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Does surgeon experience affect outcomes in pathologic stage I lung cancer?

Paul J. Scheel III, BS, Traves D. Crabtree, MD, Jennifer M. Bell, BSN, Christine Frederiksen, MS, Stephen R. Broderick, MD, A. Sasha Krupnick, MD, Daniel Kreisel, MD, PhD, G. Alexander Patterson, MD, Bryan F. Meyers, MD, MPH, and Varun Puri, MD, MSCI

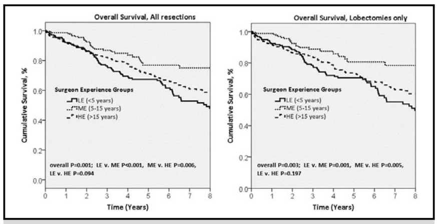
ABSTRACT

Objective: The study objective was to evaluate the influence of surgeon experience on outcomes in early-stage non–small cell lung cancer.

Methods: In an institutional database, patients undergoing operations for pathologic stage I non–small cell lung cancer were categorized by surgeon experience: within 5 years of completion of training, the low experience group; with 5 to 15 years of experience, the moderate experience group; and with more than 15 years, the high experience group.

Results: From 2000 to 2012, 800 operations (638 lobectomies, 162 sublobar resection) were performed with the following distribution: low experience 178 (22.2%), moderate experience 224 (28.0%), and high experience 398 (49.8%). Patients in the groups were similar in age and comorbidities. The use of video-assisted thoracoscopic surgery was higher in the moderate experience group (low experience: 62/178 [34.8%], moderate experience: 151/224 [67.4%], and high experience: 133/398 [33.4%], $P < .001$), as was the mean number of mediastinal (N2) lymph node stations sampled (low experience: 2.8 ± 1.6, moderate experience: 3.5 ± 1.7, high experience: 2.3 ± 1.4, $P < .001$). The risk of perioperative morbidity was similar across all groups (low experience: 54/178 [30.3%], moderate experience: 51/224 [22.8%], and high experience: 115/398 [28.9%], $P = .163$). Five-year overall survival in the moderate experience group was 76.9% compared with 67.5% in the low experience group ($P < .001$) and 71.4% in the high experience group ($P = .006$). In a Cox proportional hazard model, increasing age, male gender, prior cancer, and R1 resection were associated with an elevated risk of mortality, whereas being operated on by surgeons with moderate experience and having a greater number of mediastinal (N2) lymph node stations sampled were protective.

Conclusions: The experience of the surgeon does not affect perioperative outcomes after resection for pathologic stage I non–small cell lung cancer. At least moderate experience after fellowship is associated with improved long-term survival. (J Thorac Cardiovasc Surg 2015;149:998-1004)



Kaplan-Meier survival curves for all resections of pathologic stage 1 NSCLC.

Central Message

Moderate surgeon experience is associated with greater use of VATS, higher LN yield, and improved 5-year survival in stage 1 NSCLC.

Perspective

The impact of surgeon experience on outcomes in stage 1 NSCLC resection remains inadequately studied. We identify surgeon-specific factors associated with improved outcomes, which draws attention to potentially modifiable aspects of patient care. Surgeon training in VATS and adequate LN dissection along with early career supervision provide potential interventions for improved patient care.

See Editorial Commentary page 1005.

From the Division of Cardiothoracic Surgery, Department of Surgery, Washington University School of Medicine, St Louis, Mo.

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Address for reprints: Varun Puri, MD, MSCI, 3108 Queeny Tower, Barnes Jewish Hospital, One Barnes Jewish Hospital Plaza, St Louis, MO 63110 (E-mail: puriv@wudosis.wustl.edu).

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Surgical and institutional factors seem to influence morbidity and mortality in resection for esophageal, pancreas, colon, and lung cancers.[1-11] Several authors have studied surgeon and hospital volumes, and surgeon specialization as possible influential variables, with some reports demonstrating decreased mortality with higher surgical volume and greater degree of surgeon

Abbreviations and Acronyms

HE	= high experience
LE	= low experience
ME	= moderate experience
NSCLS	= non–small cell lung cancer
VATS	= video-assisted thoracoscopy

specialization.[6,8,11] This is particularly true in surgery for early-stage non–small cell lung cancer (NSCLC).[2,10-13]

However, previous studies evaluating the impact of the individual surgeon on outcomes in lung cancer have focused mainly on thoracic surgical specialization and surgical volume.[10-14] The role of increasing surgical experience over time as an independent practitioner remains largely unknown. In addition, these studies have largely reported on postoperative mortality, with considerably less attention on perioperative morbidity.[4,10,11] Because postoperative morbidity is more common than mortality after pulmonary resection (20%-40% vs 1%-3%),[12,15] the impact of the individual surgeon on early postoperative outcomes remains inadequately understood.

