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Extent of Lymph Node Resection Does Not Increase Perioperative Morbidity and Mortality After Surgery for Stage I Lung Cancer in the Elderly

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Abstract

Background and Objectives—Pathologic evaluation of >10 lymph nodes (LNs) is considered necessary for accurate lung cancer staging. However, physicians have concerns about increased risk in perioperative mortality (POM) and morbidity with more extensive LN sampling, particularly in the elderly. In this study, we compared the outcomes in elderly patients with stage I non-small cell lung cancer (NSCLC) undergoing extensive (>10 nodes) and limited (<10 nodes) LN resections.

Methods—Using data from the Surveillance, Epidemiology and End Results registry linked to Medicare records, we identified 4,975 patients ≥65 years of age with stage I NSCLC who underwent a lobectomy between 1992 and 2002. Risk of perioperative morbidity and POM after the evaluation of <10 vs. >10 LNs was compared among patients after adjusting for propensity scores.

Results—Multiple regression analysis showed similar POM between the two groups (OR, 1.01; 95% CI, 0.71–1.44). Other postoperative complications were similar across groups except for

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thromboembolic events, which were more common among patients undergoing resection of >10 LNs (OR, 1.72; 95% CI, 1.12–2.63).

Conclusions—These data suggest that evaluation of >10 LNs, which allows for more accurate staging, appears to be safe in the elderly patients undergoing lobectomy for stage I NSCLC without compromising postoperative recovery.

Keywords

Lung cancer; lymph nodes; mortality; morbidity; elderly; resection

INTRODUCTION

Lung cancer continues to be the number one cause of cancer mortality in the United States (US) and worldwide [1]. Surgical resection is the standard of care for patients with stage I non-small cell lung cancer (NSCLC), as it provides the best chance of cure. Unfortunately, about 18–27% of patients with Stage I develop recurrence of their disease despite undergoing surgical resection [2–4].

Pathological nodal status is one of the most important prognostic factors for NSCLC patients [5]. Despite improvements of preoperative mediastinal staging by positron emission tomography (PET) imaging, the extent of lymph node (LN) involvement frequently remains clinically underrecognized [6,7]. Similarly, visual evaluation of LNs at the time of lung resection has been shown not to be accurate for staging purposes [8]. Therefore, accurate intraoperative LN staging remains extremely important.

Several recent studies showed that extensive mediastinal LN evaluation results in higher overall survival and disease free survival rates, comparing to a more limited LN sampling, among patients with N0 disease [9,10]. The survival improvement among these patients is thought to be due to more accurate LN staging with more extensive nodal dissection. Although there is also no defined standard concerning the number of LNs that need to be removed for proper staging, recent studies suggest the minimum of 10–11 LNs need to be assessed for the optimal staging of patients with stage I NSCLC [11–14].

Despite the established importance of adequate LN assessment, physicians have frequent concerns about an increased risk for complications, prolonged hospitalization, or increased mortality with more extensive LN sampling. However, the few studies that have assessed the risks from more extensive resection have shown conflicting results. While some studies suggest that there is no significant difference in postoperative complications [13,15,16], others show increased morbidity and mortality with extensive LN sampling [17,18]. Concerns are even greater among the elderly, who have greater burden of comorbidities and are at higher risk of postoperative complications [19]. In this study, we used a population-based cancer registry to analyze the outcomes in elderly patients undergoing extensive (>10 LNs) and limited LN evaluation (≤ 10 LNs) as part of the surgical management of stage I NSCLC.

METHODS

Patients were selected from the Surveillance, Epidemiology and End Results (SEER) program, which is a national cancer registry that collects detailed data on all newly diagnosed cases of cancer and covers approximately 26% of the (US) population [20,21]. The case detection rate of the SEER registries has been reported to be 97,5% and is felt to accurately represent the entire US population [21]. The SEER registry has been combined with Medicare claims to provide additional data on inpatient treatment as well as outpatient physician services [22]. The Medicare database has information on all Medicare claims, and encompasses 97% of individuals from SEER who are ≥ 65 years.

From SEER-Medicare, we selected all patients with stage I NSCLC aged 65 years and older who underwent lobectomy between 1992–2002. The stage was classified according to the American Joint Committee on Cancer criteria [5]. Patients with pre-operative chemotherapy or radiation therapy, and those with missing values for tumor size, income, and number of LNs resected were excluded from the analysis.

