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Is intensive care necessary after major thoracic surgery? A propensity score-matched study

Majör göğüs cerrahisi sonrasında yoğun bakım gerekli midir? Eğilim skoru eşleştirme çalışması

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ABSTRACT

Background: This study aims to compare the surgical results, complications, mortality rates, and inpatient costs in two patient groups followed, whether in the intensive care unit or general ward after a major thoracic procedure and to examine clinical and surgical factors related to the development of complications.

Methods: Between January 2018 and June 2021, a total of 485 patients (150 males, 335 females; mean age: 58.3±13.2 years; range, 22 to 86 years) who underwent a major thoracic surgery in our clinic were retrospectively analyzed. The patients were divided into two groups as the intensive care unit patients (n=254) and general ward patients (n=231). In the former group, the patients were followed in the intensive care unit for a day, while in the general ward group, the patients were taken directly to the ward. The groups were compared after propensity score matching. All patients were analyzed for risk factors of morbidity development.

Results: After propensity score matching, 246 patients were enrolled including 123 patients in each group. There was no statistically significant difference between the groups in any features except for late morbidity, and inpatient costs were higher in the intensive care unit group (p<0.05). In the multivariate analysis, age, American Society of Anesthesiologists Class 3, and secondary malignancy were found to be associated with morbidity (p<0.05).

Conclusion: In experienced centers, it is both safe and cost-effective to follow almost all of the major thoracic surgery patients postoperatively in the general ward.

Keywords: General ward; intensive care; lung resection; major thoracic surgery; monitorization.

ÖZ

Amaç: Bu çalışmada majör bir göğüs cerrahisi sonrasında yoğun bakım ünitesinde veya yataklı serviste takip edilen iki hasta grubunun cerrahi sonuçları, komplikasyonları, mortalite oranları ve hastane yatış maliyetleri karşılaştırıldı ve komplikasyon gelişimi ile ilişkili cerrahi faktörler araştırıldı.

Çalışma planı: Ocak 2018 - Haziran 2021 tarihleri arasında kliniğimizde majör göğüs cerrahisi yapılmış toplam 485 hasta (150 erkek, 335 kadın; ort. yaş: 58.3±13.2 yıl; dağılım, 22-86 yıl) retrospektif olarak incelendi. Hastalar yoğun bakım ünitesi hastaları (n=254) ve yataklı servis (n=231) olmak üzere iki gruba ayrıldı. Birinci grupta hastalar yoğun bakım ünitesinde bir gün süreyle takip edilirken, yataklı servis grubunda hastalar doğrudan servise alındı. Gruplar eğilim skoru eşleştirme sonrası karşılaştırıldı. Hastaların tümü morbidite gelişimi risk faktörleri açısından incelendi.

Bulgular: Eğilim skoru eşleştirme sonrasında her grupta 123 hasta olmak üzere çalışmaya 246 hasta alındı. Geç dönem morbidite haricinde gruplar arasında istatistiksel olarak anlamlı bir fark yoktu ve hastane yatış maliyetleri yoğun bakım ünitesi grubunda daha yüksek idi (p<0.05). Çok değişkenli analizde yaş, Amerikan Anesteziyoloji Derneği Sınıf 3 ve sekonder malignite morbidite ile ilişkili bulundu (p<0.05).

Sonuç: Deneyimli merkezlerde ameliyat sonrası majör toraks cerrahisi hastalarının neredeyse tamamının yataklı serviste takibi hem güvenilir hem de maliyet etkindir,

Anahtar sözcükler: Yataklı servis, yoğun bakım, akciğer rezeksiyonu; majör toraks cerrahisi; monitörizasyon.

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Clinical follow-up in the intensive care unit (ICU) or high dependency unit (HDU) after major thoracic procedures is routine in daily practice in many centers.[1] Reasons for this state are postoperative arrhythmias, clinical follow-up of possible hemorrhages after resection, and the higher nurse/patient ratio of ICUs. These factors give the feeling that the patient may be followed better than the service and, as a result, morbidity and mortality rates would decrease.