We evaluated the impact of surgeon experience accrued after cardiothoracic surgery fellowship training on the morbidity and mortality of patients undergoing curative resection for pathologic stage I NSCLC. We hypothesized that patients undergoing operations by less-experienced surgeons would demonstrate increased perioperative morbidity and long-term mortality.

PATIENTS AND METHODS

With institutional review board approval, a single-center, retrospective review of a prospectively maintained lung cancer database was performed. Inclusion criteria were patients who underwent initial resection by lobectomy or sublobar resection for resection of pathologic stage I NSCLC lung cancer and operation performed between January 2000 and December 2012 at Washington University School of Medicine. Only pathologic stage I was included to ensure a uniform population to prevent confounding from upstaging and downstaging. We chose a start date of 2000 for this study because electronic patient records first became available for review at the time. Exclusion criteria included pneumonectomies, operations for recurrent cancer, resections involving multilobes, and operations for subsequent primary cancers in patients who had undergone a prior lung resection (Figure E1).

Surgical experience was determined on the basis of the number of years after the completion of a cardiothoracic surgery fellowship for the operating surgeon at the time of surgery. Operations conducted within the first 5 years of practice after specialty training for the surgeon were classified as the low experience (LE) group; operations performed by surgeons with 5 to 15 years of experience were classified as the moderate experience (ME) group; and operations performed by surgeons with more than 15 years of post-fellowship experience were classified as the high experience (HE) group. Thus, cases performed by a single surgeon could be in different groups depending on when a particular operation was performed in that surgeon's postfellowship career.

We abstracted the details of patient demographics, diagnosis, workup, operation, perioperative course, and outcomes from the institutional database. Missing data were obtained by review of patient charts. Perioperative events were defined per the Society of Thoracic Surgeons data-collection guidelines.[16] Patient survival was determined from clinic notes and supplemented by querying the Social Security Death Index.

Statistics

Data were managed with Microsoft Excel (Microsoft Corp, Redmond, Wash) and analyzed using SPSS 21.0 for Windows (SPSS Inc, Chicago, Ill). Descriptive statistics were expressed as mean ± standard deviation unless otherwise specified. Categoric data were expressed as counts and percentages. Comparisons between normally distributed continuous variables were performed with 1-way analysis of variance or the *t* test, and differences among the categoric data were analyzed with the chi-square test. Post hoc analyses for pairwise comparisons were performed using the Bonferroni method for categoric data and the Tukey method for continuous variables. Kaplan–Meier survival plots were generated and groups were compared using the log-rank test. For pairwise comparisons using the Bonferroni method, a P value less than .017 was considered significant. A Cox proportional hazard model was then fitted to determine variables that affected the risk of long-term mortality. For this model, we considered age, gender, smoking status, coronary artery disease, hypertension, forced expiratory volume in 1 second percent, diffusing capacity of carbon monoxide percent, body mass index, prior cancer, surgeon experience, procedure (lobectomy vs sublobar resection), adequacy of resection (negative margins), number of mediastinal (N2) lymph node stations sampled, and type of incision (video-assisted thoracoscopy [VATS] vs thoracotomy) as independent variables.

After an initial exploratory analysis of all patients with pathologic stage I lung cancer who underwent resection, we dichotomized patients into a lobectomy group and a sublobar resection group. Identical analyses as described earlier were performed in these groups. We also performed a subgroup analysis to determine whether there was an impact of accrued experience for each individual surgeon.

For those surgeons who began performing operations during the study period, their first 25 operations were compared with their subsequent 25 operations with a comparison of both preoperative variables and outcomes.

