



Routine intensive monitoring but not routine intensive care unit-based management is necessary in video-assisted thoracoscopic surgery lobectomy for lung cancer

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Background: Evidence for immediate postoperative intensive care unit (ICU) care is still lacking in the era of minimally invasive video-assisted thoracic surgery (VATS). We evaluated the safety and feasibility of general ward (GW) care after VATS lobectomy for lung cancer.

Methods: A total of 451 patients who underwent VATS lobectomy for lung cancer between June 2012 and August 2017 were retrospectively studied. The patients were divided into two groups (ICU 344 *vs.* GW 107). We compared the postoperative complications and mortality between the two groups after propensity score matching. Furthermore, we evaluated the clinical factors associated with complications, and stratified patients according to the risk for complications.

Results: Immediate complications (within 24 hours after surgery) occurred in 0.4%. Non-immediate complications occurred in 18.8%. There were no differences in the incidence of complications and mortality between the two groups, after propensity matching. However, the length of postoperative stay (12.6 ± 10.0 *vs.* 10.3 ± 4.1 days, $P=0.041$) was significantly higher in the ICU group than in the GW group. Multivariate regression analyses revealed that chronic obstructive pulmonary disease (COPD) [odds ratio (OR) =3.00, 95% confidence interval (CI): 1.51–5.97, $P=0.002$], non-stage I cancer (OR =2.54, 95% CI: 1.39–4.62, $P=0.002$), multi-port surgery (OR =3.75, 95% CI: 2.18–6.44, $P<0.001$), and age ≥ 60 years (OR =2.12, 95% CI: 1.03–4.37, $P=0.042$) were associated with complications. Immediate postoperative care in GW had no influence on complications.

Conclusions: Immediate postoperative care after VATS lobectomy for lung cancer in GW was safe and feasible without poor outcomes. Therefore, selective intensive monitoring for high risk groups may offer cost-saving and efficient use of ICU resources.

Keywords: Video-assisted thoracoscopic surgery (VATS); lobectomy; lung cancer; postoperative care

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Introduction

The immediate postoperative care of patients that have undergone lobectomy is a critical aspect of patient recovery and can be challenging (1). Various cardiopulmonary complications are responsible for significant numbers of deaths and morbidities after lung cancer surgery (2,3). Recently, the advents of minimally invasive surgical techniques and video-assisted thoracic surgery (VATS) have greatly improved the early postoperative outcomes of lung cancer patients as compared with conventional thoracotomy (4-7).

Despite relatively low operative mortality rates, the majority of patients are still routinely monitored in intensive care units (ICUs) immediately after surgery in many centers (8,9). Even low risk patients have been routinely admitted to the ICU during the immediate postoperative period for monitoring purpose. However, in this era of minimally invasive surgery, this strategy has drawbacks such as delaying surgery schedules if an ICU bed is not available, causing problems such as cough deprivation, and delirium during the ICU stay, and increasing medical and economic burdens.

Globally, the needs of VATS lobectomy for lung cancer are increasing due to early detection and treatment, and extension of surgical indications. Therefore, the potential demand of ICU is anticipated to increase, and the routine ICU care may not only be clinically ineffective but result in the inefficient use of limited ICU resources and increase health care costs. Semi-ICU is considered as an alternative to ICU for postoperative patients (8). However, many hospitals do not have a semi-ICU because it requires specialized medical personnel and resources. The aim of this study was to compare the clinical benefits and cost-effectiveness of general ward (GW) care and routine ICU care during the immediate postoperative period in lung cancer patients after VATS lobectomy. We compared the postoperative outcomes including complications between two groups after propensity score matching. Furthermore, we evaluated the clinical factors associated with complications, and stratified patients according to the risk.

Methods

This study was based on a retrospective review of the medical records of 451 patients that underwent VATS lobectomy for lung cancer from June 1, 2012 to August 30, 2017. We excluded patients undergoing pneumonectomy or

extended resection. The institutional review board of our center approved this study and waived the requirement for informed consent.