However, in the last two decades, with the increasing safety of disposable surgical instruments, the widespread use of aerostatic and hemostatic agents, an increasing number of minimally invasive surgical operations, advances in perioperative anesthesia, and analgesic techniques have lessened the air leakage, postoperative pain, and hemorrhage. Therefore, postoperative vital signs of the patients tend to be more stable.[2-4] Thus, the spreading idea of enhanced recovery after surgery (ERAS) has shown the importance of early mobilization for preventing postoperative complications.[5-8]

Despite these advances, many thoracic surgery patients are still being followed in the ICU setting.[1,3] However, this practice, which is believed to be “safer” by surgeons and anesthesiologists, also has certain disadvantages. Postponing an operation due to the absence of an ICU bed, restriction of oral intake, mobilization, and coughing of the patients, risk of delirium, and increasing medical & economic burden are some of these disadvantages.[9] With the increasing number of minimally invasive surgical operations and the popularity of patient-focused medical care, the question “which patients need ICU follow-up?” is gaining importance.

In the present study, based on the propensity score matching, we aimed to compare the surgical results, complications, mortality rates, and inpatient costs in two patient groups followed, whether in the ICU or general ward (GW) after a major thoracic procedure and to examine clinical and surgical factors related to the development of complications.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Kartal Dr. Lütfi Kırdar City Hospital, Department of Thoracic Surgery between January 2018 and June 2021. Patients who underwent major thoracic surgery were screened. Lung resection, decortication, diaphragm surgery, mesothelioma surgery, chest wall resection and reconstruction, cystotomy & capitonnage, chest wall stabilization for flail chest, mediastinal surgery, metastasectomy, and esophagectomy patients were included. Patients who underwent pneumothorax surgery, pleural biopsy, mediastinoscopy, rigid bronchoscopy, thoracal sympathectomy, tracheal resection, and patients who were only explored were excluded. Patients who could not tolerate extubation and patients who were infected with novel coronavirus disease 2019 (COVID-19) postoperatively were also excluded. Finally, a total of 1,519 patients were evaluated for the study, and 485 of them (150 males, 335 females; mean age: 58.3±13.2 years; range, 22 to 86 years) who met the inclusion criteria were enrolled (Figure 1).

Perioperative and postoperative period

We performed perioperative and postoperative fiberoptic bronchoscopy in all lung resection patients and other patients, when necessary. Intercostal nerve block was applied to all patients for postoperative analgesia. In addition, epidural catheter and paravertebral block followed by patient-controlled analgesia (PCA) were applied to selected patients.

All postoperative patients between January 2018 and December 2019 were followed in the ICU, while the postoperative patients after January 2020 were followed in the GW due to a new clinical approach. The patients were grouped as ICU and GW patients. All patients were extubated in the operation room. Patients in the ICU group were usually taken to GW after a follow-up in ICU for 24 h. Patients in the GW group were monitored in the recovery room for 1 h before being transferred to the clinic. After being taken to the clinic, all GW patients were monitored for 6 h. The monitorization consisted of cardiac rhythm, oxygen saturation, and non-invasive blood pressure monitoring along with clinical follow-up. Monitorization was stopped, oral intake was started (except for esophagectomies), and patients were mobilized at the end of 6 h. Pneumonectomy patients and patients who had a problem during monitorization were not mobilized, and their monitorization duration was continued for up to 24 h.

