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Effect of insurance type on perioperative outcomes after robotic-assisted pulmonary lobectomy for lung cancer

Pavit S. Deol, BA[a], Joseph Sipko, BS[a], Ambuj Kumar, MD, PhD[b], Athanasios Tsalatsanis, PhD[b], Carla C. Moodie, PA-C[c], Joseph R. Garrett, MPH, ARNP-C[c], Jacques P. Fontaine, MD[c,d,e], Eric M. Toloza, MD, PhD[c,d,e,*]

[a] SELECT Program, University of South Florida Health Morsani College of Medicine, Tampa, FL
[b] Office of Research, University of South Florida Health Morsani College of Medicine, Tampa, FL
[c] Department of Thoracic Oncology, Moffitt Cancer Center, Tampa, FL
[d] Department of Surgery, University of South Florida Health Morsani College of Medicine, Tampa, FL
[e] Department of Oncologic Sciences, University of South Florida Health Morsani College of Medicine, Tampa, FL

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ABSTRACT

Background: Insurance type has been reported to be an independent predictor of overall survival in lung cancer patients. We studied the effect of insurance type on patient outcomes after minimally invasive pulmonary lobectomy for lung cancer.

Methods: We retrospectively analyzed 433 consecutive patients who underwent robotic-assisted pulmonary lobectomy by one surgeon during an 80-month period. Perioperative outcomes and intraoperative and postoperative complications were noted. Disposition at discharge after surgery (favorable, eg, transfer to home with self-care or with home health nursing and/or physical therapy, versus unfavorable, eg, long-term acute care or rehabilitation facility, hospice, or death) and 5-year overall survival (5-years OS) were also recorded. We used Pearson χ^2, analysis of variance (ANOVA), and Kruskal-Wallis test to compare variables and Cox regression for survival analysis.

Results: There were 107 patients (mean age 57.5 years) with private insurance, 118 (mean age 70.3 years) with public insurance (Medicare or Medicaid), 196 (mean age 71.8 year; $P < .001$) with combination insurance plans (Medicare plus a privately supplied supplemental), and 12 patients with no insurance (excluded owing to low sample size). There were more current smokers in the public insurance group, more former smokers in the combination insurance group, and more nonsmokers in the private insurance group ($P = .03$). There were more comorbidities in the public and combination insurance groups versus the private insurance group, including gastroesophageal reflux disease ($P = .003$), hypertension ($P = .01$), and hyperlipidemia ($P < .001$). The groups had no differences in tumor size or pathologic stage. There were higher numbers of intraoperative conversions to open lobectomy in the private and public insurance groups versus the combination insurance group ($P = .001$). Also, the private and combination insurance groups had more cases of favorable disposition at discharge after surgery compared with the public insurance group ($P < .001$). Multivariable regression analyses identified private insurance type as an independent predictor of favorable disposition at discharge (public versus private plan; odds ratio, 0.43; 95% confidence interval [CI], 0.22–0.85, $P = .02$) and 5-year OS (combination versus private plan; hazard ratio, 2.68; 95% CI, 1.26–5.67, $P = .01$; public versus private plan; HR, 2.84; 95% CI, 1.37–5.89; $P = .01$).

Conclusion: Although public or combination insurance type was associated with greater risk of all-cause mortality, and public insurance type was associated with less favorable disposition at discharge after surgery and overall conversion to open lobectomy, insurance type was not associated with increased intraoperative complications, hospital duration of stay, or in-hospital mortality after minimally invasive robotic-assisted pulmonary lobectomy.

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* Reprint requests: Eric M. Toloza, MD, PhD, 12902 USF Magnolia Drive, Suite FOB-1, Tampa, FL 33612.

E-mail address: eric.toloza@moffitt.org (E.M. Toloza).