Lobectomy was considered when expected postoperative forced expiratory volume in one second (FEV1) was more than 40% without major hypoxemia (<60 mmHg) or hypercapnia (46 mmHg). Resection including mediastinal lymph node dissection was performed through VATS under general anesthesia with selective single lung ventilation in clinical stage I and II. Patients were allocated to an ICU group (immediate ICU transfer after surgery) or a GW group (immediate GW transfer after surgery), according to postoperative management strategies. In our center, selected patients were received care in the GW according to the availability of ICU. Patients who are older than 75 years, has a history of TIA and cerebral infarction without residuals (patients who has history of cerebrovascular accident with significant sequelae were excluded from surgery indication), and an expected FEV1 less than 60% were excluded from GW care. Most patients of ICU group stayed in the ICU for 24 hours after surgery. The duration of ICU stays were decided depending on patient's conditions and severity after surgery. GW group was transferred from the recovery room to the GW after 1 hour, if their conditions were stable after surgery. Clinical data were collected for all patients from operative and anesthesia records, and nursing notes, and included age, sex, smoking status, tumor size, American Society of Anesthesiologists (ASA) grade, pathologic stage, operative time, preoperative pulmonary function test results, estimated blood loss and postoperative hospital stay. The comorbidities recorded included diabetes, hypertension, liver cirrhosis, chronic kidney disease, cerebrovascular disease, coronary artery disease, atrial fibrillation, heart failure, chronic obstructive pulmonary disease (COPD), and bronchiectasis. All postoperative complications were recorded including prolonged air leak (>5 days), transfusion on postoperative day 0, pneumonia, chylothorax, wound infection, reintubation, readmission to ICU, arrhythmia and mortality. Immediate complications were defined as occurring within 24 hours after surgery. Non-immediate complications were defined as occurring after 24 hours of surgery. Mortality was defined as all surgery related deaths that occurred within 1 month after surgery or during the hospitalization period. Hospital charges are presented as the sum of all costs incurred for all hospital stays in US dollars (exchange rate: 1,106.3 Korean won/\$). To evaluate the safety and feasibility of GW care, the outcomes including complications, postoperative hospital stay, and hospital

costs of both groups were compared after propensity score matching for variables such as age, sex, and smoking status. In addition, to decide the selection criteria for GW care following VATS lobectomy, clinical factors for complications were evaluated.

Statistical analysis

Statistical analysis was conducted using SPSS for Windows (ver. 21.0; IBM Corp., Armonk, NY, USA). Continuous variables are expressed as means \pm standard deviation and were compared using the student's *t*-test. Categorical values are expressed as percentages and were compared using the χ^2 test or Fisher's exact test, as appropriate. In this study, the clinical factors for total complications were evaluated because of low incidence of immediate complications. Univariate logistic regression analysis was performed to determine associations between baseline clinical characteristics and complication. Multivariate analysis was performed using the binary logistic regression model with backward stepwise method. Results are expressed as odds ratios (ORs) with 95% confidence interval (CI) and two-tailed P values of <0.05 were considered significant. To stratify the patients into groups according to their risk for complications, we used the variables remaining significant ($P<0.05$) in the multivariate analysis to construct a scoring system. We assessed how well the model can discriminate between patients with and without complications using a receiver operating characteristic (ROC) curve and the area under the curve (AUC). The AUC can be understood as the probability that a randomly chosen patient with complications will have a higher score than a randomly chosen patient without complications.

Results

Patient characteristics

A total of 451 patients were included in the study. Thoracoscopic pulmonary resections were successfully performed in all patients. Three hundred forty four patients were in ICU group, and 107 patients were in GW group. The two groups differed in age, sex and smoking habit (Table 1). Mean ages in the ICU and GW groups were 64.5 and 62.4 years, respectively ($P=0.050$). The proportion of male was higher in the ICU (64.0% vs. 50.5%, $P=0.013$). The proportion of current smoker was significantly higher in the ICU (26.7% vs. 16.8%, $P=0.037$). There were no significant

differences of clinical state, comorbidities, ASA, and preoperative PFT in the two groups. A total of 286 patients underwent single port VATS lobectomy and 165 patients multiport VATS lobectomy. Average duration of immediate postoperative ICU stay was 1.4 days in the ICU group.