Data regarding the number of LNs evaluated after resection was obtained from SEER. For the purpose of this study, based on the data from prior publications [11,12,14], patients were divided into two groups according to the number of LNs evaluated during surgery: limited LN sampling and extensive LN sampling groups consisting of patients with ≤ 10 and >10 LNs evaluated, respectively [11,12,14].

Information on baseline socio-demographic data, comorbidities, pathologic staging, and type of resection were obtained from SEER and Medicare databases [23]. Histological subtypes were classified into categories of adenocarcinoma, bronchioalveolar carcinoma, squamous cell carcinoma, large cell carcinoma, and other histologic types. To obtain a summary measure of the burden of comorbidities within our sample population, we used the Deyo adaptation of the Charlson comorbidity index [24]. Chemotherapy and radiotherapy use was gathered from SEER and Medicare records using previously reported codes [25].

The primary study outcome, perioperative mortality (POM), was defined as death within 30 days of surgery [19]. The date of surgery was identified from inpatient Medicare files. Secondary outcomes included other common surgical complications within 30 days of surgery, which were identified using Medicare claims. They included extrapulmonary infections (shock, septicemia, bacterial infection, postoperative infection, bacteremia, kidney infection, and infection related procedure), cardiovascular complications (acute myocardial infarction and acute coronary occlusion without myocardial infarction), thromboembolic events (deep vein thrombosis and pulmonary embolism), respiratory complications (adult respiratory distress syndrome, respiratory failure, bronchitis, pneumonia, empyema, abscess of lung, abscess of mediastinum and respiratory infection), reoperations (thoracotomy for postoperative complications, reoperation for empyema, bronchial fistula repair, and hemorrhage control), and transfusions (transfusion of packed red blood cells or whole blood). As additional measures of postoperative complications, we compared the number of patients in the two groups who had a prolonged length of stay, which was defined as a total

length of stay of 14 days after surgery [26], the number of intensive care unit admissions and 90 day mortality rates.

Statistical Analysis

Differences in the distribution of baseline characteristics between patients that underwent lobectomy with 10 LNs vs. >10 LNs removed were evaluated using the chi-square test. We used the propensity score method to control for potential biases due to systematic differences in the distribution of baseline characteristics of patients undergoing evaluation of 10 LNs vs. >10 LNs [27]. The propensity score is the conditional probability of undergoing evaluation of 10 LNs vs. >10 LNs, given a set of pretreatment characteristics. We used logistic regression to determine propensity scores for undergoing >10 LN evaluation based on patient's demographic (age, gender, marital status, race/ethnicity, income), clinical (comorbidities), and tumor characteristics (histology, size, grade, location, laterality). Once the model was developed, we used multiple regression analysis to compare the baseline characteristics of patients who underwent evaluation of 10 LNs vs. >10 LNs after adjusting for propensity scores.

Unadjusted comparisons of the rates of POM as well as other perioperative complications of patients who underwent extensive lymph node sampling and those who did not, were also conducted using the logistic regression. Then a multiple logistic regression model was used to compare POM and rates of complications among patients between each of the two groups controlling for propensity scores. Additionally, we divided patients into five propensity score strata and compared these outcomes between our two groups within each quintile. Based on the number of patients in the cohort, we estimated that the study had an 80% power to detect a 2% increase in the risk of POM with extensive LN resection. Similarly, the study had an 80% power to detect an increase between 1.5% to 4% for other postoperative complications. All statistical tests reported in the manuscript are two-sided, and were performed with the SAS 9.0 statistical package (SAS Institute, Inc., Cary, NC). The threshold of significance was set at p less than 0.05. The study was exempt by the Institutional Review Board of the Mount Sinai Medical Center.