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Introduction

Lung cancer is the leading cause of cancer-specific mortality in the world, and its most common type is non-small cell lung cancer (NSCLC).[1] Without treatment, overall survival (OS) is poor. Five-year overall survival (5-year OS) for early stage NSCLC without undergoing treatment is <5%, but proper treatment can increase 5-year OS to 36% for stage-IIIA NSCLC and ≥82% for stage IA NSCLC.[2] Lobectomy with mediastinal lymph node dissection is the accepted standard for surgical treatment of NSCLC, with pneumonectomy sometimes being required. Current literature has shown that patients who have public insurance plans (ie, Medicare or Medicaid) or no insurance are less likely to undergo lung resection for treatment of NSCLC compared with those who have private insurance plans.[1] This may lead to a delay in receiving proper treatment for a patient's unique clinical presentation. Some literature suggests that delaying time from diagnosis to initiating proper treatment can result in less favorable outcomes after treatment, such as worse overall survival.[3] In addition, some literature also suggests that insurance type is an independent predictor of overall survival in lung cancer patients.[4] However, minimal literature exists that specifically compares surgical outcomes between lung cancer patients with different insurance type and who underwent lobectomy. This study aims to address that question.

Minimally invasive video-assisted thoracoscopic (VATS) surgery has proven advantages for reduction of postoperative pain, preserved postoperative immune response, quicker resumption of daily activities, and better aesthetic and functional results compared with open lobectomy.[5–10] In addition, robotic-assisted VATS (R-VATS) lobectomy for NSCLC via the da Vinci Robotic Surgical System (Intuitive Surgical Corp., Sunnyvale, CA) has been shown to have safe and comparable outcomes compared with conventional VATS.[11] This study aimed to compare perioperative outcomes among lung cancer patients with private insurance, public insurance (Medicaid or Medicare), or a combination plan (Medicare plus a private supplement plan) after R-VATS lobectomy.

Insurance type may reflect a patient's broader socioeconomic status, and various factors, such as income level, education level, occupation, and availability of transportation to the hospital may all affect a patient's surgical outcomes as well. This retrospective study design inherently has its limitations. For instance, not all the variables mentioned earlier, such as income level and occupation, were available, but findings from the study nonetheless would have significant implications. We hypothesize that patients who have public or combination plans will have less favorable outcomes compared with those with private insurance plans. If this hypothesis holds true, the study will have important implications in areas such as future patient care, physician decision making, and recommendations for an improved health care system.

Methods

We retrospectively studied consecutive patients who underwent robotic-assisted pulmonary lobectomy by one surgeon from September 2010 through May 2017 at a single institution. Prospectively collected data within patients' electronic medical records were retrospectively reviewed. The number of procedures performed by the surgeon during the specified period determined the sample size of the study.

All of our patients underwent fiberoptic bronchoscopy by the operating surgeon after the induction of general anesthesia. After placement of the dual-lumen endotracheal tube, the patient was then placed in either a right or left lateral decubitus position. Our robotic-assisted lobectomy technique uses a three-port system, which includes a 4-cm camera port along the sixth intercostal space (ICS) at the anterior axillary line, which doubles as the assistant's access port, and two 1-cm instrument ports along the third ICS at the anterior axillary line and along the ninth ICS at the posterior axillary line.

From September 2010 through December 2011, our group used the da Vinci S robotic surgical system (Intuitive Surgical Corp.), with the Si system (Intuitive Surgical Corp.) being used from January 2012 to March 2017, and the Xi system (Intuitive Surgical Corp.) being used from April 2017 to the present. Lobectomy is performed by initially dividing the pulmonary vein followed by division of the pulmonary artery branch(es) and bronchus. The pulmonary fissure is then divided. After delivery of the lobectomy within an endopouch through the sixth ICS port incision, robotic-assisted complete mediastinal lymph node dissection is then performed. At the end of the procedure, a 32-French chest tube is introduced through the ninth ICS port incision and connected to drainage at −20 cmH2O continuous suction.

Eligible patients in this study were ≥18 years of age and had undergone elective robotic-assisted VATS lobectomy for clinically diagnosed lung cancer, with or without neoadjuvant therapy. Independent variables included insurance type at time of surgery stratified as either private, public (Medicare or Medicaid), or a combination plan (Medicare plus a private supplement plan). Other variables analyzed included age, sex, body mass index, body surface area, and forced expiratory volume in 1 second as a percentage (FEV1%) of predicted at the time of surgery. Past medical history and smoking history were also analyzed. Five-year overall survival (5-year OS) was measured, and follow-up time was assessed based on the date that the patient was last seen in clinic or contacted or on the date of their death if they were deceased. We investigated differences in surgical outcomes between patients by analyzing variables, such as operative time, estimated blood loss, conversion to open lobectomy, perioperative complications, chest tube duration, hospital length of stay (LOS), and in-hospital mortality. Any clinically significant intraoperative complications were noted, including bleeding from major pulmonary vessels, phrenic or recurrent laryngeal nerve injury, bronchial injury, or diaphragm injury. Clinically significant postoperative complications were also compared, including pulmonary-related complications, such as pneumonia, pulmonary embolism, and respiratory failure, in addition to cardiac complications including atrial fibrillation and myocardial infarction. Finally, patient disposition at discharge was categorized as favorable (transfer to home with self-care or with home health nursing or physical therapy) or unfavorable (long-term acute care or rehabilitation facility, hospice, or death).