RESULTS

Between January 2000 and December 2012, 800 patients underwent resection for pathologic stage I lung cancer by 8 surgeons. Of these operations, 178 resections (22.2%) were in the LE group (<5 years experience for the operating surgeon), 224 resections (28.0%) were in the ME group (5-≤15 years experience for the surgeon), and 398 resections (49.8%) were in the HE group (15 years experience for the surgeon). Operations were performed by 6 different surgeons in the LE group, 5 surgeons in the ME group, and 2 surgeons in the HE group. Patients in the 3 groups were similar in age and distribution of comorbidities (Table 1). The LE group had a higher proportion of male patients and nonwhite patients than the HE group (Table 1).

Of the 800 operations, there were 638 lobectomies (79.8%) and 162 sublobar resections (20.2%). The LE group was more likely to undergo lobectomies than sublobar resections (157/178 [88.2%]) compared with the ME group (176/224 [78.6%], $P = .011$) and HE group (305/398 [76.6%], $P = .001$). The use of VATS was higher in the ME group than in the other 2 groups (LE: 62/178 [34.8%], ME: 151/224 [67.4%], HE: 133/398 [33.4%],

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TABLE 1. Patient demographics and comorbidities for all resections (lobectomy and sublobar resection)

Variable	LE (n = 178)	ME (n = 224)	HE (n = 398)	*P*
Mean age (y)	64.6 ± 11.4	64.3 ± 10.5	65.5 ± 11.4	.365
Male gender	95 (53.4%)	104 (46.4%)	162 (44.9%)	.017*
Nonwhite race	38 (21.3%)	30 (13.4%)	42 (10.6%)	.002†
Smoking status				.144
Never	14 (7.9%)	30 (13.4%)	52 (13.1%)	
Past	91 (51.1%)	112 (50.0%)	218 (54.8%)	
Current	73 (41.0%)	82 (36.6%)	128 (32.2%)	
Prior stroke	11 (6.2%)	12 (5.4%)	27 (6.8%)	.779
Coronary artery disease	40 (22.5%)	34 (15.2%)	81 (20.4%)	.145
Hypertension	103 (57.9%)	120 (53.6%)	216 (54.3%)	.652
Congestive heart failure	3 (1.7%)	2 (0.9%)	8 (2.0%)	.570
Peripheral vascular disease	10 (5.6%)	7 (3.1%)	18 (4.5%)	.469
Baseline FEV1% predicted	79.7 ± 21.1	80.9 ± 19.9	79.3 ± 22.1	.656
Baseline DLCO% predicted	70.8 ± 21.6	72.7 ± 20.6	71.4 ± 21.6	.642
Body mass index	27.1 ± 5.8	27.2 ± 5.9	26.9 ± 6.2	.827
Prior cancer	69 (38.8%)	77 (34.4%)	134 (33.7%)	.483
Clinical stage				.666
I	159 (89.3%)	207 (92.4%)	368 (92.5%)	
II	9 (5.1%)	7 (3.1%)	16 (4.0%)	
III	10 (5.6%)	10 (4.5%)	14 (3.5%)	

DLCO, Carbon dioxide diffusing capacity; *FEV1*, forced expiratory volume in 1 second; *HE*, high experience; *LE*, low experience; *ME*, moderate experience. *LE versus ME, $P = .167$, LE versus HE, $P = .005$, ME versus HE, $P = .166$. †LE versus ME, $P = .047$, LE versus HE, $P = .001$, ME versus HE, $P = .222$.