RESULTS

We identified 5,176 patients 65 years of age with complete staging data that had undergone lobectomy for stage I NSCLC. Among these, we excluded 24 patients that received preoperative radiation therapy, 169 patients who underwent neoadjuvant chemotherapy, and 8 patients that had missing socio-demographic information, leaving a cohort of 4,975 eligible study patients. Of these 3,778 (75.9%) patients underwent limited LN evaluation (10 LNs). Patients' baseline socio-demographic and tumor characteristic are summarized in Table 1. There were no significant differences in the distribution of age ($p = 0.75$) or gender ($p = 0.26$) among study groups. Patients who underwent evaluation of >10 LNs were more likely to be white ($p = 0.0005$) and have a higher income ($p = 0.05$). There were also differences in several tumor characteristics, including histological type ($p = 0.01$), location ($p = 0.01$), and size ($p = 0.0001$), among patients undergoing limited vs. extensive LN sampling. The burden of comorbidities was not significantly different among the groups ($p =$

0,28). However, the distribution of baseline covariates was similar across the groups after adjusting for propensity scores.

We analyzed the median number of nodes examined in both groups. There were considerable differences in the median (inter-quartile range) number of lymph nodes evaluated in each group: 5,0 (3,0–7,0) vs 15,0 (12,0–18,0) for the ≤ 10 and >10 nodes groups, respectively. Thus, it is unlikely that our results are due to a similar distribution in the number of lymph nodes sampled across groups.

The overall 30-day POM was 3,6% (95% confidence interval [CI], 3,06–4,1%). The most common complications in both groups were respiratory related events (28,4%), followed by extrapulmonary infections (5,9%). POM was similar among patients undergoing limited vs. extensive LN evaluation (odds ratio [OR], 1,01; 95% CI, 0,71–1,43; Table 2). Similarly, analysis of postoperative complications did not show statistical significant differences in the rate of specific complication between the two groups, except for thromboembolic events (OR, 1,70; 95% CI, 1,11–2,59) and number of reoperations (OR, 1,66; 95% CI, 1,02–2,70). However, there was no significant difference in prolonged LOS between the two groups, with 18,0% of patients in ≤ 10 LNs resected and 15,5% in >10 LNs resected groups being hospitalized for ≥ 14 days after surgery (OR, 0,84; 95% CI, 0,70–1,01). There were 72,4% of patients with ≤ 10 LNs resected and 74,9% with >10 LNs resected that required admission to the intensive care unit postoperatively (OR, 1,14; 95% CI, 0,98–1,33).

Results of multiple logistic regression analysis, adjusting for propensity scores, confirmed a lack of significant difference in POM between the two groups (OR, 1,01; 95% CI, 0,71–1,44; Table 3). Similarly, analysis stratified by propensity scores quintiles showed no difference in POM among patients who had ≤ 10 LNs vs. >10 LNs evaluated (OR range from 0,69 to 1,89). To further assess if the risk of mortality increases with a higher number of resected nodes, we conducted secondary analyses comparing 30 day mortality among patients with ≤ 5 vs. ≥ 20 LNs removed. The analysis confirmed the lack of significant difference in 30 day mortality between these two groups after adjusting for propensity scores (OR=1.23, 95% CI 0.62–2.43).

Postoperative complications also showed lack of significant difference among the groups after adjusting or stratifying for propensity scores. The only exception was thromboembolic events that were more common among patients undergoing resection of >10 LNs (OR, 1,72; 95% CI, 1,12–2,63). There were no significant differences in the percent of patients with a prolonged LOS or number of ICU admission between each of the two groups. To analyze if POM rates are affected by potential delayed complications, we also compared 90 day mortality between the two study groups. The analysis confirmed the lack of significant difference in 90 day mortality between the two groups after adjusting for propensity scores (OR=1,03, 95% CI 0,77–1,36; $p=0,87$).

DISCUSSION

Adequate LN evaluation is critical for accurate staging of NSCLC. Several studies have shown that at least 10 LNs should be resected for staging purposes and appropriate selection

of candidates for adjuvant chemotherapy. The most common cited reason against extensive LN resection is increased risk of perioperative complications, particularly in the elderly [28]. Our study analyzed the risk of these potential complications among elderly patients undergoing lobectomy for stage I NSCLC, using a large, nationwide database. Our results showed that removal and evaluation of >10 LNs is safe in patients 65 years of age. Thus, concerns about increased risk of postoperative complications should not limit the use of more extensive LN resection for accurate staging of elderly patients.

