

Preoperative and Intraoperative Factors Predictive of Length of Hospital Stay after Pulmonary Lobectomy

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Background: Length of hospital stay is an important determinant of overall surgical costs. Health care resources are finite, so reductions in length of stay are desirable. We reviewed our experience with pulmonary lobectomy to identify preoperative and intraoperative factors that predicted the length of postoperative hospital stay. By identifying these factors, we hoped to favorably influence future patient management.

Methods: Records of patients undergoing pulmonary lobectomy for benign or malignant disease over a four-year period (1998-2001) were reviewed. Data was collected on age, sex, pulmonary function, pulmonary pathology, cigarette smoking, type of thoracotomy incision, use of surgical sealants, surgeon, and length of hospital stay.

Results: Three hundred and sixty patients underwent lobectomy. Forward stepwise regression identified age ($p=0.022$), FEV₁ (forced expiratory volume in one second) ($p=0.047$), diffusion capacity ($p=0.020$), and surgeon ($p<0.001$) as independent factors predictive of hospital length of stay. When these four factors were analyzed in a multiple linear regression model, the surgeon variable emerged as the strongest predictor of length of stay ($p<0.001$).

Conclusions: Although patient factors were influential, the individual surgeon was the most important determinant of hospital length of stay after pulmonary lobectomy. It may be possible to reduce length of hospital stay by identifying variations in practice within the surgical group, and encouraging widespread adoption of "best practice" surgical techniques. (*Ann Thorac Cardiovasc Surg* 2003; 9: 222-5)

Key words: lung neoplasms/surgery, postoperative complications/prevention and control, length of stay, utilization review, health care costs

Background

Most healthcare systems are struggling to contain rising costs and allocate scarce resources sensibly. Postoperative length of hospital stay is an important component of the overall cost of elective surgical services. Reductions in postoperative length of stay may produce cost savings that can be invested in other areas of surgical patient care. We have become increasingly concerned about the

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sustainability of our thoracic surgical unit's funding, so we initiated an audit of our clinical practices and their effect on postoperative length of hospital stay. Since pulmonary lobectomy is one of the commonest major procedures performed in our thoracic surgical unit, we began with a review of this procedure. We set out to identify preoperative and intraoperative factors that predicted length of stay after pulmonary lobectomy. By identifying these factors, we hoped to favorably influence future patient management.

Patients and Methods

St. Joseph's Healthcare in Hamilton, Ontario, Canada, is a regional thoracic surgical center, and a McMaster University teaching hospital. We retrospectively reviewed

Table 1. Summary data on 360 patients undergoing pulmonary lobectomy

Age	65.0±11.0 years
Sex (male:female)	201:159
FEV ₁	2.12±0.67 liters
Diffusion capacity (% predicted)	62.2±17.3%
Pathology (malignant:benign)	315:45
Smoking (active smokers:non-smokers)	119:241
Thoracotomy (posterior-lateral:muscle sparing:minimally invasive)	253:97:10

FEV₁ = forced expiratory volume in one second.

Table 2. Forward stepwise regression analysis of possible variables predictive of length of stay after pulmonary lobectomy

Variable	Significance
Age	p=0.022
Sex	p=0.426
FEV ₁	p=0.047
Diffusion capacity	p=0.020
Pathology (benign or malignant)	p=0.260
Smoking	p=0.427
Thoracotomy incision (type)	p=0.467
Surgical sealants	p=0.493
Surgeon	p<0.001

FEV₁ = forced expiratory volume in one second.

medical records of patients undergoing pulmonary lobectomy for malignant or benign pulmonary disease at our hospital from 1998 to 2001 (four-year period). Data was collected on preoperative and intraoperative factors that could potentially impact on postoperative length of hospital stay. These factors included age, sex, pulmonary function, pulmonary pathology, cigarette smoking, type of thoracotomy incision, use of surgical sealants, surgeon, and length of hospital stay. Anesthesia techniques and postoperative analgesia management (thoracic epidural catheters) were used uniformly in these patients, so data on these aspects of patient care were not analyzed. The impact of postoperative factors, or complications, on length of stay is the subject of a separate on going analysis so those data are not presented.

Continuous data are presented as mean values with standard deviations (mean±SD). Forward stepwise regression was used to identify independent factors that may be predictive of hospital length of stay. Variables with a p<0.10 in the stepwise regression analysis were then entered into a multiple linear regression model. In the multiple linear regression model a p<0.05 was considered significant. Statistical analysis was done using SigmaStat software (SPSS Inc., Chicago, IL, USA).

Table 3. Multiple linear regression analysis of variables predictive of length of stay after pulmonary lobectomy

Variable	Significance
Age	p=0.42
FEV ₁	p=0.20
Diffusion capacity	p=0.38
Surgeon	p<0.001

FEV₁ = forced expiratory volume in one second.

Results

Three hundred and sixty patients underwent lobectomy at our hospital between 1998 and 2001. Data on these patients is presented in summary form in Table 1. Length of hospital stay ranged from 2 to 89 days with a mean of 7.3±6.3 days and a median of 6 days. Median length of hospital stay by individual surgeon (four thoracic surgeons) was 3, 6, 6, and 7 days. Operative mortality (in-hospital mortality) was 2.2% (8 patients). Forward stepwise regression identified age (p=0.022), FEV₁ (forced expiratory volume in one second) (p=0.047), diffusion capacity (p=0.020), and surgeon (p<0.001) as independent factors predictive of hospital length of stay (Table 2). When these four factors were analyzed in a multiple linear regression model, only the surgeon variable emerged as a significant independent predictor of length of stay (p<0.001) (Table 3).