Both patient groups were compared in terms of age, sex, diagnosis, comorbidity, American Society of Anesthesiologists (ASA) score, ejection fraction, forced expiratory volume in 1 sec (FEV1), diffusion capacity of the lung for carbon monoxide (DLCO), chemoradiotherapy status, operation side, type of intervention & surgery, presence of chest wall resection, duration of ICU stay, drainage amount, drain removal time, discharge time, morbidity, mortality, and inpatient costs. In addition, all the patients were analyzed for risk factors of morbidity development. All the complications in the postoperative period

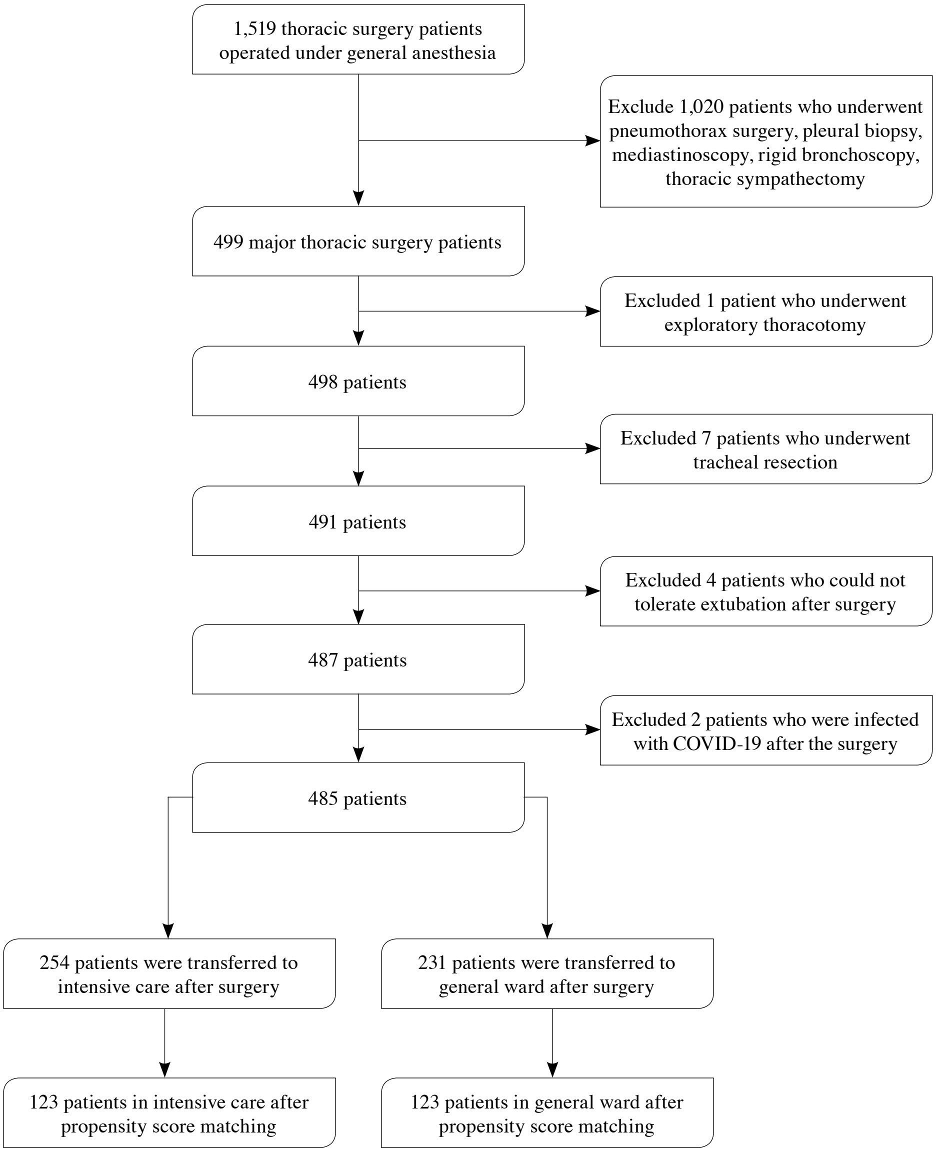

Figure 1. The CONSORT flow diagram of the study.

were recorded as morbidity. Postoperative first 30-day morbidity was accepted as “early surgical morbidity”, whereas the morbidity after 30 days was “late surgical morbidity”. Charlson Comorbidity Index (CCI) and revised Clavien-Dindo classification (CDC) were used to compare preoperative comorbidity with postoperative morbidity and mortality.[10,11]

Propensity score matching was applied in the ICU and GW groups to control preoperative period features' randomization. After propensity score, which was calculated with independent factors of age, ASA score, and comorbidity, we matched 123 patients in each group.