The importance of adequate pathological staging of lung cancer has been demonstrated in several studies [6,7,29]. As with other cancers, there is an increasing attention being paid to the number of LNs that should be resected and analyzed for proper lung cancer staging and improved outcomes. Analysis of data for cancers of the colon, breast, bladder and esophagus demonstrates that the number of LNs evaluated during staging is associated with postoperative survival [30–33]. In lung cancer, several recent studies, including large samples of patients, suggest the minimum of 10–11 LNs need to be assessed for early NSCLC [11–14]. The possible therapeutic survival benefit of extensive LN dissection has been evaluated in a randomized control trial that showed no difference in recurrence rates in patients with early stages of NSCLC who underwent either extensive LN dissection or LN sampling [34].

Prior studies evaluating complications after limited vs. extensive LN resection have shown conflicting results [17,18]. Okada and colleagues reported an increase in postoperative morbidity among 377 patients undergoing extensive LN resection vs. 358 patients with limited LN resection (17,3% vs. 10,1%, $P = 0,005$) [17]. Conversely, other studies show no difference in perioperative complications after different extent of nodal resection [15,16,35,36]. Allen and colleagues collected 30-day postoperative data from 1,111 patients, undergoing resection for clinical stages I and II NSCLC, as part of ACOSOG Z0030 trial [15]. The results of this study showed no difference in the rate of cardiovascular or pulmonary complications, median length of postoperative stay, duration of chest tube drainage, and rate of reoperations. However, systematic LN dissection was associated with a greater blood loss and, on average, 15 minutes longer operating time than LN sampling. The fact that patients in this study underwent different types of pulmonary resection, including pneumonectomy (4%), and had different stages of disease (stage I to IIIA), makes interpretation of the results more difficult. Additionally, this was a sample of highly selected patients that met the inclusion criteria of the study. Our study extends these results by showing that more extensive LN resection is not associated with increased POM or other potential complications in an unselected sample of elderly patients from the general population.

Our results suggest that POM and other complications were not significantly different among groups, except for rates of thromboembolic events. Thus, our results highlight the importance of DVT prevention in the elderly population during the postoperative period, with early ambulation, pneumatic compression devices, and prophylactic treatment with unfractionated or low molecular weight heparin. In addition, our study showed a trend toward a higher rate of reoperations among patients who had >10 LNs evaluated. While

previous studies did not find a difference in reoperation rate between patients with different extent of LN evaluation [15,16], these findings should be further evaluated in future studies.

There are some strengths and limitations of our study. Our cohort included patients >65 years of age, the standard age criterion for SEER-Medicare studies. Thus, we cannot exclude increased risk of POM or other complications among older patients with lung cancer. The SEER registry does not contain data about operative time, but as some studies suggest, more extensive LN resection leads to increased duration of the surgical procedure [15,16,35]. However, even if it is the case in our cohort, longer operative time does not seem to affect postoperative recovery, prolong length of stay, or rates of postoperative ICU admissions. Also, the SEER database fields regarding number of lymph nodes evaluated does not discriminate between fragments of the same lymph node versus intact separate lymph nodes, and there is no standardization on how lymph node fragments are handled. This ambiguity may limit the precision by which the patients in our study were assigned to either of the groups. In addition to the overall number of LNs examined, evaluation of the number of stations is also important. Unfortunately, we were unable to examine the effect of number of LN stations evaluated on perioperative outcomes, as this information is not reported in SEER. We also would have liked to analyze the rate of chyle leaks, which is a rare, but morbid complication, but this information is not recorded in the SEER-Medicare database. The potential difference in the rates of chyle leaks could have possibly explained higher rates of DVTs in patients with extensive LN resection due to the greater use of central venous access for parenteral nutrition. Additional limitations of SEER-Medicare data include lack of information related to the specific surgical technique used (thoracoscopy vs. thoracotomy) and the surgeon's training and experience. Also, excluding the patients with missing important clinical values from the analysis could potentially introduce a bias to our results. Finally, observational data cannot provide definitive evidence about whether a certain treatment changes outcomes, because nonrandomized studies cannot fully control for the distribution of important covariates among treatment groups. However, propensity scores allow researchers to control for a large number of variables and the potential effect of other measured confounders included in the propensity score model. Using these methods, we did not observe a significant correlation in perioperative morbidity and mortality between the elderly patients undergoing lobectomy for stage I lung cancer and the extent of lymph node resection. Nevertheless, it is important to recognize that propensity score methods do not adjust for unmeasured confounders. However, the strength of SEER-Medicare is that its large sample size enabled us to have sufficient power for detecting relatively moderate associations between the extent of LN resection and POM or other complications. The population-based recruitment of cases increases the external validity of our findings, unlike with hospital-based series. Moreover, the rigorous data extraction and coding procedures allow for the high level of case detection rate (>97% of all cancer cases) and guarantees the quality of cancer data in the SEER registry.