Discussion

Pulmonary lobectomy is one of the commonest operative procedures performed on thoracic surgical services. In many centers, patients undergoing lobectomy remain in hospital for approximately one week.¹⁻⁴⁾ These patients often have associated comorbid conditions that are responsible for prolonged hospital stays. Surgical issues, such as air leaks and painful thoracotomy incisions, also contribute to the length of stay.³⁻⁵⁾ Some centers have found

ways to overcome these problems; they have reported exceptionally short postoperative hospital stays.^{6,7)} These centers, and their surgeons, are often private-practice in makeup. It is therefore tempting for the academic community to dismiss the achievements in length of stay reduction as exercises in patient selection, or unique experiences that are not transferable to the larger thoracic surgical community.⁸⁾ These attitudes can hamper the dissemination of best practices in surgery, and impede progress in units such as ours.

Our study was motivated by a desire to reduce the length of stay after pulmonary lobectomy in our unit. We set out to identify factors predictive of length of stay in our own center, and then alter our practice based on our findings and the published experience of other surgeons. In this study, we have only examined preoperative and intraoperative factors that may influence length of stay. We have not considered postoperative factors, such as complications. Complications, almost by definition, prolong hospital stay. Therefore, complications are both outcomes and factors predictive of other outcomes. By restricting our analysis to preoperative and intraoperative factors we remained focused on the question of interest, namely, what can we do preoperatively or intraoperatively to reduce length of stay?⁹⁾

Preoperative preparation for pulmonary lobectomy usually consists of smoking cessation and optimization of pulmonary function. Surprisingly, active cigarette smoking was not a predictor of length of stay in this study. Nevertheless, abundant evidence points to the value of smoking cessation several weeks before pulmonary resection.¹⁰⁾ Using stepwise regression, we identified advanced age, low FEV₁, and low diffusion capacity (transfer factor) as factors influencing length of postoperative hospital stay after pulmonary lobectomy. Other investigators have emphasized the importance of these three factors in predicting complications after pulmonary lobectomy.¹¹⁻¹³⁾ One of these factors, age, obviously cannot be altered. FEV₁ can be improved with pulmonary rehabilitation and bronchodilators before surgery, but prolonged periods of preoperative preparation are often not feasible in patients with lung cancer. Diffusion capacity, an indicator of underlying pulmonary parenchymal reserve, is not very responsive to preoperative pulmonary treatments.

Intraoperative factors that could conceivably lead to shorter postoperative hospital stays include type of thoracotomy (posterior-lateral, muscle sparing, minimally invasive) incision and use of surgical sealants. We did not find either factor to be predictive of length of stay.

Other surgeons have reported similar results.¹⁴⁻¹⁶⁾

Our unit is staffed by four full-time, and in our opinion equally competent, thoracic (non-cardiac, general thoracic) surgeons. The acceptably low operative mortality reported herein supports that contention. We were therefore surprised to find that the surgeon was the only significant variable predictive of length of stay in our multiple linear regression model. One of our surgeons had a median length of hospital stay that was approximately half (3 versus 6 days) that of the rest of the group. Published studies of pulmonary surgery have emphasized the relationship between surgeon specialty and outcome,¹⁷⁾ and hospital volume and outcome.¹⁸⁾ However, there is little data on the individual surgeon as a variable within high-volume academic units.¹⁹⁾

Our four surgeons are experienced clinicians; two have practiced thoracic surgery for over 20 years and two have practiced for 10-15 years. The outlier surgeon (shortest length of stay) is the least experienced of the four. All four surgeons maintain a broad practice in general thoracic surgery, but each has different subspecialty interests. Surprisingly, the outlier surgeon's subspecialty interest is not pulmonary surgery. Statistical analysis did not show a relationship between operative approach (posterior-lateral, muscle sparing, minimally invasive) and hospital length of stay, but the outlier surgeon is known to favor muscle sparing and thoracoscopic approaches whenever possible. One other feature of the outlier surgeon's practice, namely intraoperative attention to air leaks, may be important in determining length of stay. Our study supports the notion that subtle variations in surgical practice, well within the control of individual surgeons, are important determinants of postoperative length of stay.^{6,7)}

Although we were unable to document and formally analyze the suspected subtleties of surgical practice that may be critical to reducing postoperative length of stay, we believe that length of stay after pulmonary lobectomy can be reduced by attention to two important issues: air leak and pain. Other surgeons agree.^{5-7,16)} Careful fissure dissection, intraoperative oversewing of raw surfaces with fine monofilament sutures, and liberal use of pleural flaps to cover raw surfaces can minimize air leak. Control of air leak allows early chest tube removal; this eliminates one source of postoperative pain. Minimizing the trauma of the thoracotomy incision, irrespective of its type, can also reduce pain. Our unit now faces the challenge of instituting changes that may lead to a shorter length of hospital stay after pulmonary lobectomy. If length of stay

can be reduced consistently, we will have an opportunity to redirect valuable resources to other areas of thoracic surgical patient care.

Conclusions

Patient factors, such as age, FEV₁, and diffusion capacity, influence length of hospital stay after pulmonary lobectomy. However, in our unit the surgeon was the only significant variable predictive of length of stay. It may be possible to reduce length of stay by identifying best surgical practices and encouraging widespread adoption of their use.

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