Statistical analysis

Statistical analysis was performed using the IBM SPSS for Windows version 28.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were presented in mean ± standard deviation (SD) or median and interquartile range (IQR) for continuous variables and in number and frequency for categorical variables. The conformity of the continuous data to the normal distribution was examined with the Kolmogorov-Smirnov test. Comparisons between the patient groups were made with the unpaired t-test (for normally distributed data) and the Mann-Whitney U test (for skewed data). The Pearson chi-square and

Table 1. Demographic characteristics and clinical data of patients

	Before propensity score matching							After propensity score matching						
	Surgical ward (n=231)			ICU (n=254)				Surgical ward (n=123)			ICU (n=123)			
	n	%	Mean±SD	n	%	Mean±SD	*p*	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			58.7±13.4			57.9±12.9	0.526			61.6±10.1			61.6±10.1	1.000
Sex							0.759							0.781
Female	73			77				38			36			
Male	158			177				85			87			
Comorbidity														
Any	154	66.6		160	63.0		0.398	95	77.2		95	77.2		1.000
Hypertension	68	29.4		77	30.3		0.833	52	42.2		51	41.4		0.897
Diabetes mellitus	42	18.2		40	15.7		0.498	31	25.2		28	22.8		0.654
Coronary artery disease	34	14.7		26	10.2		0.134	21	17.0		16	13.0		0.373
COPD	19	8.2		26	10.2		0.468	12	9.8		18	14.6		0.242
Secondary malignancy	33	14.3		35	13.8		0.873	16	13.0		17	13.8		0.852
ASA score			1.9±0.7			1.9±0.8	0.885			2.1±0.7			2.1±0.7	1.000
Ejection fraction (%)			62.2±3.6			62.3±3.7	0.719			61.5±3.9			61.2±3.8	0.522
FEV 1 (liter)			2.6±0.6			2.5±0.5	0.250			2.5±0.6			2.5±0.6	0.518
FEV 1 (%)			88.3±16.5			86.2±10.2	0.134			86.7±17.2			85.6±10.6	0.571
DLCO			82.9±16.6			80.9±14.0	0.213			81.1±16.1			80.9±12.9	0.950
Chemo and/or radio therapy (total)	46	19.9		37	14.6		0.118	22	17.9		20	16.2		0.735
Neoadjuvant theraphy for lung cancer	33	14.3		13	5.1		<0.001	16	13.0		9	7.3		0.140

ICU: Intensive care unit; SD: Standard deviation; COPD: Chronic obstructive pulmonary disease; ASA: American Society of Anesthesiologists Classification; FEV1: Forced expiratory volume 1; DLCO: Diffusing capacity of carbon monoxide.

Fisher exact test were used for comparing categorical variables. The receiver operating characteristic (ROC) curve analysis test was used to determine the ASA, FEV1, and DLCO cut-off values for late morbidity development. Finally, the logistic regression analysis was performed to investigate patient-related independent factors that might be effective in late morbidity situations. A *p* value of <0.05 was considered statistically significant at 95% confidence interval (CI).

RESULTS

Patient characteristics

Among these patients, 254 were in the ICU group, while 231 were in GW. At least one comorbid disease was observed in 314 patients (64.7%). The most common comorbid disease was hypertension (29.9%). All demographic data, clinical characteristics, and comorbidities are shown in Table 1.

Peri- and postoperative characteristics

In patient groups created after propensity score matching (n=123 ICU, n=123 GW), epithelial lung tumor (n=187, 76.0%) was the most frequent diagnosis. This diagnosis was followed by metastatic lung tumor (n=13, 5.3%), bronchiectasis (n=9, 3.7%), mesenchymal and lymphohistiocytic lung tumor (n=8, 3.3%). The diagnostic rate of patient groups is shown in Figure 2.