Postoperative complications

Immediate complication occurred in 2 patients (0.4%), which were atelectasis ($N=2$) and arrhythmia ($N=1$). However, non-immediate complication occurred in 85 patients (18.8%). There was no postoperative bleeding, and reoperation was not necessary. The type of late complication are as following; prolonged air leak ($N=70$, 15.5%), pneumonia ($N=14$, 3.1%), chylothorax ($N=8$, 1.8%), and ARDS ($N=4$, 0.9%). Sixteen patients were readmitted to the ICU, and the most common cause of ICU readmission was pneumonia requiring mechanical ventilation ($N=12$). The mean ICU readmission occurred 9.6 ± 10.8 days after surgery. Mortality occurred in 1 patient; he died due to multi-organ failure related to pneumonia. There were no significant differences in the rates of immediate complication, non-immediate complication, and mortality between two groups after 1:1 propensity score matching (GW 93 vs. ICU 93) (Table 2). However, the mean postoperative stay (12.6 ± 10.0 vs. 10.3 ± 4.1 , $P=0.041$) of the ICU group was significantly higher than the GW group (Figure 1). The hospital costs of the ICU group was higher than the GW group, but there was no statistical significance ($\times 1,000$, \$, 14.5 ± 16.0 vs. 11.2 ± 2.1 , $P=0.050$).

Risk factors of complication after VATS lobectomy

In univariate regression analysis, male (OR =0.51, 95% CI: 0.30–0.86, $P=0.012$), smoker (OR =3.66, 95% CI: 2.24–5.99, $P<0.001$), COPD (OR =5.62, 95% CI: 3.32–9.53, $P<0.001$), non-stage I (OR =1.97, 95% CI: 1.16–3.35, $P=0.013$), multiport (OR =3.71, 95% CI: 2.27–6.06, $P<0.001$), preoperative FEV1 <80 (OR =1.90, 95% CI: 1.15–3.12, $P=0.012$) and age ≥ 60 (OR =2.29, 95% CI: 1.24–4.24, $P=0.008$) were associated with complication after VATS lobectomy. Multivariate analysis including these factors showed that COPD (OR =3.00, 95% CI: 1.51–5.97, $P=0.002$), non-stage I (OR =2.54, 95% CI: 1.39–4.62, $P=0.002$), multi-port surgery (OR =3.75, 95% CI: 2.18–6.44, $P<0.001$) and age ≥ 60 (OR =2.12, 95% CI: 1.03–4.37, $P=0.042$) were independently associated with complication after VATS lobectomy (Table 3).

Table 1 The comparison of baseline characteristics between ICU care and general ward group during immediate postoperative period

Characteristics	Before propensity score matching			After propensity score matching		
	ICU (N=344)	GW (N=107)	P	ICU (N=93)	GW (N=93)	P
Age	64.5±10.1	62.4±9.5	0.050	64.1±8.3	64.1±8.3	1.000
Male	220 (64.0)	54 (50.5)	0.013	51 (54.8)	51 (54.8)	1.000
Single port	219 (63.7)	66 (61.7)	0.711	60 (64.5)	57 (61.3)	0.649
Tumor size (cm)	2.7±1.8	2.6±1.5	0.407	2.6±1.3	2.6±1.5	0.879
Clinical stage			0.266			0.284
I	269 (78.2)	89 (83.2)		70 (75.3)	76 (81.7)	
II	75 (21.8)	18 (16.8)		23 (24.7)	17 (18.3)	
Smoking status						
Current smoker	92 (26.7)	18 (16.8)	0.037	16 (17.2)	16 (17.2)	1.000
Former-smoker	44 (12.8)	13 (12.1)	0.862	7 (7.5)	12 (12.9)	0.226
No-smoker	208 (60.5)	76 (71.0)	0.048	70 (75.3)	65 (69.9)	0.411
Pack-years	15.7±24.4	11.2±21.2	0.068	8.9±18.5	12.1±22.2	0.290
Comorbidities						
Coronary artery disease	12 (3.5)	6 (5.6)	0.328	3 (3.2)	5 (5.4)	0.470
Atrial fibrillation	1 (0.3)	1 (0.9)	0.381	0	1 (1.1)	0.316
Heart failure	3 (0.9)	1 (0.9)	0.952	1 (1.1)	1 (1.1)	1.000
Cerebrovascular disease	10 (2.9)	2 (1.9)	0.560	4 (4.3)	2 (2.2)	0.407
HTN	103 (29.9)	30 (28.0)	0.706	35 (37.6)	28 (30.1)	0.278
DM	61 (17.7)	15 (14.0)	0.370	19 (20.4)	14 (15.1)	0.337
LC	4 (1.2)	3 (2.8)	0.230	0	3 (3.2)	0.081
CKD	6 (1.7)	3 (2.8)	0.494	1 (1.1)	3 (3.2)	0.312
COPD	70 (20.3)	14 (13.1)	0.092	13 (14.0)	14 (15.1)	0.835
Bronchiectasis	12 (3.5)	4 (3.7)	0.903	2 (2.2)	4 (4.3)	0.407
ASA score	1.9±0.5	1.9±0.5	0.444	1.9±0.5	1.9±0.5	0.888
Preoperative PFT						
FEV1 (liter)	2.3±0.6	2.4±0.6	0.162	2.3±0.7	2.4±0.6	0.441
FEV1 (%)	86.3±17.7	88.1±16.6	0.347	88.2±16.0	87.7±17.0	0.840
DLCO	82.9±21.2	87.0±22.2	0.105	82.5±22.3	86.3±22.8	0.295