Mean, standard error of the mean, and range, or else median and interquartile range, were reported for continuous and ordinal variables. Categorical data were expressed as count and percentages. Where applicable, we used Pearson χ^2, analysis of variance (ANOVA), or Kruskal-Wallis test to compare variables, and Cox regression analysis was used for survival analysis. Multivariable logistic regression analyses were performed that incorporated variables, which had a statistically significant difference among the three insurance groups, including age at surgery, smoking status, preoperative gastroesophageal reflux disease (GERD), preoperative hypertension (HTN), preoperative hyperlipidemia (HLD), and overall conversion to open lobectomy to assess the magnitude of effect of insurance type on disposition at discharge and on 5-year OS.

Results

The data outlined above were analyzed for 433 patients who underwent R-VATS lobectomy to treat their lung cancer. Twelve patients did not have any insurance coverage, and their procedures

Table I
Patient demographics

Patient characteristics	Private n = 107	Public n = 118	Combination n = 196	*P* value
Age,* y	57.5 ± 0.8 (24–79)	70.3 ± 0.9 (29–86)	71.8 ± 6.7 (40–87)	< .001
BMI, kg/m^2	28.9 ± 0.7 (18–59)	27.5 ± 0.5 (14–40)	27.9 ± 0.4 (17–48)	.17
BSA*, m^2	1.9 ± 0.03 (1.4–2.9)	1.9 ± 0.02 (1.3–2.5)	1.9 ± 0.02 (1.3–2.9)	.65
FEV1%*	87.5 ± 1.7 (48–138)	85.0 ± 2.0 (28–138)	88.3 ± 1.4 (40–137)	.34
Male	38 (35.5%)	57 (48.3%)	89 (45.4%)	.13
Female	69 (64.5%)	61 (51.7%)	107 (54.6%)	.13

BMI, body mass index; *BSA*, body surface area.
* Mean ± standard error or mean (range).

Table II
Smoking status and comorbidities

Patient comorbidities	Private n = 107	Public n = 118	Combination n = 196	*P* value
Current smokers	33 (30.8%)	47 (39.8%)	46 (23.5%)	.03
Former smokers	50 (46.7%)	53 (44.9%)	113 (57.7%)	.03
Nonsmokers	24 (22.4%)	18 (15.3%)	37 (18.9%)	.03
COPD	14 (13.1%)	29 (24.6%)	40 (20.4%)	.09
Asthma	8 (7.5%)	9 (7.6%)	9 (4.6%)	.45
Prior pneumonia	6 (5.6%)	14 (11.9%)	16 (8.2%)	.24
Diabetes mellitus	22 (20.6%)	21 (17.8%)	34 (17.3%)	.78
GERD	14 (13.1%)	18 (15.3%)	54 (27.6%)	.003
Previous cancers	47 (43.9%)	53 (44.9%)	86 (43.9%)	.98
Hypertension	49 (45.8%)	67 (56.8%)	124 (63.3%)	.01
Hyperlipidemia	33 (30.8%)	51 (43.2%)	112 (57.1%)	<.001
Atrial fibrillation	4 (3.7%)	9 (7.6%)	17 (8.7%)	.27
Other arrhythmias	5 (4.7%)	8 (6.8%)	7 (3.6%)	.43
Coronary artery disease or previous MI	13 (12.1%)	18 (15.3%)	39 (19.9%)	.20

COPD, chronic obstructive pulmonary disease; *MI*, myocardial infarction.