The distribution frequency of operative and postoperative results between the groups were evaluated. There was no statistically significant difference between the groups in terms of operation side, type of surgical intervention, type of operation, presence of chest wall resection, amount of drainage, drain removal time, and discharge time (p>0.05). The only significant difference between the two groups was seen in inpatient costs (p<0.001). The distribution of data between two groups after propensity score is shown in Table 2.

Morbidity and mortality

After propensity score matching, 246 patients were compared for morbidity and mortality. There was no statistically significant difference between the two groups in early morbidity (p=0.615). Late morbidity incidence was higher in the ICU group than in GW, and this difference was statistically significant (p=0.039).

The mean CCI score of the GW group was 0.99±0.97, while it was 1.02±1.12 in the ICU group. There was no statistically significant difference between the two

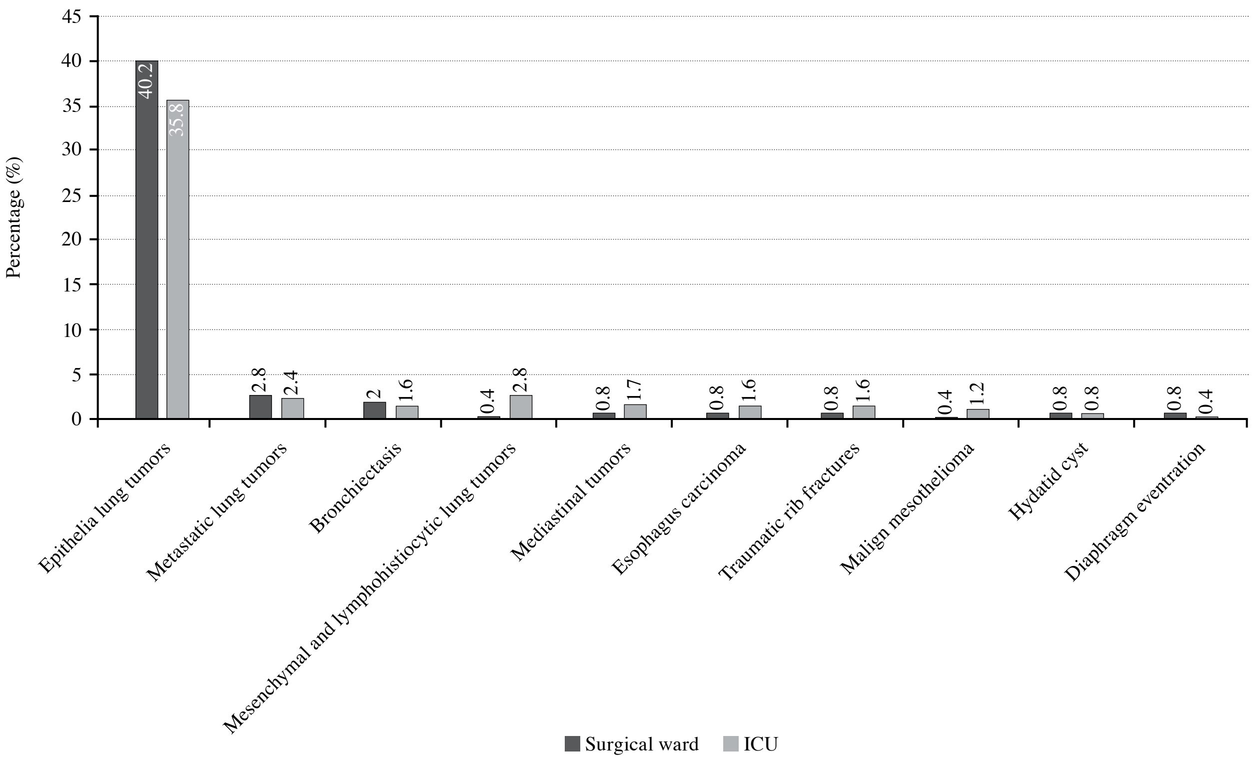

Figure 2. Diagnostic rate of patient groups.