In summary, the results of this large study, using a nationwide cancer database, show that removal and evaluation of >10 LNs, which allows for more accurate staging, appears to be safe in the elderly patients undergoing lobectomy for stage I NSCLC without compromising postoperative recovery. Except for some increase in perioperative rate of thromboembolic events, there was no significant difference detected in perioperative morbidity, LOS,

reoperations, or mortality between the two groups of patients. Results of ongoing randomized studies will give important information regarding the effect of systematic LN dissection on long-term survival.

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Table I**Demographic and Clinical Characteristics of Patients Undergoing Lobectomy**

Characteristic	Number of LNs Resected		P-value	Adjusted P-value ^I
	10 (n=3,778)	>10 (n=1,197)		
Age in years, No. (%)			0.75	1.00
65 – 69	1067 (28.2)	354 (29.5)		
70 – 74	1270 (33.6)	392 (32.8)		
75 – 79	942 (24.9)	302 (25.2)		
80	499 (13.3)	149 (12.5)		
Gender, No. (%)			0.26	0.99
Male	1931 (51.1)	634 (53.0)		
Marital status, No. (%)			0.07	0.95
Married	2205 (58.4)	734 (61.3)		
Race/Ethnicity, No. (%)			0.0005	0.98
White	3260 (86.3)	1088 (90.9)		
Black	219 (5.8)	49 (4.1)		
Hispanic	107 (2.8)	23 (1.9)		
Other	192 (5.1)	37 (3.1)		
Income quartiles, No. (%)			0.05	1.00
First	994 (26.3)	268 (22.4)		
Second	948 (25.1)	303 (25.3)		
Third	1013 (26.8)	344 (28.7)		
Fourth	823 (21.8)	282 (23.6)		
Histology, No. (%)			0.01	1.00
Adenocarcinoma	1675 (44.3)	530 (44.2)		
Bronchioalveolar carcinoma	182 (4.8)	37 (3.1)		
Squamous carcinoma	1215 (32.2)	416 (34.8)		
Large cell carcinoma	218 (5.8)	49 (4.1)		
Other	488 (12.9)	165 (13.8)		
Tumor laterality, No. (%)			0.13	0.98
Right	2121 (56.1)	642 (53.6)		
Tumor lobar location, No. (%)			0.01	1.00
Upper	2262 (59.9)	759 (63.4)		
Middle	209 (5.5)	40 (3.3)		
Lower	1283 (34.0)	391 (32.7)		
Other	24 (0.6)	7 (0.6)		
Tumor size in mm, No. (%)			.0001	0.55
20	1128 (29.9)	345 (28.8)		
21 – 30	1189 (31.5)	337 (28.2)		
31 – 50	1082 (28.6)	327 (27.3)		
51 – 70	273 (7.2)	130 (10.8)		
70	106 (2.8)	58 (4.9)		

Characteristic	Number of LNs Resected		P-value	Adjusted P-value ^I
	10 (n=3,778)	>10 (n=1,197)		
Tumor grade, No. (%)			0.20	1.00
I	458 (12.1)	143 (12.0)		
II	1442 (38.2)	472 (39.4)		
III	1315 (34.8)	435 (36.3)		
IV	194 (5.1)	56 (4.7)		
Undetermined	369 (9.8)	91 (7.6)		
Comorbidity Score, No. (%)			0.28	0.98
0 – 1	3204 (84.8)	1034 (86.4)		
2 – 3	378 (10.0)	101 (8.4)		
4	196 (5.2)	62 (5.2)		

^I Adjusted for propensity score;

LN = lymph nodes;

Unadjusted Analysis between Extent of Lymph Node Resection and Outcomes in Elderly Patients with Stage I Non-Small Cell Lung Cancer