Values are N (%) or mean ± SD. ICU, intensive care unit; HTN, hypertension; DM, diabetes mellitus; LC, liver cirrhosis; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; ASA, the American Society of Anesthesiologists Classification; PFT, pulmonary function test; FEV1, forced expiratory volume 1; DLCO, diffusing capacity of carbon monoxide.

Scoring system for overall complications

Despite the differences in the regression coefficients (β), for simplicity, 1 point was assigned for each of the risk factors (Table 4). The 3 risk groups were established; low

risk (no risk factors, 14.6%), intermediate risk (1 risk factor, 38.8%), and high risk (2–4 risk factors, 46.6%, Table 5). Complication rates were highest in the high risk group (low vs. intermediate vs. high; 1.5% vs. 10.9% vs.

Table 2 The propensity score-matched operative outcomes in intensive care unit and general ward care group

Variables	ICU (N=93)	GW (N=93)	P
Operative time (min)	213.1±86.7	229.4±96.2	0.228
Estimated blood loss (mL)	302.1±259.1	374.4±356.9	0.136
Length of postoperative stay (d)	12.6±10.0	10.3±4.1	0.041
Length of chest tube duration (d)	8.1±4.8	8.4±5.4	0.688
Complication	15 (16.1)	18 (19.4)	0.565
Immediate complication	2 (2.2)	0	0.155
Transfusion on postoperative day 0	0.1±0.3	0.1±0.3	0.818
Atelectasis	2 (2.2)	0	0.155
Arrhythmia	1 (1.1)	0	0.316
Non-immediate complication	13 (14.0)	18 (19.4)	0.325
ARDS	1 (1.1)	0	0.316
Pneumonia	1 (1.1)	0	0.316
Reintubation	1 (1.1)	0	0.316
Readmission to ICU	4 (4.3)	1 (1.1)	0.174
Prolonged air leak >5 days	13 (14.0)	18 (19.4)	0.325
Chylothorax	1 (1.1)	1 (1.1)	1.000
Hospitalization ≥15 days	25 (26.9)	13 (14.0)	0.029
Mortality	1 (1.1)	0	0.316
Cost (×10 ³ \$)	14.5±16.0	11.2±2.1	0.050

Values are N (%) or mean ± SD. ICU, intensive care unit; ARDS, acute respiratory distress syndrome.