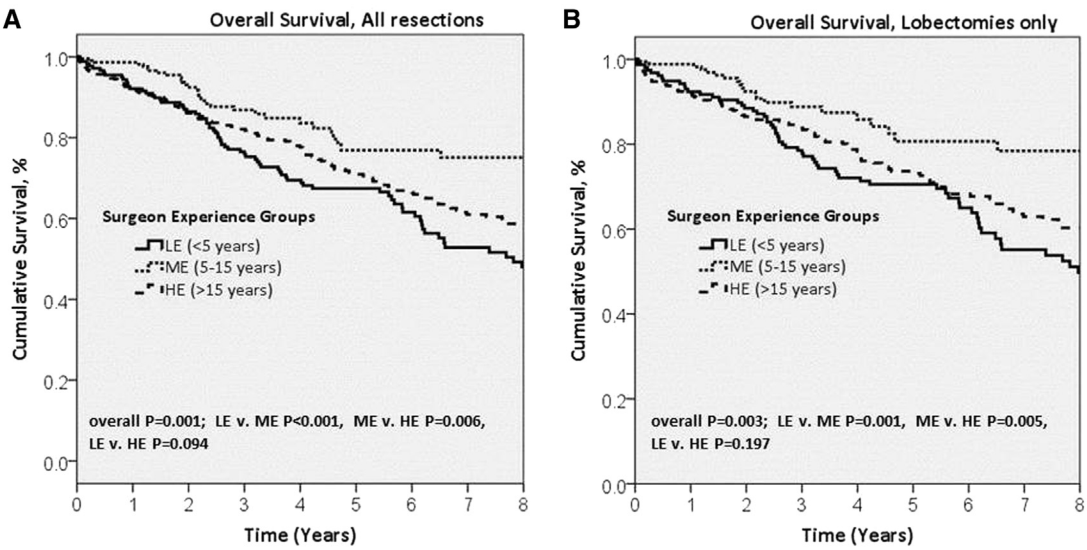
all $P < .001$). Because VATS was more widely adopted in our program in 2007 and 2008, we performed a subgroup analysis considering operations performed after January 2008. The ME group was still more likely to undergo VATS operations (133/160 [83.1%]) compared with the LE group (49/79 [62.0%], $P < .001$) but was similar to the HE group (129/177 [72.9%], $P = .024$, not significant with Bonferroni correction). The number of microscopically incomplete resections (R1 resections) was similar across all groups (LE: 5/178 [2.8%], ME: 7/224 [3.1%], HE: 10/398 [2.5%], $P = .903$). The mean number of mediastinal (N2) lymph node stations sampled per operation was highest for the ME group and lowest for the HE group (LE: 2.8 ± 1.6, ME: 3.5 ± 1.7, HE: 2.3 ± 1.4, $P < .001$, LE vs ME, $P < .001$, LE vs HE, $P = .001$, ME vs HE, $P < .001$).

The risk of any perioperative morbidity defined per Society of Thoracic Surgeons criteria was similar across all groups (LE: 54/178 [30.3%], ME: 51/224 [22.8%], HE: 115/398 [28.9%], $P = .163$). The risk of specific complications was also similar across the groups (Table 2). There were no differences in length of hospital stay or perioperative mortality among the groups. Unadjusted 5-year overall survival in the ME group was 76.9% compared with 67.5% in the LE group ($P < .001$) and 71.4% in the HE group ($P = .006$) (Figure 1, *A*).

TABLE 2. Comparison of perioperative outcomes among the 3 groups for all resections (lobectomy and sublobar resection)

Variable	LE (n = 178)	ME (n = 224)	HE (n = 398)	*P* value
Prolonged air leak	13 (7.3%)	8 (3.6%)	33 (8.3%)	.075
Pneumonia	11 (6.2%)	10 (4.5%)	21 (5.3%)	.745
Bronchopleural fistula	0 (0.0%)	1 (0.4%)	2 (0.5%)	.646
Blood transfusion	4 (2.2%)	1 (0.4%)	4 (1.0%)	.224
Empyema	2 (1.1%)	1 (0.4%)	0 (0.0%)	.123
Respiratory failure	11 (6.2%)	7 (3.1%)	25 (6.3%)	.212
Dysrhythmia	24 (13.5%)	24 (10.7%)	50 (12.6%)	.677
Deep vein thrombosis	4 (2.2%)	3 (1.3%)	5 (1.3%)	.647
Renal failure	2 (1.1%)	1 (0.4%)	4 (1.0%)	.712
Hemorrhage requiring reoperation	2 (1.1%)	0 (0.0%)	4 (1.0%)	.305
Stroke	0 (0.0%)	2 (0.9%)	2 (0.5%)	.452
Any perioperative morbidity	54 (30.3%)	51 (22.8%)	115 (28.9%)	.163
Mean length of hospital stay	6.6 ± 6.3	5.3 ± 4.8	5.8 ± 6.6	.086
Readmission within 30 d	13 (7.3%)	11 (4.9%)	32 (8.0%)	.335
30 d/hospital mortality	2 (1.1%)	0 (0.0%)	6 (1.5%)	.190

HE, High experience; *LE*, low experience; *ME*, moderate experience.