Table II

Complication	Number of LNs Resected		Odds Ratio ^f	95% CI	P-value
	10 N (%)	>10 N (%)			
Primary Outcome					
30-day mortality	135 (3.6)	43 (3.6)	1.01	0.71–1.43	0.98
Secondary Outcomes					
30-day readmission	301 (8.0)	79 (6.6)	0.82	0.63–1.06	0.12
Prolonged LOS [*]	633 (18.0)	175 (15.5)	0.84	0.70–1.01	0.06
Postoperative ICU stay [*]	2547 (72.4)	843 (74.9)	1.14	0.98–1.33	0.10
Extrapulmonary infections	220 (5.8)	75 (6.3)	1.08	0.83–1.42	0.57
Cardiovascular	64 (1.7)	18 (1.5)	0.89	0.52–1.50	0.65
Thromboembolic	64 (1.7)	34 (2.8)	1.70	1.11–2.59	0.01
Respiratory	1095 (29.0)	319 (26.7)	0.89	0.77–1.03	0.12
Reoperation	48 (1.3)	25 (2.1)	1.66	1.02–2.70	0.04
Transfusion	143 (3.8)	37 (3.1)	0.81	0.56–1.17	0.26

^{*} N=4645;

^f Odds ratio for patients who underwent resection of >10 lymph nodes compared with patients who had 10 lymph nodes resected;

LOS = length of stay; ICU = intensive care unit; LN = lymph nodes; CI = confidence interval;

Some patients may have had more than one complication

Table III

Adjusted Analysis between Extent of Lymph Node Resection and Outcomes in Elderly Patients with Stage I Non-Small Cell Lung Cancer

Complications	Entire Sample			Propensity Score Quintiles									
	OR ^I	95% CI	P-value	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
	OR ^I	95% CI	P-value	OR ^I	95% CI	OR ^I	95% CI	OR ^I	95% CI	OR ^I	95% CI	OR ^I	95% CI
Primary Outcome													
30-day mortality	1.01	0.71–1.44	0.94	1.17	0.02–1.24	1.89	1.00–3.60	1.34	0.61–2.79	0.69	0.26–1.86	0.88	0.44–1.74
Secondary Outcomes													
30-day readmission	0.83	0.64–1.08	0.17	0.73	0.37–1.44	1.17	0.65–2.10	0.86	0.51–1.46	0.61	0.32–1.16	0.87	0.51–1.48
Prolonged LOS*	0.85	0.71–1.02	0.09	0.94	0.58–1.51	0.93	0.62–1.38	0.92	0.62–1.36	0.85	0.56–1.30	0.70	0.47–1.02
Postoperative ICU stay*	1.13	0.96–1.32	0.13	0.90	0.60–1.36	1.69	1.16–2.48	1.14	0.82–1.59	0.89	0.64–1.23	1.2	0.87–1.65
Extrapulmonary infections	1.07	0.82–1.41	0.61	0.93	0.41–2.09	2.66	1.59–4.45	0.83	0.44–1.60	0.63	0.33–1.21	0.88	0.48–1.61
Cardiovascular	0.97	0.57–1.65	0.90	1.37	0.46–4.10	0.66	0.19–2.29	0.71	0.20–2.53	1.98	0.70–5.61	0.45	0.10–2.11
Thromboembolic	1.72	1.12–2.63	0.01	1.23	0.27–5.65	2.81	1.21–6.50	1.23	0.55–2.71	1.48	0.55–3.98	1.81	0.65–5.04
Respiratory	0.89	0.77–1.03	0.12	0.59	0.38–0.92	1.14	0.83–1.58	0.97	0.70–1.32	0.73	0.52–1.02	0.94	0.70–1.25
Reoperation	1.57	0.96–2.57	0.07	1.02	0.23–4.60	7.26	1.80–29.26	1.59	0.53–4.79	1.07	0.34–3.38	1.27	0.52–3.09
Transfusion	0.83	0.57–1.21	0.33	0.63	0.22–1.80	1.05	0.47–2.35	1.06	0.50–2.21	0.78	0.34–1.83	0.65	0.29–1.45

Quintile 1 includes patients with the lowest estimated probability of receiving extensive lymph node resection. Conversely, Quintile 5 includes patients with the highest estimated probability of receiving extensive lymph node resection.

N=4645;

^IOdds ratio for patients who underwent resection of >10 lymph nodes compared with patients who had 10 lymph nodes resected;

LOS = length of stay; ICU = intensive care unit; OR = odds ratio; 95% CI = confidence interval; LOS = length of stay;