Table III
Tumor characteristics

Tumor characteristics	Total n = 421	Private n = 107	Public n = 118	Combination n = 196	*P* value
Tumor size, cm*	3.2 ± 0.1 (0–14.2)	3.2 ± 0.2 (0–9)	3.3 ± 0.2 (0.8–14.2)	3.2 ± 0.1 (0.2–9.7)	.89
Pathology					
Primary lung cancer	381 (90.5%)	90 (84.1%)	109 (92.4%)	281 (92.9%)	.09
Pulmonary metastasis	37 (8.8%)	15 (14.0 %)	9 (7.6%)	13 (6.6%)	.09
Other pathology†	3 (0.7%)	2 (1.9%)	0 (0.0%)	1 (0.5%)	.09
Pathologic stage for primary lung cancer					
Stage IA	191 (50.1%)	42 (46.7%)	53 (48.6%)	96 (52.7%)	.95
Stage IB	64 (16.8 %)	14 (15.6%)	21 (19.3%)	29 (15.9%)	.95
Stage IIA	34 (8.9%)	8 (8.9%)	12 (11.0%)	14 (7.7%)	.95
Stage IIB	16 (4.2%)	4 (4.4%)	4 (3.7%)	8 (4.4%)	.95
Stage IIIA	61 (16.0%)	17 (18.9%)	14 (12.8%)	30 (16.5%)	.95
Stage IIIB	4 (1.0%)	1 (1.1%)	2 (1.8%)	1 (0.5%)	.95
Stage IV	11 (2.9%)	4 (4.4%)	3 (2.8%)	4 (2.2%)	.95

* Mean ± standard error or mean (range).
† Benign or lymphoma.

were covered through charity or by self-pay. These patients were excluded from the study owing to the small size of the group. The exclusion of these patients resulted in a total of 421 patients who were divided into 3 groups for analysis: 107 (25%) patients had private insurance, 118 (28%) had public insurance, and 196 (47%) had a combination plan that consisted of Medicare plus a private supplemental plan. The mean age of 57.5 ± 0.8 years (range, 24–79 years) in the private insurance group was significantly less than that for the public insurance group (70.3 ± 0.9 years; range, 29–86 years) and for the combination insurance group (71.8 ± 0.5 years; range, 40–87 years; $P < .001$; Table I). There was no difference in male-to-female gender distribution ($P = .13$), body mass index ($P = .17$), body surface area ($P = .65$), or FEV1% ($P = .34$) among the 3 insurance groups (Table I).

Current smokers (currently smoking or quit up to 1 month before time of surgery) were more common in the public insurance group (39.8%; $P = .03$); former smokers (quit smoking 2 months or greater before time of surgery) were more common in the combination insurance group (57.7%; $P = .03$); and nonsmokers were more common in the private insurance group (22.4%; $P = .03$; Table II). The public and combination insurance groups in our cohort had more co-morbidities compared with the private insurance group, including GERD (15.3% and 27.6%, respectively, vs 13.1%; $P = .003$), HTN (56.8% and 63.3%, respectively, vs 45.8; $P = .01$), and HLD (43.2% and 57.1%, respectively, vs 30.8%; $P < .001$; Table II).

There was no differences in tumor size ($P = .89$), cancer pathology ($P = .09$), or pathologic stage for primary lung cancer ($P = .95$) among the 3 different insurance groups (Table III).

Rates of intraoperative complications were comparable among the 3 insurance groups (Table IV). However, the private and public insurance groups had higher rates of overall conversion to open

Table IV
Intraoperative complications

Complication variable	Total n = 421	Private n = 107	Public n = 118	Combination n = 196	*P* value
Overall intraoperative complications	26 (0.06%)	4 (0.04%)	12 (0.1%)	10 (0.05%)	.23
Bleeding (PA)	13 (3.1%)	3 (2.8%)	6 (5.1%)	4 (2.0%)	.31
Bleeding (PV)	5 (1.2%)	0 (0.0%)	2 (1.7%)	3 (1.5%)	.42
Recurrent laryngeal nerve injury	4 (1.0%)	1 (0.9%)	2 (1.7%)	1 (0.5%)	.58
Bleeding (other)	1 (0.2%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	.28
Phrenic nerve injury	1 (0.2%)	0 (0.0%)	0 (0.0%)	1 (0.5%)	.56
Bronchial injury	1 (0.2%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	.28
Diaphragm injury	1 (0.2%)	0 (0.0%)	0 (0.0%)	1 (0.5%)	.56

PA, pulmonary artery, *PV*, pulmonary vein.

