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Immediate Postoperative Care in the General Thoracic Ward Is Safe for Low-risk Patients after Lobectomy for Lung Cancer

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Background: Following major lung resection, patients have routinely been monitored in the intensive care unit (ICU). Recently, however, patients are increasingly being placed in a general thoracic ward (GTW). We investigated the safety and efficacy of the GTW care after lobectomy for lung cancer. ***Materials and Methods:*** 316 patients who had undergone lobectomy for lung cancer were reviewed. These patients were divided into two groups: 275 patients were cared for in the ICU while 41 patients were care for in the GTW immediately post-operation. After propensity score matching, postoperative complications and hospital costs were analyzed. Risk factors for early complications were analyzed with the whole cohort. ***Results:*** Early complications (until the end of the first post-operative day) occurred in 11 (3.5%) patients. Late complications occurred in 42 patients (13.3%). After propensity score matching, the incidence of early complications, late complications, and mortality were not different between the two groups. The mean expense was higher in the ICU group. Risk factors for early complications were cardiac comorbidities and low expected forced expiratory volume in one second. The location of postoperative care had no influence on outcome. ***Conclusion:*** Immediate postoperative care after lobectomy for lung cancer in a GTW was safe and cost-effective without compromising outcomes in low-risk patients.

Key words: 1. Postoperative care
2. Lobectomy

INTRODUCTION

Thoracic surgery is one of the specialties that more frequently use intensive care unit (ICU) resources because cardiopulmonary complications require active, life-supporting treatments as well as early postoperative surveillance. Lung cancer is the most common indication for major lung resection and subsequent ICU admission for postoperative care. Despite relatively low operative mortality rates, postoperative complications still occur frequently after major lung resection [1-4]. Cardiopulmonary complications, including myocardial infarction, pulmonary embolism, severe arrhythmia, pneumonia, sepsis, and acute lung injury, are potentially life-threatening. Therefore, even low-risk patients undergoing

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major lung resection have been routinely admitted to the ICU during the postoperative period for surveillance purposes. However, this strategy has disadvantages, including delaying surgery schedules if an ICU bed is unavailable, causing psychological problems such as delirium during the ICU stay, and increasing financial and medical burdens. Due to early diagnosis and extension of surgical indications, cases of major lung resection due to lung cancer have been increasing; therefore, the demand for ICU care has also been expected to increase. High-dependency unit (HDU) care is recommended as an alternative to ICU stays for postoperative lung resection patients [5]. However, many institutions do not include an HDU because it requires specialized medical personnel and resources [6]. Recently, selected patients have been placed in general thoracic surgical wards (GTW) instead of ICUs in the interest of reducing costs and also due to advances in surgical skills and perioperative care. However, few studies have compared the postoperative outcomes between ICU and GTW patients to assess the efficacy of routine ICU care or to identify which patients should be admitted to the ICU. The aims of this study were to compare the postoperative outcomes between ICU and GTW patients in terms of complications and also to stratify high-risk groups who are more likely to require ICU care.

MATERIALS AND METHODS

1) Patients

This study included 316 patients who underwent lobectomy or bilobectomy for the treatment of non-small cell lung cancer (NSCLC) from September 2006 to July 2008. We excluded patients undergoing pneumonectomy or extended resection, such as chest wall resection or diaphragm resection, to decrease the heterogeneity of the cohort, because pneumonectomy or extended resection could cause more severe complications than those resulting from lobectomy.

2) Study design

This is an observational cohort study. Patients were allocated into either the ICU group or the GTW group. Patients' characteristics and outcomes were compared. The primary goal was to determine the safety and efficacy of GTW care in selected patients. The secondary goal was to identify selection criteria for ICU care. In order to evaluate the safety and efficacy of GTW care in selected patients, the outcomes of both groups were compared after 1 : 4 propensity score matching for variables such as age, sex, American Society of Anesthesiology (ASA) score, Charlson comorbidity index (CCI), and operative method (Fig. 1). Cardiopulmonary complication rates, significant event rates, and costs were compared between both groups, and the rate of missing significant complications in the GTW group was evaluated. In order to define the selection criteria for ICU care following lobectomy, risk factors for early and late complications were investigated. This study was approved by the Institutional Review Board of Severance Hospital, Yonsei University College of Medicine.