Time	No. at risk, LE	No. at risk, ME	No. at risk, HE
1 year	164	198	350
2 years	152	149	301
3 years	125	102	258
4 years	105	68	211
5 years	86	53	170

Time	No. at risk, LE	No. at risk, ME	No. at risk, HE
1 year	145	158	270
2 years	137	118	238
3 years	114	82	214
4 years	97	54	176
5 years	79	43	145

FIGURE 1. A, Kaplan–Meier overall survival for all resections (lobectomy and sublobar). B, Kaplan–Meier overall survival for patients undergoing lobectomy only. *HE*, High experience; *LE*, low experience; *ME*, moderate experience.

During the study period, 638 patients underwent lobectomy for pathologic stage I lung cancer. Of these, 157 (24.6%) were in the LE group, 176 (27.6%) were in the ME group, and 305 (47.8%) were in the HE group. Again, the LE group comprised a higher proportion of male patients and nonwhite patients than the HE group but not the ME group (Table E1). By considering operations performed from January 2008 onward (since the more widespread use of VATS), the ME and HE groups were more likely to undergo operations via VATS compared with the LE group (LE 40/67 [59.7%], ME 103/126 [81.7%], HE 87/123 [70.7%], overall $P < .001$; LE vs ME, $P = .001$; ME vs HE, $P = .041$; LE vs HE, $P = .123$). The proportion of R1 resections was similar across the 3 groups (LE: 3/157 [1.9%], ME: 6/176 [3.4%], HE: 5/305 [1.6%], $P = .426$). The number of mediastinal (N2) lymph node stations

TABLE 3. Comparison of perioperative outcomes for patients undergoing lobectomy

Variable	LE (n = 157)	ME (n = 176)	HE (n = 305)	*P* value
Air leak	12 (7.6%)	5 (2.8%)	26 (8.5%)	.050*
Pneumonia	10 (6.4%)	9 (5.1%)	18 (5.9%)	.882
Bronchopleural fistula	0 (0.0%)	1 (0.6%)	2 (0.7%)	.606
Blood transfusion	4 (2.5%)	1 (0.6%)	4 (1.3%)	.304
Empyema	2 (1.3%)	1 (0.6%)	0 (0.0%)	.162
Respiratory failure	11 (7.0%)	6 (3.4%)	23 (7.5%)	.180
Dysrhythmia	23 (14.6%)	24 (13.6%)	44 (14.4%)	.960
Deep vein thrombosis	4 (2.5%)	3 (1.7%)	2 (0.7%)	.244
Renal failure	2 (1.3%)	1 (0.6%)	3 (1.0%)	.796
Hemorrhage requiring reoperation	2 (1.3%)	0 (0.0%)	3 (1.0%)	.362
Stroke	0 (0.0%)	1 (0.6%)	1 (0.3%)	.650
Any perioperative morbidity	50 (31.8%)	46 (26.1%)	92 (30.2%)	.487
Mean length of hospital stay	6.96 ± 6.63	5.55 ± 4.34	6.24 ± 7.15	.128
Readmission within 30 d	13 (8.3%)	10 (5.7%)	26 (8.5%)	.502
30 d/hospital mortality	2 (1.3%)	0 (0.0%)	5 (1.6%)	.244

HE, High experience; *LE*, low experience; *ME*, moderate experience. *LE versus ME, $P = .047$ (statistically not significant after adjustment for subgroup analysis); LE versus HE, $P = .744$; ME versus HE, $P = .014$ (statistically significant).

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TABLE 4. Cox proportional hazard model for overall survival in entire cohort of patients undergoing lobectomy or sublobar resection

Variable	HR	95% CI
Surgeon experience included		
Age	1.05	1.03-1.06
Gender (male)	1.48	1.13-1.94
Race (nonwhite)	1.24	0.87-1.77
Smoking status (never)	Reference category	
Smoking (past)	0.93	0.56-1.55
Smoking (current)	1.36	0.80-2.31
Coronary artery disease	1.20	0.89-1.61
Hypertension	1.13	0.86-1.48
Baseline FEV1% predicted (scaled)	0.87	0.72-1.05
Baseline DLCO% predicted (scaled)	0.88	0.75-1.02
Body mass index	0.98	0.95-1.01
Prior cancer	1.33	1.02-1.72
Experience (<5 y)	Reference category	
Experience (5-15 y)	0.52	0.34-0.80
Experience (>15 y)	0.77	0.58-1.03
Sublobar resection	0.98	0.70-1.38
Thoracoscopic approach	0.89	0.64-1.22
No. of mediastinal (N2) lymph node stations sampled	0.90	0.82-0.98
R1 resection	2.55	1.28-5.10
Surgeon experience not included		
Age	1.05	1.03-1.06
Gender (male)	1.48	1.13-1.94
Race (nonwhite)	1.30	0.912-1.86
Smoking status (never)	Reference category	
Smoking (past)	0.97	0.58-1.61
Smoking (current)	1.39	0.82-2.36
Coronary artery disease	1.20	0.89-1.62
Hypertension	1.11	0.85-1.46
Baseline FEV1% predicted scaled	0.88	0.73-1.06
Baseline DLCO% predicted scaled	0.86	0.74-1.01
Body mass index	0.98	0.95-1.01
Prior cancer	1.33	1.02-1.72
Sublobar resection	0.93	0.67-1.31
Thoracoscopic approach	0.83	0.60-1.14
No. of mediastinal (N2) lymph node stations sampled	0.89	0.82-0.97
R1 resection	2.57	1.29-5.12