Table V
Perioperative outcomes

Outcomes	Total n = 421	Private n = 107	Public n = 118	Combination n = 196	*P* value
Estimated blood loss, mL	150 ± 200 (20–5,250)	150 ± 150 (25–3,500)	200 ± 263 (25–2,800)	150 ± 175 (20–5,250)	.06
Skin-to-skin operative time, min	180 ± 81.5 (55–515)	190 ± 77 (93–515)	183.5 ± 100.5 (81–485)	176 ± 76.5 (55–504)	.13
Chest tube duration, d*	4 ± 3 (1–90)	3 ± 4 (1–33)	4 ± 4 (1–90)	4 ± 3 (1–58)	.17
Hospital LOS (d)	4 ± 4 (1–39)	4 ± 4 (1–23)	5 ± 5 (2–39)	4 ± 4 (2–22)	.17
In-hospital mortality	7 (1.7%)	1 (0.9%)	0 (0.0%)	6 (3.1%)	.1
Overall conversion to open lobectomy	30 (7.1%)	11 (10.3%)	15 (12.7%)	4 (2.0%)	.001

* Median ± interquartile range (min-max range).

Table VI
Postoperative complications

Complications	Total n = 421	Private n = 107	Public n = 118	Combination n = 196	*P* value
Average number of postoperative complications per patient*	0.57 ± 0.05 (0–7)	0.5 ± 0.08 (0–4)	0.69 ± 0.1 (0–7)	0.55 ± 0.07 (0–5)	.35
Pulmonary-related complications					
Prolonged air leak for ≥5 days	85 (20.2%)	24 (22.4%)	26 (22.0%)	35 (17.9%)	.54
Pneumonia	25 (5.9%)	6 (5.6%)	10 (8.5%)	9 (4.6%)	.37
Chyle leak	17 (4.0%	4 (3.7%)	4 (3.4%)	9 (4.6%)	.86
Mucous plug requiring intervention	16 (3.8%)	2 (1.9%)	8 (6.8%)	6 (3.1%)	.12
Respiratory failure or hypoxia requiring home oxygen	8 (1.9%)	2 (1.9%)	2 (1.7%)	4 (2.0%)	.98
Pneumothorax after chest tube removal requiring intervention	7 (1.7%)	2 (1.9%)	1 (0.8%)	4 (2.0%)	.71
Aspiration	6 (1.4%)	1 (0.9%)	3 (2.5%)	2 (1.0%)	.48
Pulmonary embolism	2 (0.5%)	1 (0.9%)	1 (0.8%)	0 (0.0%)	.42
Cardiovascular complications					
Atrial fibrillation	41 (9.7%)	8 (7.5%)	13 (11.0%)	20 (10.2%)	.64
Other arrythmia requiring intervention	7 (1.7%)	0 (0.0%)	3 (2.5%)	4 (2.0%)	.28
Shock/multiorgan system failure	6 (1.4%)	1 (0.9%)	2 (1.7%)	3 (1.5%)	.88
Cardiopulmonary arrest	4 (1.0%)	0 (0.0%)	0 (0.0%)	4 (2.0%)	.10
Myocardial infarction	2 (0.5%)	0 (0.0%)	1 (0.8%)	1 (0.5%)	.65
Cerebrovascular accident	1 (0.2%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	.28

* Mean ± standard error or mean (range).

Table VII
Disposition after discharge

Disposition	Total n = 421	Private n = 107	Public n = 118	Combination n = 196	*P* value
Favorable disposition*	310 (73.6%)	78 (72.9%)	66 (55.9%)	166 (84.7%)	<.001
Unfavorable disposition†	111 (26.4%)	29 (27.1%)	52 (44.1%)	30 (15.3%)	<.001

* Home with self-care or with home health.
† Transfer to long-term acute care or rehabilitation facility, discharge to assisted-living facility or to hospice, or died.

lobectomy compared with the combination insurance group (10.3% and 12.7%, respectively, vs 2.0%; 0.001; Table V). Besides conversion to open lobectomy, there were similar perioperative outcomes among the 3 groups as well (Table V).

There were also similar rates of postoperative complications among the 3 insurance groups, with no statistically significant differences for pulmonary-related and cardiovascular complications (Table VI).

