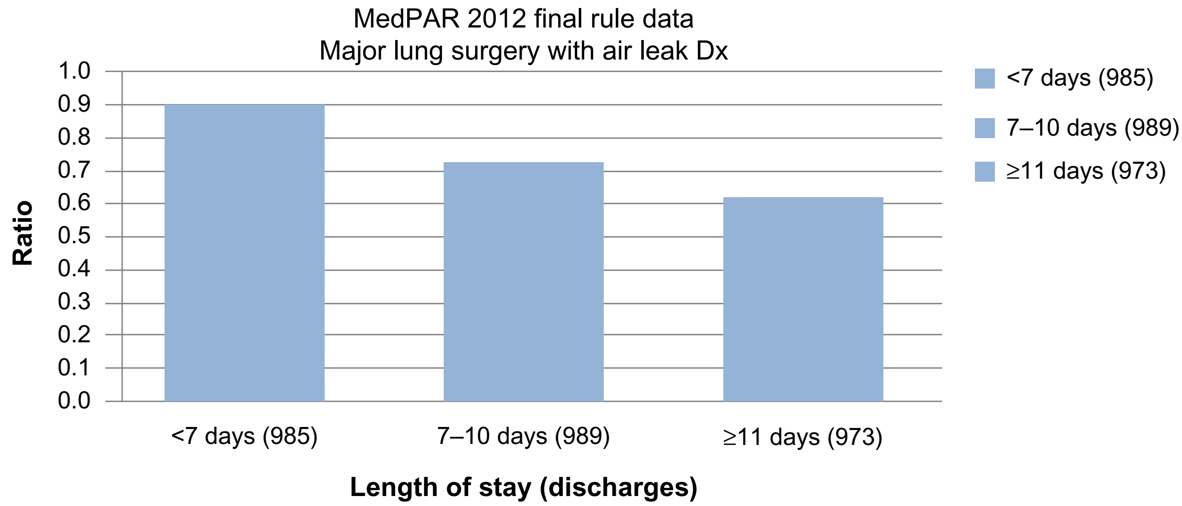

Figure 4 Ratio of hospital payments to costs by LOS group.
Abbreviations: MedPAR, Medicare Provider Analysis and Review; Dx, diagnosis; LOS, length of stay.

among physicians that equate to no true standard of care for air leak management.[15]

The subjective nature in which air leaks are monitored coupled with mixed confidence on when to remove a chest tube, or discharge a patient with an indwelling chest tube results in variable but prolonged LOS. A recent study published median LOS for patients with an air leak at POD 2 was 11 days compared to 7 days in patients without an air leak at POD 2.[1] Another study comparing air leaks to other postoperative complications such as nausea, vomiting, and poor pain control found air leaks to lengthen LOS by 4.2 days.[5] Varela et al found that the total expenses resulting from a postoperative air leak amount to $53,756.19 (39,437.39 €) per incident.[14]

The purpose of this paper is to evaluate the relationship between air leak-associated LOS and hospital margins among patients who underwent lung resection, by using actual US Medicare claims data. The CMS MedPAR database houses all discharge data for all Medicare hospitalizations in the USA. Data from fiscal year 2012 were used for the purposes of this study and provided LOS, charge, cost, and payment data on 21,717 patients who underwent either lobectomy, segmentectomy, or LVRS within a 12-month period. To date, this is the largest data set on this patient population that has ever been published. The large number of discharges helps mitigate a limitation of this study, which is the ability to discern whether the air leak was the cause of prolonged hospitalization. Although the data cannot separate out those hospitalizations that were prolonged due only to an air leak, there is a clear association between air leak diagnosis and LOS in this and in previous studies.[1–3,5] Further, even if air leak was not the sole reason for prolonged LOS, air leak is associated with other complications and is a factor impacting hospital stay and the associated financial implications noted in this analysis. Thoracic surgeons, pulmonologists, and intensivists are all too familiar with the scenario of a frustrating prolonged hospitalization related solely to a prolonged air leak after lung surgery, and the related complications.