FEV1% and DLCO% were scaled to the interquartile range. The HR for FEV1% and DLCO% represents the hazard of the event occurring for a typical person in the middle of the upper half of the distribution compared with the hazard of the event for a typical person in the middle of the lower half of the distribution. *CI*, Confidence interval; *DLCO*, carbon dioxide diffusing capacity; *FEV1*, forced expiratory volume in 1 second; *HR*, hazard ratio.

sampled was again highest in the ME group and lowest in the HE group (LE: 3.0 ± 1.5, ME: 3.8 ± 1.5, HE: 2.5 ± 1.5, overall $P < .001$; LE vs ME, $P < .001$; LE vs HE, $P = .001$; ME vs HE, $P < .001$). Patients in the ME group had a lower incidence of prolonged postoperative air leak, whereas the remaining perioperative outcomes were similar across the groups (Table 3). Five-year overall survival in the ME group was 80.7% compared with 70.5% in the LE group ($P < .001$) and 73.6% in the HE group ($P = .006$) (Figure 1, *B*). In comparing data on each individual surgeon's initial 25 and next 25 cases, no clear trends were seen.

In the Cox proportional hazard model evaluating the entire cohort (lobectomy and sublobar resections), increasing age, male gender, prior cancer, and R1 resection were associated with an elevated risk of mortality. Being in the ME group and having a greater number of mediastinal (N2) lymph node stations sampled were associated with a lower hazard of long-term mortality (Table 4). In a subgroup analysis, identical results were observed for patients undergoing lobectomy (data not shown).

DISCUSSION

Our main findings in this study are that experience after fellowship training does not affect short-term outcomes after resection for lung cancer. However, surgeons with at least moderate experience have a higher use of minimally invasive techniques and possibly improved long-term survival.

Currently, most statistical models use a variety of patient- and disease-specific variables, such as age, pulmonary function, comorbidity scores, and pathologic stage, to predict short- and long-term outcomes after pulmonary resection.[16-20] In addition, a number of studies have explored the role of surgeon specialty training, hospital case volume, and surgeon case volume in perioperative morbidity and long-term survival after surgery for lung cancer, but the results have been inconsistent.[2,4,10-14] These studies have largely used administrative databases and pooled information from multiple centers to conduct the analyses. This strategy, although providing a robust sample size in most cases, cannot account for variations in practice patterns across surgeons and institutions, in both the intraoperative and the postoperative care of patients. Thus, we explored the impact of the individual surgeon's experience as a possible determinant of outcomes in a setting where all the surgeons are specialty trained, have been trained in the same setting, and use uniform perioperative management protocols.

In one of the first studies of its kind in lung cancer, Bach and colleagues[13] evaluated the volume of lung resections at individual centers and found an inverse relationship between volume and postoperative complications. They also noted improved long-term survival at higher-volume hospitals. Subsequently, Goodney and colleagues[2] analyzed the national Medicare database and noted that perioperative mortality was lower for specialty-trained thoracic surgeons compared with others after adjusting for hospital volumes. They considered more than 20 cases per year to indicate a high-volume surgeon. By these criteria, all the operators involved in our study are specialty trained in thoracic surgery and are high-volume surgeons. Other authors, including those from Europe and Asia, have also investigated the volume–outcomes relationship with mixed results. Sioris and colleagues[10] noted no effect of hospital volume on outcomes, but university hospitals performed better than community hospitals.[10] Lien and colleagues[4] studied a population from Taiwan and reported lower in-hospital mortality with increasing individual surgeon volume of resections. Reviews have raised questions about the methodologic quality of studies in the field, and Kozower and Stukenborg[14] thought that "careful examination of the literature demonstrates that lung cancer resection volume is not strongly associated with mortality and should not be used as a proxy measure for quality." Finally, in a meta-analysis, von Meyenfeldt and colleagues[11] pooled data from 19 studies and concluded that although hospital volume and surgeon specialty are determinants of outcome, individual surgeon volume is not important.