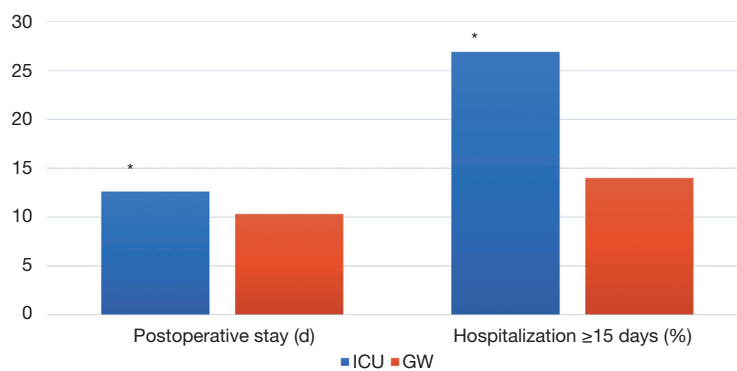


Figure 1 Comparison of postoperative days and lengths of hospital stay after propensity score matching. After propensity score matching, the mean postoperative stay (12.6±10.0 vs. 10.3±4.1, P=0.041) of the ICU group were significantly higher than the GW group. *, P<0.05. ICU, intensive care unit; GW, general ward.

Table 3 Multivariate regression analysis for complications among whole population

Variable	Univariate analysis		Multivariate analysis		
	OR (95% CI)	P	β^*	OR (95% CI)	P
Male	0.51 (0.30–0.86)	0.012			
Smoker	3.66 (2.24–5.99)	<0.001			
COPD	5.62 (3.32–9.53)	<0.001	1.10	3.00 (1.51–5.97)	0.002
Non-stage I	1.97 (1.16–3.35)	0.013	0.93	2.54 (1.39–4.62)	0.002
Multiport	3.71 (2.27–6.06)	<0.001	1.32	3.75 (2.18–6.44)	<0.001
Preoperative FEV1 <80	1.90 (1.15–3.12)	0.012			
Age \geq 60	2.29 (1.24–4.24)	0.008	0.75	2.12 (1.03–4.37)	0.042

β^* , regression coefficients. COPD, chronic obstructive pulmonary disease; FEV1, forced expiratory volume 1.

Table 4 Complication score calculated with parameters available just before video-assisted thoracoscopic surgery lobectomy for lung cancer

Parameter	Score
COPD	
No	0
Yes	1
Stage I	
No	1
Yes	0
Age (years)	
<60	0
\geq 60	1
Multiport	
No	0
Yes	1
Total score	0–4

COPD, chronic obstructive pulmonary disease.

31.0%, $P < 0.001$). The relative risk of complications in the intermediate and high risk groups compared with the low risk group was 7.92 (95% CI: 1.04–60.37, $P = 0.046$), and 29.14 (95% CI: 3.96–214.56, $P = 0.001$). The area under the ROC curve was 0.752 (0.695–0.809) for the logistic regression model and 0.702 (0.646–0.757) for the simplified score for complications (*Figure S1*).

Discussion

In this study, GW care did not increase the incidence of complications or mortality compared with ICU care, and monitoring of immediate postoperative management did not fail either. Immediate complication occurred in 0.4%, and a large proportion of patients that undergo VATS lobectomy do not need the routine intensive monitoring during the immediate postoperative period. Therefore, selective intensive monitoring for high risk groups may offer cost-saving and efficient use of ICU resources instead of customary ICU monitoring during immediate postoperative period.

Table 5 A scoring system for complications

Risk score	Patients N (%)	Risk factors	Patients (n, %)	Complications (n, %)	OR	95% CI	P
Low	66 (14.6)	0	66 (14.6)	1 (1.5)	1	–	–
Intermediate	175 (38.8)	1	175 (38.8)	19 (10.9)	7.92	1.04–60.37	0.046
High	210 (46.6)	2	144 (31.9)	30 (20.8)	29.14	3.96–214.56	0.001
		3	61 (13.5)	31 (50.8)			
		4	5 (1.1)	4 (80.0)			

OR, odds ratio; CI, confidence interval.

Recent years have witnessed a trend toward minimally invasive surgery. Furthermore, the VATS approach has been further developed to reduce both the size and number of access incisions (6). Although this minimally invasive approach is intended to shorten postoperative recovery times, postoperative recovery protocols are still geared to address slow recovery after open thoracotomy, and current postoperative management remains the rate-limiting step during patient recovery. In this context, routine ICU use has been questioned, as indiscriminate, routine ICU use appears to be of little value in terms of predicting complications or management decision making. Thus, given increasing emphasis on cost effectiveness and limited ICU resources, this aspect of patient care requires critical evaluation (8). Several institutions use semi-ICU as an alternative to ICU, but this also has limitations because it requires specialized medical personnel and resources. Even in South Korea, which is not a low economic country, many hospitals do not have a semi-ICU. Recently, GW is being used as an alternative to ICU with advances in anesthesiology, surgery, and perioperative management. The main concern about the location of postoperative care is whether the GW is as safe as the ICU. However, this issue has scarcely been evaluated (9-11).