ICU: Intensive care unit.

groups regarding CCI (p=0.912). The mean CDC score was 0.48±1.15 in the GW group, whereas it was 0.62±1.27 in the ICU group. Similarly, no significant difference was observed between the two groups in terms of CDC (p=0.199).

Seventeen (6.9%) of all 246 patients were readmitted to ICU. The most common indication for ICU readmission was pneumonia, seen in six (2.4%) patients. Nine (7.3%) patients were admitted to the ICU after the GW group's clinic admission. In the ICU group, eight (6.5%) patients were readmitted to ICU shortly after they were taken to GW. There was no statistically significant difference between the groups in terms of the readmission to ICU (p=0.802).

Six (2.4%) patients after propensity score matching had 30-day mortality. There was no significant difference (p=0.342) between the patient groups for mortality rates. The CCI, CDC, early morbidity, late morbidity, and mortality rates of patients between the two groups after propensity score matching are shown in Table 3.

We reviewed the data of independent factors such as age, sex, secondary malignancy, pneumonectomy, chemoradiotherapy, ASA score, FEV1, and DLCO data in the multivariate logistic regression analysis affecting early morbidity. Only age factor (odds ratio [OR]: 1.06; 95% CI: 1.00-1.11, p=0.033) had statistical significance on early morbidity.

We used the ROC curve analysis to determine ASA score, FEV1, and DLCO cut-off values to assess independent factors that could affect late morbidity. The cut-off value was assigned as 3 for ASA score (sensitivity 58%, specificity 85%), 2.6 (L) for FEV1 (sensitivity 50%, specificity 60%) and 80 (%) for DLCO (sensitivity 58%, specificity 57%). We analyzed independent factors such as age, sex, secondary malignancy, pneumonectomy, chemoradiotherapy, ASA=3, FEV1 ≥2.6 L, and DLCO ≥80% that could affect late morbidity in multivariate logistic regression analysis. Among these factors, only ASA=3 (OR: 3.88; 95% CI: 1.12-13.43, p=0.032) and secondary

Table 2. Propensity score-matched operative and postoperative characteristics

	Surgical ward (n=123)					ICU (n=123)					
	n	%	Mean±SD	Median	IQR	n	%	Mean±SD	Median	IQR	*p*
Intervention side											0.431
Right	73	59.3				77	62.6				
Left	50	40.7				43	35.0				
Center	-	-				3	2.4				
Intervention type											0.235
Thoracotomy	92	74.8				84	68.3				
VATS	29	23.6				35	28.5				
Sternotomy	-	-				3	2.4				
Rethoracotomy	2	1.6				1	0.8				
Chest wall resection	17	13.8				12	9.8				0.323
Surgical procedure											0.132
Lung resection only (excluding pneumonectomies)	81	65.9				89	72.3				
Pneumonectomy	13	10.6				4	3.3				
Lung resection plus chest wall resection	13	10.6				8	6.5				
Chest wall resection only	4	3.2				4	3.3				
Mediastinal mass excision	4	3.2				5	4.0				
Parenchymal mass excision	3	2.4				4	3.3				
Other	5	4.1				9	7.3				
Chest tube											
Drainage amount (mL)				500	400				400	500	0.881
Drain removal (day)			6.2±4.7					6.7±5.1			0.407
Hospital bed use											
Total length of stay (day)			7.3±3.5					7.7±3.6			0.303
Total bed cost (American dollar)			36.4±17.7					52.5±22.6			**<0.001**

ICU: Intensive care unit; SD: Standard deviation; VATS: Video-assisted thoracoscopic surgery.