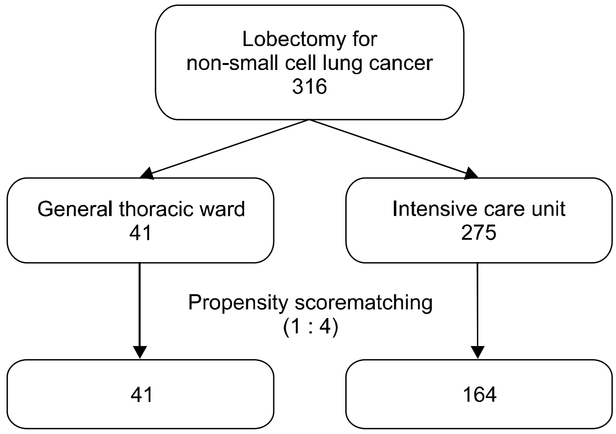

Fig. 1. Flow diagram of participants.

3) Preoperative evaluation, operation and postoperative care

All patients were assessed and operated on by the same surgical team, and their preoperative and postoperative management were standardized. Preoperative evaluation included clinical history, physical examination, routine blood tests, electrocardiography, pulmonary function tests, and a lung perfusion scan. The ASA score and the CCI were assessed preoperatively. The lung cancer staging protocol included a chest X-ray, fiberoptic bronchoscopy, thoracic and upper abdominal computed tomography scans, and whole-body positron emission tomography scans. Resection was considered if the expected postoperative forced expiratory volume in one second (FEV1) was more than 40% without major hypoxemia (<60 mmHg) or hypercapnia (>46 mmHg). Surgical procedures were carried out under general anesthesia with selective single-lung ventilation. Anatomical pulmonary resection and systematic mediastinal lymph node dissection were performed through posterolateral thoracotomy or video-assisted thoracoscopic surgery (VATS) in clinical stage I. Postoperative extubation was conducted in the operating room if possible. In the early period of the study, ICU admission was routinely applied to all patients. However, in the late period of the study, selected patients were received care in the GTW. Indication for GTW care were age under 75 years, no coronary artery occlusive disease, and an expected FEV1 over 60%. Most ICU patients stayed in the ICU for one day postoperatively. The ICU stay was prolonged in some patients based on their medical conditions. During the ICU stay, arterial blood pressure, heart rate, oxygen saturation, and chest tube drainage were monitored continuously. GTW patients stayed in the recovery room for one to two hours postoperatively and then were transferred to the GTW if their vital signs were stable.

4) Immediate postoperative care in the GTW

The GTW in this study was a specialized ward with 35 beds for the care of pulmonary disease patients and surgical patients, especially thoracic surgical patients, and nurses in this ward are competent in the care of thoracic surgical patients. Electrocardiography and oxygen saturation were monitored with a continuous monitoring system. Levels of tachycardia, bradycardia, and desaturation were preset to alert medical staff by audible alarm. Also, caretakers were instructed to call nurses if there was an alarm or any change in the condition of the patients. Monitoring parameters, blood pressure, and chest tube drainage were checked every hour until 6 am of the first postoperative day by doctors or nurses. Three doctors and two or three nurses were on duty during the night, and no supplementary nursing staff were involved in the postoperative care of the lobectomy patients. Pain control was achieved using patient-controlled analgesia with epidural anesthesia and supplemental intravenous opioids.

5) Data

Data were retrieved from a prospective institutional lung cancer database system. Complications were divided into early and late complications depending on the time of their postoperative occurrence. The point of time for dividing early and late complications was the end of the first postoperative day, because routine ICU care was usually performed for one day. Late complications were considered to occur after the first postoperative day.

Several parameters concerning postoperative outcome were recorded, including the number and cause of ICU re-admission, length of ICU stay, need for blood transfusion, postoperative complications, and surgical mortality. For patients who had been transferred to the GTW postoperatively but were subsequently admitted to the ICU for severe complications, both the timing and causes of admission were recorded. Operative mortality was calculated while accounting for all deaths that occurred within 30 days postoperatively or during the hospitalization period. Early postoperative costs were defined as costs incurred after the end of the surgical procedure through the end of the first postoperative day.