In this study, the safety and feasibility of GW care was comparable with that of ICU care after VATS lobectomy. The routine ICU admission did not significantly affect the overall postoperative complication rate. Immediate complication was always atelectasis, which were not fatal and were mostly treatable in the GW. However, non-immediate complications were mainly pneumonia required ICU readmission for mechanical ventilation (1 patient led to mortality). These results indicate that immediate postoperative ICU care does not prevent severe complications or deaths after VATS lobectomy. On the contrary, unnecessary ICU stay may lead to postoperative pneumonia following exposure to nosocomial infections or delayed early ambulation and rehabilitation (12). It has been reported that early mobilization due to adoption of a non-ICU based policy improves outcomes after surgery by preventing functional decline, reducing pain, enhancing well-being, and reducing hospital stays (13). In the present study, significant intergroup differences were between postoperative stays and hospital costs, which suggest routine ICU use may prolong recovery. Furthermore, by not utilizing expensive ICU resources, immediate postoperative monitoring in a GW could potentially improve overall treatment efficacy by efficiently providing ICU resources

for more appropriate patients (14).

Therefore, it is necessary to establish criteria to judge whether or not ICU admission. Traditionally, there are several studies on the risk factors associated with postoperative complications (2,15-18). In this study, COPD, non-stage I, multiport surgery and age ≥ 60 were independent risk factors for complications. We developed a simple scoring system based on these risk factors to determine the standard of the location of the immediate postoperative care. In particular, the highest risk group had a 29.14-fold higher risk of complications than those of the lowest risk group. Therefore, selective intensive monitoring for these risk groups may offer cost-saving and efficient use of ICU resources instead of customary ICU monitoring during immediate postoperative period. This score could be helpful in the decision of the location of the immediate postoperative care, predominantly those with low risk groups, which could increase the treatment efficacy at lower cost.

The present study is inherently limited by its retrospective, single center design. Furthermore, this study cannot show the risk factors for immediate complication due to small case number who had immediate complication. However, it also has several advantages. This study performed with a homogenous group of patients, and all procedures, preoperative evaluations and postoperative care were conducted in the same surgical team with a homogenous manner. Furthermore, these patients analyzed after propensity score matching to reduce the effects of confounding factor.

Conclusions

This study shows it is possible to manage patients safely in a GW after VATS lobectomy for lung cancer. However, it should be noted that COPD, non-stage I cancer, multiple port VATS and age ≥ 60 have been shown to be independently associated with postoperative complications (19). Therefore, the patient without these risk factors can be managed safely in GW immediately after VATS lobectomy.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The institutional review board of our center approved this study and waived the requirement for informed consent.

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Supplementary

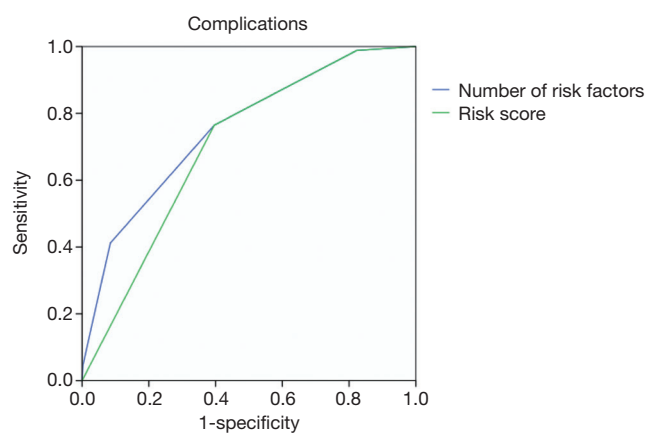


Figure S1 Receiver operating characteristic (ROC) curves. The area under the ROC curves was 0.702 (0.646–0.757) for the simplified score and 0.752 (0.695–0.809) for the logistic regression model.