Regarding patient disposition at discharge after surgery, the private and combination insurance groups had higher percentages of patients with favorable disposition (ie, home with self-care or with home health) compared with those in the public insurance group (72.9% and 84.7%, respectively, vs 55.9%; $P < .001$; Table VII and Fig 1). Conversely, there was a higher percentage of patients in the public insurance group who had an unfavorable disposition (ie, transfer to long-term acute care or rehabilitation facility, discharge to assisted living facility or hospice, or death) compared with those in the private and combination insurance groups (44.1% vs 27.1% and 15.3%, respectively, $P < .001$; Table VII and Fig 1).

Kaplan-Meyer analysis comparing 5-year OS for the 3 insurance groups showed that within our patient follow-up timeframe (recorded as date last seen in clinic or contacted or date of death),

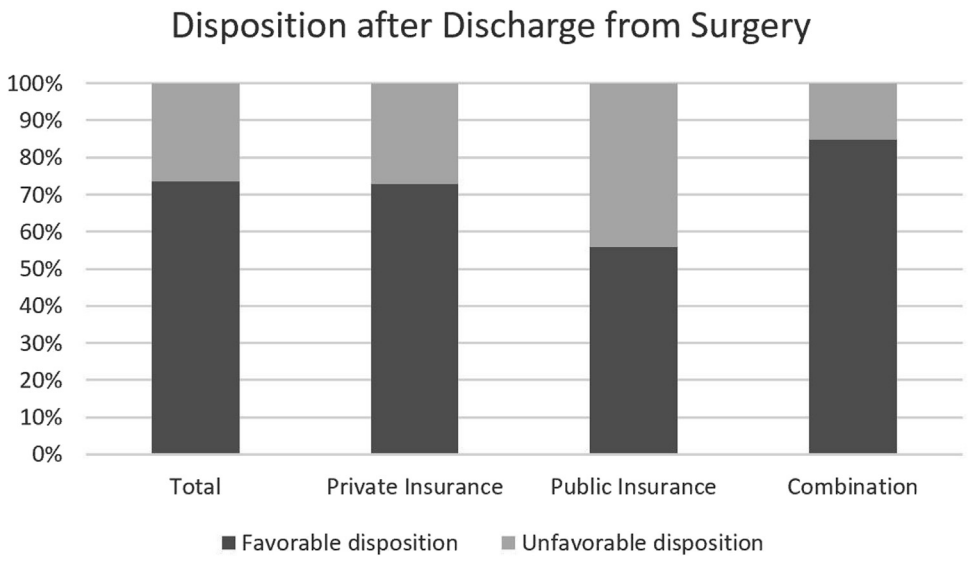

Fig 1. Disposition upon discharge after surgery by insurance type.