The MedPAR discharge data for the air leak group were divided into three LOS categories (LOS: <7 days, 7–10 days, and ≥11 days) to help evaluate impact on hospital financials at different clinical time points. The time points (<7 days, n=985; >7 days, n=1,962) were selected to separate prolonged and non-prolonged air leak cases. The separation between a mild LOS (7–10 days, n=989) and more prolonged LOS (≥11 days, n=973) was decided to approximately, evenly divide short and lengthier LOS and to assess the potential increasing financial implications for air leak hospitalizations of moderate and severe prolonged LOS.

Overall, 13.6% of all Medicare fee for service patients hospitalized for a lobectomy, segmentectomy, or LVRS from October 1, 2011 through September 30, 2012 were coded as having an air leak diagnosis. The presence of air leaks in these patients increased LOS by 37% and hospital costs by 14.9%. LOS for cases with an air leak diagnosis was on average 2.7 days longer than those cases without an air leak diagnosis (10.0 days vs 7.3 days, respectively; $P<0.001$). Total costs were also higher in the air leak diagnosis group ($22,641 vs $18,852). In addition, although the payment-to-cost ratio (hospital financial margin) was similar between the air leak and non-air leak diagnosis groups (0.750 air leak vs 0.763 non-air leak), the payment-to-cost ratio substantially and significantly decreased as LOS increased in the air leak diagnosis group. Patients with LOS $<$7 days, LOS 7–10 days, and LOS $>$11 days had median hospital costs of $17,594, $21,711, and $33,786 with corresponding payment rates of $16,494, $16,307, and $19,337, respectively. This resulted in a continual decline in the cost-to-payment ratios for each LOS category (LOS $<$7 days=0.912, LOS 7–10 days=0.758, and LOS $>$11 days=0.634).

This analysis provides evidence there is a negative financial impact to hospitals as LOS increases in patients diagnosed with an air leak after lobectomy, segmentectomy, or LVRS. Because surgical patients are usually inpatients under a DRG, the amount of payment is set based on the original set of diagnosis and procedure codes. As the hospitalization stay lengthens, costs rise, however, barring other events, the DRG payment associated with the primary surgical procedure remains the same. This ultimately reduces the already low margins hospitals face in today's era of declining payment. New interventions to diminish prolonged air leak along with research in the objective method of monitoring and measuring air leaks that might allow earlier chest tube removal have the potential of substantial savings in health care costs as well as improved hospital margin.

Limitations

First, administrative claims data are not always accurate and do not allow identification of whether the air leak was the primary or sole reason of prolonged hospitalization. As such, this study's results only indicate a correlative relationship between air leaks and increased LOS, leading to increased hospital costs and decreased margins. Further study is necessary to support any causal conclusions. However, even if air leak was not the sole reason for prolonged LOS, these data are consistent with previously published data and clinical experience that postoperative air leaks result in prolonged hospital stay and increased costs. Second, 2012 was the first year the new codes for air leak were available. Under- or over-reporting of postoperative air leak may occur that confound the true extent and impact of air leak. However, it is more likely the data underrepresents the full extent or incidence of postoperative air leaks, particularly as a new diagnosis code. Third, although charges and payments are available, true cost data are not publicly reported, and so the cost data in this paper are estimates of costs using widely accepted methods in the reimbursement world. Nonetheless, this is unlikely to change the primary finding of a substantially decreased hospital margin with an increasing air leak-associated prolonged hospitalization. Finally, these data are from Medicare patients only and therefore does not represent impact across all patient populations and payers, although it is likely to be representative of similar impacts on hospital financials in non-Medicare patients as well.

Conclusion

Prolonged air leaks following lung resection remain a clinical challenge for providers and a source of morbidity and increased hospital LOS for patients. Air leaks are associated with a prolonged LOS and increased hospital charges and costs. Although payments to hospitals also increase with longer hospital stay, this is disproportional to the increased cost of hospitalization resulting in a diminishing hospital margin with increasing LOS. This first analysis of CMS MedPAR data helps to provide a more complete picture of the overall impact to the hospitals by quantifying the reduction in hospital margin as air leak-associated LOS increases. Additional studies to confirm these results of this analysis would be helpful to illuminate the consequences of air leaks following major lung surgery. Intraoperative and postoperative interventions to reduce prolonged air leak may not only benefit patients by decreasing complications and hospital LOS but also save health care resources with the potential to significantly preserve hospital margin.

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Disclosure

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