Table 3. Outcomes of the patients after propensity score matching

	Surgical ward (n=123)		ICU (n=123)		
	n	%	n	%	*p*
Charlson comorbidity index					0.858
0	44	35.8	47	38.2	
1-2	68	55.3	67	54.5	
≥3	11	8.9	9	7.3	
Clavien-Dindo classification					
0	98	79.7	89	72.4	
1-2	15	12.2	24	19.5	
≥3	10	8.1	10	8.1	
Early morbidity					0.615
Any	20	16.2	23	18.6	
Prolonged air leak	6	4.8	10	8.2	
Pneumonia	4	3.2	2	1.6	
Atelectasis	3	2.4	1	0.8	
Chylothorax	2	1.6	2	1.6	
Atrial fibrillation	1	0.8	2	1.6	
Lung edema	1	0.8	1	0.8	
Bleeding	1	0.8	1	0.8	
Myocardial infarction	-	-	2	1.6	
Pulmonary thromboembolism	-	-	2	1.6	
Bronchopleural fistula	1	0.8	-	-	
Pleural effusion	1	0.8	-	-	
Late morbidity					**0.039**
Any	4	3.2	12	9.8	
Pneumonia	2	1.6	5	4.0	
Poor clinical condition	-	-	2	1.6	
Dyspnea	1	0.8	1	0.8	
Pulmonary thromboembolism	-	-	2	1.6	
Wound infection	1	0.8	1	0.8	
Diaphragm eventration	-	-	1	0.8	
Mortality	2	1.6	4	3.2	0.342
Pneumonia	1	0.8	2	1.6	
Pulmonary thromboembolism	-	-	2	1.6	
Respiratory distress	1	0.8	-	-	

ICU: Intensive care unit.

malignancy (OR: 5.02; 95% CI: 1.59-15.75, p=0.006) had statistical significance on late morbidity.

DISCUSSION

In our study, patients who had major thoracic surgical procedures and were observed in GW had similar early morbidity and mortality rates to those observed in the ICU. Thus, late period morbidity was seen less in the GW group. As most of the postoperative patient observation in ICUs is only for monitoring purposes, this observation can be achieved in GW with an experienced nursery. With this approach, it would be possible to decrease bed occupancy in ICUs and possible complications caused by ICU stay only. Also, it is necessary to emphasize that it would also decrease the total cost.

Patients who had major thoracic surgical procedures are primarily observed in ICUs in the early postoperative period due to their age, comorbidities, high ASA scores, and the risk of the surgery itself. Nevertheless, in recent years, the need for ICU stay after a major operation has been questioned.[12] While ICU observation has a positive effect on survival in some types of cardiac surgery, it does not have any effect on other types of elective surgeries.[13,14] This effect is also similar for the rate of complication development. The postoperative complication rate was reported to be between 13 and 25% after lung resection in different studies.[9,15,16] Due to these high complication rates, ICU observation continues to be practiced as a mandatory habit. This habit is similar to our ICU patient group, which were routinely followed in ICU. We believe that this behavior is probably due to habitual practices from the past and the lack of monitorization equipment in GW. However, the idea of "observing patients in GW after pulmonary resections is safe" is gaining popularity. As patients are observed in the ICU for the first postoperative day, but most of the complications occur in later days.[9,15] In our study, the complication rate after major thoracic surgical procedures was similar between the groups, and even the GW group had an advantage over the ICU group for late complications. We believe that this may be related to the late-term complications of situations such as deep venous thrombosis and nosocomial infections.

The need for ICU follow-up is controversial not only in lung resections, but in patients who need thoracic surgical care such as esophageal surgery and elder trauma patients.[17,18] Our study shows that, in addition to lung resections, in major thoracic surgery procedures concerning esophagus resection, mediastinal surgery, mesothelioma surgery, diaphragm surgery, chest wall, and trauma surgery, it is safe to observe the patients in GW. Among major procedures, we only observed tracheal resections in ICU. The reason for this is that we keep the patient intubated through the first postoperative day in our daily clinical practice. However, we believe that tracheal resection patients extubated at the operation room may be observed in GW.