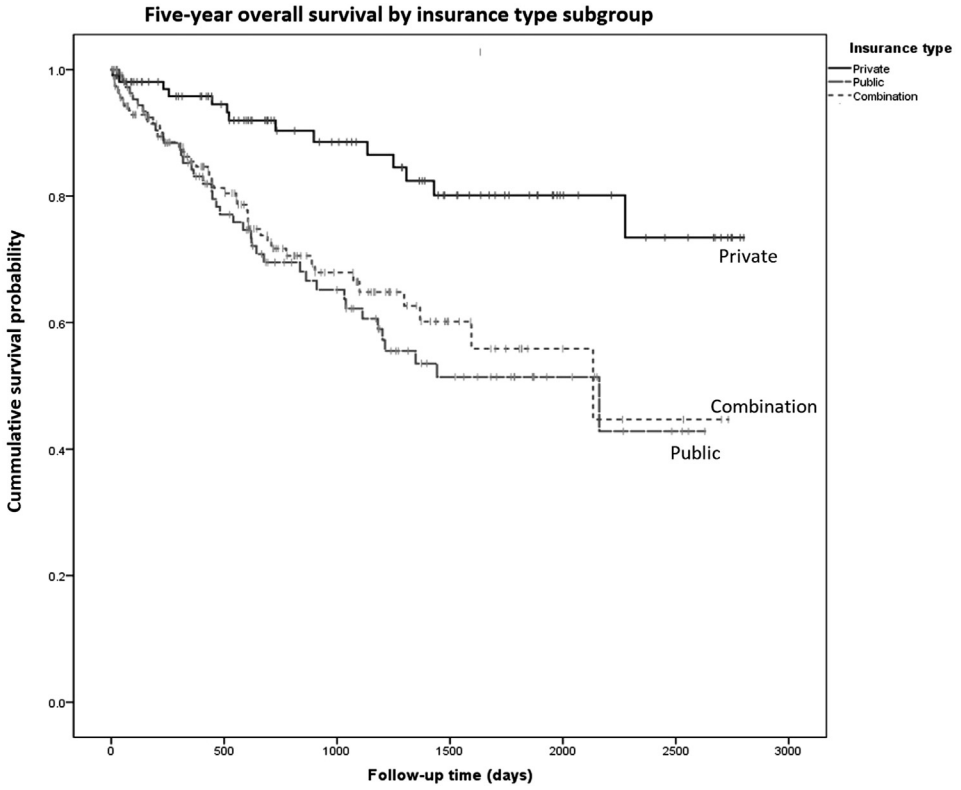

Fig 2. Kaplan-Meier survival curves for the private insurance group (solid line), public insurance group (dashed line), and combination insurance group (dotted line).

the private insurance group had better 5-year OS compared with the combination and public insurance groups (Fig 2). Furthermore, those in the combination insurance group had better 5-year OS compared with the public insurance group.

We subsequently performed analyses to identify the independent predictors of unfavorable disposition at discharge after surgery and of 5-year OS. We found that, after our multivariable analyses incorporating variables that were statistically significant in univariate analyses among the 3 insurance groups, including age at surgery, smoking status, preoperative GERD, preoperative HTN, preoperative HLD, and overall conversion to open lobectomy, insurance type was an independent predictor for both favorable disposition at discharge (public versus private plan; odds ratio [OR], 0.43; 95% confidence interval [CI], 0.22–0.85; $P = .02$) and for 5-year OS (combination versus private plan; hazard ratio [HR], 2.68; 95% CI, 1.26–5.67; $P = .01$; public versus private plan; HR, 2.84; 95% CI, 1.37–5.89; $P = .01$; Table VIII). Smoking status (former versus never; HR, 2.27; 95% CI, 1.15–4.48; $P = .012$; current versus never; HR, 2.30; 95% CI, 1.12-4.70; $P = .02$) and overall conversion to open lobectomy (HR, 2.77; 95% CI, 1.47–5.19;

Table VIII
Multivariable analyses on predictors of disposition after discharge and of survival

	Favorable disposition		Overall survival	
	Odds ratio (95% CI)	*P* value	Hazard ratio (95% CI)	*P* value
Insurance type				
Private	—	—	—	—
Combination	1.84 (0.90–3.78)	0.09	2.68 (1.26–5.67)	.01
Public	0.43 (0.22–0.85)	0.02	2.84 (1.37–5.89)	.01
Smoking status				
Never	—	—	—	—
Former	0.52 (0.26–1.01)	0.06	2.27 (1.15–4.48)	.02
Current	0.78 (0.38–1.60)	0.50	2.30 (1.12–4.70)	.02
Age at surgery	1.01 (0.98–1.04)	0.62	1.02 (0.99–1.05)	.32
Preop GERD	0.79 (0.43–1.47)	0.46	0.88 (0.69–1.12)	.30
Preop HTN	0.90 (0.55–1.50)	0.69	0.89 (0.71–1.11)	.28
Preop HLD	1.09 (0.65–1.82)	0.32	1.08 (0.87–1.34)	.50
Conversion to open lobectomy	0.66 (0.30–1.48)	0.23	2.77 (1.47–5.19)	.002

Preop GERD, preoperative gastroesophageal reflux disease; *Preop HTN*, preoperative hypertension; *Preop HLD*, preoperative hyperlipidemia.

$P = .002$) were also found to be independent predictors of 5-year OS (Table VIII).

Discussion

Findings from this study showed that patients with public and combination insurance plans had lower odds of 5-year OS compared with those with private insurance. The public and combination groups were relatively comparable in terms of survival probability. In addition, those with public insurance alone had higher odds of having an unfavorable disposition at discharge after surgery compared with those who had a private insurance plan or who had a private supplement in addition to their public insurance plan (combination insurance). The private and combination groups in this study were comparable in terms of postsurgical disposition. These findings support our hypothesis that patients who do not have a fully private insurance plan have less favorable outcomes after their surgical treatment. This may be explained by insurance type serving as a reflection of a patient's broader economic status. Insurance type, along with other factors such as income level, education level, occupation, and availability of transportation all may contribute to decreased ability of a patient to access resources of the health system. Emphasis should therefore be placed on ensuring that these patients have the resources they need for adequate care. Similar findings have been reported for other surgical oncology populations as well. For instance, a survival analysis that looked at 860 head and neck cancer patients who underwent resection of an upper aerodigestive tract malignancy demonstrated a hazard ratio of 2.1 (95% CI, 1.5–3.0; $P = .002$) for Medicaid or uninsured patients when compared with the private insurance group.[12] Although our study found no difference in surgical complication rates, the patients in the head and neck cancer study without private insurance were also more likely to have a complication from the surgery.