Our study focused on measuring the impact of the experience of a surgeon measured in number of years in practice after completing cardiothoracic surgical fellowship training. Although this approach is novel to lung cancer surgery, it has been used in evaluating other cancer operations.[3,21] It has been shown that despite existing evidence-based guidelines, decision-making in surgery continues to be strongly affected by anecdotal experience.[22]

We did not find a significant difference in perioperative morbidity or mortality with varying surgeon experience. Except for relatively minor differences in demographics, the patients across the 3 groups were similar in comorbidity. All except 1 surgeon in the group have been trained by the senior-most surgeon in this cohort and have fairly similar patterns of practice in both patient selection and operative procedures. These factors can likely explain the consistent perioperative outcomes across groups. Previous studies evaluating perioperative outcomes have largely focused on mortality,[2,4,11] and those studying postoperative morbidity and the surgical volume have not evaluated the individual surgeon's impact on outcomes.[13]

Adequate lymph node sampling/dissection is one of the cornerstones in lung cancer surgery. Others have demonstrated improved patient outcomes in node-negative NSCLC with greater number of lymph nodes sampled.[23-25] Our use of the number of lymph node stations sampled was driven by the data available to us in our database and has been recognized by other authors as a surrogate for the number of lymph nodes resected.[25] We noted that the ME group tended to have a higher yield of lymph nodes, and this also correlated with survival. It is plausible that surgeons who are in the early phase of their careers may be completely focused on "getting the specimen out" with less attention being paid to nodal sampling with its added operative time and perceived additional morbidity. Highly experienced surgeons may have a lower lymph node yield because the importance of nodal sampling has been predominantly realized over the last 2 decades, and these surgeons may have completed training in an earlier time period. It is also plausible that there may be a higher degree of trainee involvement with highly experienced surgeons, and some parts of the operation (including lymph node assessment) may be performed independently by the residents. Regardless, our finding points to the need for continued attention toward highlighting the importance of adequate nodal assessment.

We noted that patients operated on by moderately experienced surgeons had a somewhat longer overall survival compared with the other 2 groups. This correlated with better mediastinal lymph node assessment by the moderately experienced surgeons, a factor that has been associated with improved survival in previous publications.[23-25] Also, there was a higher likelihood for the use of VATS techniques in the ME group. Others have reported improved long-term survival after VATS lobectomy (compared with open thoracotomy) in systematic reviews and meta-analyses of studies involving patients with clinical stage I NSCLC.[26,27] The other variables noted to be associated with diminished survival, namely, increasing age, male gender, and incomplete resection, are well-established predictors for poorer long-term survival in lung cancer.[16,18]

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Study Limitations

The study's retrospective nature introduces the possibility of selection bias. With patients from a single center, a limited sample size may lead to type II error where true differences between groups may be missed. We had 8 surgeons in the group, largely similarly trained; thus, it may limit the generalizability of our findings. Last, intraoperative decision-making is subjective and perioperative management varies, which could lead to misclassification bias. To limit such misclassification, we used Society of Thoracic Surgeons guidelines for classifying perioperative adverse events, and when in doubt on chart review, an event was classified as positive.

CONCLUSIONS

Our study demonstrated that surgeon experience does not affect early perioperative outcomes after resection for early-stage lung cancer. However, patients operated on by moderately experienced surgeons may have better long-term survival after resection for pathologic stage I lung cancer. Expanding this study to a larger patient and surgeon population would be needed to validate the results and identify the underlying causes for these differences to provide the best patient care.

Conflict of Interest Statement

Traves D. Crabtree reports consulting fees from Ethicon Endosurgery. Bryan F. Meyers reports consulting fees, lecture fees, and grant support from Ethicon Endosurgery. All other authors have nothing to disclose with regard to commercial support.