In recent years, disposable instruments used in surgery and anesthesia have become more sophisticated with advances in technology, and this situation set a new trend toward minimally invasive surgery. All these advances enabled us to perform risky operations safer. Undoubtedly, in this patient group, whose morbidity is higher, clinical care from pre- to postoperative period and ERAS protocols gained more importance. Beyond these practices, perioperative anesthetic management and postoperative pain control are essential. Thoracotomy causes severe postoperative pain, which induces hypoxemia and respiratory complications including atelectasis, followed by pulmonary infections.[19] That is why postoperative proper pain management is crucial. The most common and accepted technique after thoracic surgery is epidural analgesia. Studies comparing postoperative opioid use and epidural analgesia have shown that the latter has more analgesic effects and less adverse reaction incidence.[20] Therefore, in patients who have no contraindication, epidural analgesia may be the first choice after the operation.[21] Thoracic surgery procedures are usually performed under general anesthesia, but many institutions combine general anesthesia with epidural analgesia. Recently, the paravertebral block has been reported as an alternative to epidural analgesia.[21,22] Several studies have reported that patients who have intercostal nerve block after video-assisted thoracoscopic surgery or conventional thoracic surgical procedures have better pain control than patients without intercostal nerve block.[23,24] In our clinic, we use a combination of intercostal nerve block, epidural analgesia, or paravertebral block and ensure pain control by PCA.

The selection of the patients who should be observed in GW or ICU is also controversial in the literature. In a study, it is suggested to observe patients with old age, high body mass index, and comorbidities in ICU after surgery.[25] For thoracic surgery procedures, surgery for bronchiectasis, pneumonectomy, and patients aged ≥57 years had more risk than other patients and, therefore, postoperative ICU care was advised.[26] In another study, it was suggested to test preoperative brain natriuretic peptide levels to predict postoperative atrial fibrillation risk.[27] In a study by Yao and Wang,[28] blood loss during the operation was related to increased morbidity. In addition, CCI >2, steroid use, high ASA scores, presence of nasogastric tube, peripheral/central venous catheterization, postoperative heart failure/acute kidney failure, total parenteral nutrition, late postoperative mobilization, and prolonged ventilation and intubation were associated with the increased pneumonia risk in the postoperative period.[29] On the other hand, old age was not related to the increased morbidity.[30] For pneumonectomy patients, neoadjuvant therapy, right side, intraoperative blood transfusion, and CCI >3 were risk factors for increased morbidity.[31,32]

In our study, ASA score and secondary malignancy were statistically significant for late morbidity development. In our clinical practice, we routinely observe and monitor almost all the patients in GW. However, in case of a potential risk, we believe that patients in these groups can be admitted to the ICU, provided that the ICU follow-up is kept short. As in patients with an ICU stay of more than three days, quality of life and survival rates decrease, cardiac and cerebrovascular event incidence increase, and additional morbidities occur.[33] It is essential to avoid unnecessary and routine postoperative ICU observations to prevent these complications and reduce the total treatment cost.

The single-center, retrospective design is the main limitation to this study. Furthermore, our study includes all major thoracic surgery patients and represents a heterogeneous patient population. However, the same surgical team performed all pre- and postoperative procedures, showing a consistent clinical behavior. Additionally, as the patient groups were compared after propensity score matching, the groups became more homogenized, and probable reasons which could affect the results were minimized.

In conclusion, our study showed that it is possible to observe patients in the general ward after major thoracic surgery procedures. However, a more careful approach is necessary in case of the patient group with old age, high American Society of Anesthesiologists score, and secondary malignancy. Based on these findings, it is safe and cost-effective to follow almost all thoracic surgery patients postoperatively in the general ward. If there is enough access to equipment, instrument, nursing care, and medical support, we believe that it is unnecessary to follow postoperative patients in the intensive care unit setting. Thus, intensive care unit beds may be reserved for other patients who have more need for intensive care, particularly during the COVID-19 pandemic.

Ethics Committee Approval: The study protocol was approved by the Kartal Dr. Lütfi Kırdar City Hospital Clinical Research Ethics Committee (date: 30.11.2021, no: 2021/514/214/29). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Conception, design, literature review, writing: T.D.; Statistical analysis: S.D.; Materials, data collection: S.K., M.B., B.Ç., A.Ö.; Critical review, writing: F.D.G.; Supervision, critical review: R.D.

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