In addition, the differences in age and smoking history among the groups may contribute to differences in outcomes. Multivariate analysis found that age was not an independent predictor of postsurgery disposition or overall survival. In addition, smoking status was not an independent predictor of disposition after surgery. However, smoking status was indeed found to be an independent predictor of overall survival. The public and combination insurance cohorts had higher percentages of patients who were current or former smokers, which may have added to the decreased odds of 5-year OS in these groups. Although conversion to open lobectomy remained an independent predictor of 5-year overall survival after multivariable analysis, there was a very small number of patients in the total sample size that did in fact have a conversion during the surgery ($n = 30$; 7.1%), which means that other factors like insurance type and smoking status likely played a larger role in predicting overall survival.

Furthermore, it is reported that underinsured patients are less likely to undergo surgical treatment for lung cancer.[1] This finding could possibly mean that those with public insurance or combination plans possibly waited later to have their lung cancer diagnosed or treated. Similarly, it has been reported that patients who are uninsured or who have Medicaid are more likely to refuse guideline-recommended treatment for their lung cancer compared with those who have better insurance, such as a private plan.[13]

Findings from this study have important implications for future patient care, physician decision making, and recommendations for an improved health care system. For instance, as discussed previously, lung cancer patients with public insurance plans or no insurance are more likely to refuse treatment or delay appropriate treatment for their disease. Physicians can therefore engage these patients earlier to discuss possible treatment options and a patient's prognosis given their specific circumstances. In addition, screening programs can be started in communities that are known to be more socioeconomically disadvantaged. Individuals in these communities may have lower education and income levels and may also have higher rates of smoking or alcohol use. Therefore, efforts can be placed on taking a population-based approach to ensure that these patients are getting the health care they need.

Limitations of this study include the fact that it was retrospective and that we were unable to collect all of the data variables of interest, such as income level, marital status, education level, and occupation. Future research can focus on analyzing these along with other socioeconomic factors to assess whether different variables besides insurance type may contribute to the observed disparities in surgical outcomes.

However, a separate analysis previously performed by our group analyzed income by using patient ZIP code as a proxy for median income. In that study, the patient population was an earlier subset of that in our current study and included fewer patients. The study patients were grouped by ZIP code-based median income of <300% of the poverty level ($35,000) versus >$35,000 dollars. The results of that analysis found that there was no statistically significant difference between the 2 income groups for postoperative complication rates, chest tube duration, median LOS, or in-hospital mortality.[14] This previous finding that income does not significantly affect postoperative outcomes helps support our finding that

insurance status as public or combination plan is a significant contributor to postoperative outcomes.

Also, we did not divide the public insurance group further into those who had Medicaid versus those who had Medicare. Part of the reason for this omission was that some patients had both types of insurance, and there was a relatively low number of patients who solely had Medicaid insurance in the public insurance group ($n = 15$). Furthermore, survival that was analyzed in this study used all-cause mortality to establish the follow-up time frame over a 5-year period. Future direction may analyze the 3 patient groups for cancer-specific mortality.

Although public or combination insurance type was associated with greater risk of all-cause mortality and public insurance status was associated with less favorable discharge disposition after surgery and overall conversion to open lobectomy, insurance type was not associated with increased intraoperative complications, hospital LOS, or in-hospital mortality after R-VATS lobectomy. Those with private insurance could have had more favorable outcomes owing to increased socioeconomic status or younger age. Our study suggests that R-VATS lobectomy is safe and feasible in patients with different insurance types and presents opportunities for future research on how to ensure those who are at risk have the resources they need to maintain quality of life after surgery.

Ethical statement

This study was approved by our institution's Scientific Review Committee and by our university's Institutional review Board, and written informed consent was obtained from all patients.

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Conflict of interest

EMT and JPF have had financial relationships with Intuitive Surgical Corp. in the form of honoraria as robotic thoracic surgery observation sites and proctors.

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