6) Statistical analysis

Statistical analysis was performed using SPSS 15.0 for Windows (Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL). The probability of elective ICU admission (propensity score) was calculated using logistic regression analysis. An SPSS macro (http://sswnt5.sowo.unc.edu/VRC/Lectures/index.htm) was applied for propensity score matching. Chi-square testing for categorical variables and unpaired Students' T-test and the Mann-Whitney test for continuous variables were applied to compare the parameters. The following variables were applied as potential risk factors for early complications, late complications, and mortality: advanced age (>70), sex, ASA score, CCI, pulmonary comorbidity, neoadjuvant treatment, cardiac comorbidity, low expected FEV1 (<65%), and incision type. Multiple logistic regressions were performed for multivariate analysis. Variables included in multiple logistic regressions were selected when their p-value was less than 0.2 in the univariate analysis.

Table 1. Comparison of general characteristics

	General thoracic ward (n=41)	Intensive care unit (n=275)	p
Age (years)	60.1±8.4	63.2±9.7	0.31
Female	22 (53.7%)	87 (31.6%)	0.02
ASA score			0.06
1	22 (53.7%)	96 (34.9%)	
2	18 (43.9%)	165 (60.0%)	
3	1 (2.4%)	14 (5.1%)	
Charlson cormorbidity index			0.05
0	37 (90.2%)	192 (69.8%)	
1	3 (7.3%)	66 (24.0%)	
2	1 (2.5%)	16 (5.8%)	
3	0	1 (0.4%)	
Cardiac comorbidity	0	32 (11.6%)	0.01
Pulmonary comorbidity	1 (2.4%)	14 (5.1%)	0.70
Expected FEV1 (% of normal)	84.1±17.2	73.4±21.1	0.37
Neoadjuvant treatment	1 (2.4%)	13 (4.7%)	0.43
VATS lobectomy	23 (56.1%)	66 (24.0%)	<0.001
Early complications	1 (2.43%)	10 (3.6%)	0.21
Late complications	4 (9.8%)	38 (13.8%)	0.48
Mortalities	0	8 (2.5%)	0.39

ASA=American Society of Anesthesiology; FEV1=Forced expiratory volume in one second; VATS=Video-assisted thoracoscopic surgery.

RESULTS

Out of 316 patients undergoing lobectomy for NSCLC during the study period, 133 patients were female. The mean age was 63.1±8.8 years, and 78 patients were over the age of 70. Forty-one patients were in the GTW group, and 275 patients were in the ICU group. The two groups differed in terms of sex, ASA, CCI, cardiac comorbidity, and incision type (Table 1).

The mean ICU stay was 1.1±1.1 days, with 40 patients staying in the ICU for more than one day. Reasons for prolonged ICU care included pulmonary edema due to intraoperative cardiac arrest (one patient), myocardial infarction (one patient), pneumonia (one patient), arrhythmias (two patients), poor sputum expectoration (six patients), and poor general conditions (23 patients). Early complications occurred in 11 (4.4%) patients, almost all of which were arrhythmias (72.7%). However, no arrhythmias induced hemodynamic instability. Only one patient experienced a significant complication of myocardial infarction, and no surgical mortalities

Table 2. Patterns of complications

	Early complications	Late complications
Cardiac complications	9 (2.8%)	8 (2.5%)
Atrial fibrillation	6	7
Other arrhythmia	2	1
Myocardial infarction	1	0
Pulmonary complications	2 (0.6%)	22 (7.0%)
Athelectasis	2	0
Pneumonia	0	19
Acute respiratory distress syndrome	0	3
Others	0	12 (3.8%)
Chylothorax	0	7
Empyema	0	2
Broncho-pleural fistula	0	3