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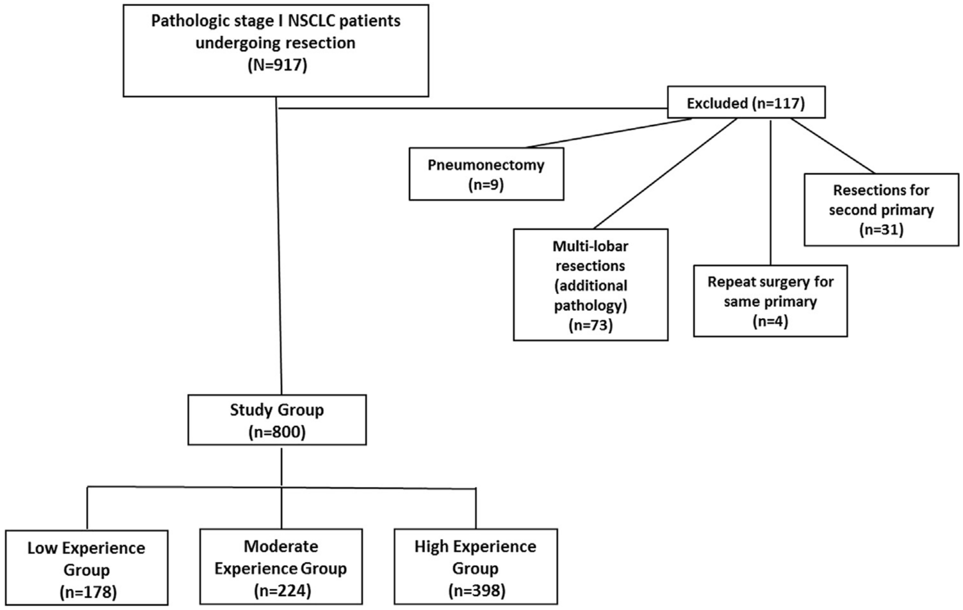

FIGURE E1. CONSORT diagram. *NSCLC*, Non–small cell lung cancer.

TABLE E1. Patient demographics and comorbidities for patients undergoing lobectomy

Variable	LE (n = 157)	ME (n = 176)	HE (n = 305)	*P* value
Mean age (y)	64.2 ± 11.7	64.1 ± 10.5	64.6 ± 11.5	.851
Male gender	86 (54.8%)	83 (47.2%)	117 (38.4%)	.003*
Nonwhite race	33 (21.0%)	26 (14.8%)	34 (11.1%)	.017†
Smoking status				.436
Never	14 (8.9%)	24 (13.8%)	43 (14.1%)	
Past	81 (51.6%)	90 (51.1%)	162 (53.1%)	
Current	62 (39.5%)	62 (35.2%)	100 (32.8%)	
Prior stroke	8 (5.1%)	7 (4.0%)	17 (5.6%)	.741
Coronary artery disease	36 (22.9%)	28 (15.9%)	54 (17.7%)	.228
Hypertension	89 (56.7%)	101 (57.4%)	162 (53.1%)	.601
Congestive heart failure	2 (1.3%)	1 (0.6%)	8 (2.6%)	.220
Peripheral vascular disease	7 (4.5%)	6 (3.4%)	11 (3.6%)	.864
Deep vein thrombosis	5 (3.2%)	6 (3.4%)	12 (3.9%)	.907
Baseline FEV1% predicted	82.0 ± 20.0	82.6 ± 19.3	82.6 ± 21.1	.951
Baseline DLCO% predicted	73.0 ± 20.9	74.4 ± 20.9	73.2 ± 21.6	.802
Body mass index	27.0 ± 5.6	27.6 ± 5.9	27.1 ± 6.6	.622
Prior cancer	60 (38.3%)	55 (31.3%)	99 (32.5%)	.347
Clinical stage				.491
I	139 (88.5%)	160 (90.9%)	283 (92.8%)	
II	8 (5.1%)	6 (3.4%)	12 (3.9%)	
III	10 (6.4%)	10 (5.7%)	10 (3.3%)	

DLCO, Carbon dioxide diffusing capacity; *FEV1*, forced expiratory volume in 1 second; *HE*, high experience; *LE*, low experience; *ME*, moderate experience. *LE versus ME, *P* = .17; LE versus HE, *P* = .001; ME versus HE, *P* = .06. †LE versus ME, *P* = .14; LE versus HE, *P* = .004; ME versus HE, *P* = .25.