Table 3. Comparison after propensity score matching

	General thoracic ward (n=41)	Intensive care unit (n=164)	p
Age (years)	60.1±8.4	60.8±8.4	0.31
Female	22 (53.7%)	68 (41.5%)	0.10
ASA score			0.21
1	22 (53.7%)	66 (40.2%)	
2	18 (43.9%)	91 (55.5%)	
3	1 (2.4%)	7 (4.3%)	
Charlson cormorbidity index			0.21
0	37 (90.3%)	128 (78%)	
1	3 (7.3%)	31 (18.9%)	
2	1 (2.4%)	5 (3%)	
3	0	0	
Cardiac comorbidity	0	5 (3%)	0.26
Pulmonary comorbidity	1 (2.4%)	7 (4.3%)	0.61
Expected FEV1 (% of normal)	83.0±16.4	81.5±16.8	0.47
Neoadjuvant treatment	1 (2.4%)	7 (4.3%)	0.16
VATS lobectomy	23 (56.1%)	55 (33.5%)	0.005
Early complication	1 (2.4)	5 (3%)	0.26
Late complication	4 (9.8%)	16 (9.8%)	0.66
Mortality	0	3 (1.8%)	0.39

ASA=American Society of Anesthesiology; FEV1=Forced expiratory volume in one second; VATS=Video-assisted thoracoscopic surgery.

Table 4. Risk factors for complications

	Hazard ratio	95% confidence interval	p
Early complications			
Low expected FEV1	1.086	1.024～1.175	0.008
Cardiac comorbidity	37.382	2.168～644.569	0.047
Late complications			
Advanced age	2.183	1.15～4.144	0.017
Low expected FEV1	1.020	1.002～1.032	0.028
Cardiac comorbidity	2.582	1.132～5.911	0.024

FEV1=Forced expiratory volume in one second.

developed during the early postoperative period. Late complications occurred in 42 (13.3%) patients. In contrast to the early complications, pulmonary complications (52.4%) made up the majority of the late postoperative complications (Table 2). Although five patients needed transfusions, reoperation was not necessary in these patients. Nine patients were readmitted to the ICU, and the most common cause of ICU readmission was respiratory insufficiency due to postoperative pneumonia requiring mechanical ventilator support. The mean ICU readmission occurred 4.7±3.6 days after surgery. Mortality occurred in eight patients; all of these patients died of respiratory failure related to pneumonia.

By 4 : 1 propensity score matching, 164 patients in the ICU group were matched with 41 patients in the GTW group. Both groups were adjusted in terms of age, sex, ASA score, CCI, expected FEV1, and cardiac and pulmonary comorbidities except for the type of incision. Rates of early complication, late complication, and mortality were not significantly different between the groups (Table 3). However, the mean early postoperative cost of the ICU group was significantly higher than that of the GTW group (₩2,186,519 vs. ₩1,901,110, p=0.001).

In univariate and multivariate analyses, risk factors for early complications were cardiac comorbidity and low expected FEV1, and the risk factors for late complications were advanced age, cardiac comorbidity, and low expected FEV1 (Table 4). Clinical outcomes were not influenced by the location of the immediate postoperative care.

DISCUSSION

The results of this study indicate that GTW care instead of ICU care increased neither the complication rate nor the failure of surveillance for immediate postoperative management in selected patients. In addition, GTW care is less expensive than ICU care. Major lung resection carries a relatively high risk of complication. Therefore, these patients have traditionally been sent to the ICU for their immediate postoperative care. However, this practice may be hampered by a lack of ICU facilities and trained personnel, as well as the increasing costs of ICU care.

The HDU is recommended as an alternative to the ICU, but many institutions, especially in Korea, do not have an HDU because it also requires specialized medical personnel and resources [6]. GTW care has recently been tried as an alternative to ICU care not only in the interest of being cost-effective, but also due to advances in surgery, anesthesiology, and perioperative care. The main concern when deciding the location of postoperative care is whether the GTW is as safe as the ICU. However, there are no general guidelines for routine postoperative ICU admissions after major lung resection, even in low-risk patients, and the topic has rarely been reported in the literature. Wyser et al. and Lickers et al. found favorable complication rates in the setting of postoperative care in ICUs for the first postoperative day [2,7]. In contrast, Stéphan et al. reported that all patients could be sent to a general surgical ward unless complications requiring admission to the ICU occurred [3]. Schweizer et al. reported that effective postanesthesia care unit (PACU) care followed by GTW care could reduce the utilization of ICU from 57% to 4% [8]. Although these two studies were not intended to analyze efficacy of GTW care, their results reflect that GTW care is not an option that compromises the health of the patient. Brunelli and colleagues conducted an important study that revealed that ICU care has no advantage over GTW care according to a multi-center propensity score matched analysis [5]. However, a limitation of that study was that although the authors performed propensity score matching to decrease heterogeneity, preoperative, operative and postoperative management of the two groups were wholly different. One unique and meaningful aspect of our study is that it was the first case-control study performed with a homogeneous group of patients managed by identical surgical and anesthesiologic strategies and matched by propensity score. In our study, the efficacy of GTW care was comparable with that of ICU care after lobectomy. Only six out of 205 patients included in the matched analysis actually required intensive monitoring during the postoperative period, and no patient experienced an event sufficiently significant to require ICU admission. Most complications after major lung resection in our study were cardiovascular or pulmonary, and this finding was similar to those of previous studies [2-4]. Patterns of complications were different according to postoperative time. Early complications were almost always cardiac arrhythmias, such as atrial fibrillation, which were not fatal and were mostly manageable in the GTW. However, late complications were almost always pulmonary complications that required ICU re-admission for mechanical ventilation and led to mortality in many cases. These results imply that immediate postoperative ICU care does not prevent severe complications or mortalities following major lung resection.

The financial aspects were more favorable in the GTW group. GTW care reduced patient costs by 15%. In addition, both the medical system and society will benefit financially by decreasing inappropriate use of the ICU. Elective ICU care was potentially beneficial in less than 5% of patients in our study. In other reports, 4 to 18% of patients needed ICU care after major pulmonary resection [8,9]. Therefore, the establishment of criteria for ICU admission is necessary. However, few previous articles have reported or suggested guidelines for ICU admission. In this study, risk factors for early complications were low expected FEV1 and cardiac comorbidities, while those for late complications were advanced age, low expected FEV1 and cardiac comorbidities. Since most early and late complications were cardiac or pulmonary in origin, underlying cardiopulmonary comorbidities can typically predict the development of these complications. Risk factors for early complications (low expected FEV1 and cardiac comorbidities) should be indications for ICU admission during the immediate postoperative period. Age is a proven risk factor not only for thoracic surgery but also for other surgeries. However, advanced age did not predict early complications in this study. Based on our findings, advanced age would not be an indication for ICU care in the immediate postoperative period. In elderly patients, more attention to the prevention of late complications like pneumonia should be given throughout the entire postoperative period even if they experience no adverse events in the immediate postoperative period.

Previous studies have indicated that concomitant diseases, such as ischemic heart disease, diabetes mellitus, or chronic obstructive lung disease, represent significant risk factors for an adverse outcome, and performance status, ASA score, and CCI were reported as useful parameters for postoperative complications [4,10-13]. However, in this study, these parameters were not statistically significant prediction factors. This finding may be due to the fact that cardiac comorbidity is a more specific predictive parameter than are ASA score and CCI, which reflect many factors other than cardiopulmonary function. Recently, HDU with non-invasive continuous monitoring has become more available and is proven to be safe and effective [13]. However, Dhond and colleagues reported that the HDU generates new demand for critical care services and is unlikely to relieve the pressure on ICU beds perse or to reduce the overall cost of critical care [6]. The HDU may be an alternative to the ICU in patients with risk factors, but it is not recommended as an alternative for GTW for low-risk patients, as GTW care is safe and cost-effective.

This study had several limitations. The first limitation is that this study is a retrospective and non-randomized study. Although the two groups were adjusted by propensity score, some patients at the extremes of the propensity scores were excluded from the analysis. Therefore, prospective, randomized trials are warranted. Second, despite propensity score matching, the number of patients who underwent VATS was higher in the GTW group. This difference may not significantly increase heterogeneity, however, because preoperative conditions, which can affect VATS selection and subsequent clinical outcomes, were adjusted extensively. The primary goal of this study was to compare the early postoperative period between ICU and GTW patients, so discordance in the VATS rate may not be an important limitation.

CONCLUSION

Immediate postoperative care after lobectomy for lung cancer in the GTW was safe and cost-effective without compromising outcomes in low-risk patients.

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