Mortality and associated factors in a thoracic surgery ICU*,**

Mortalidade e fatores associados em uma UTI de cirurgia torácica

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Abstract

Objective: To assess mortality and identify mortality risk factors in patients admitted to a thoracic surgery ICU. **Methods:** We retrospectively evaluated 141 patients admitted to the thoracic surgery ICU of the Denizli State Hospital, located in the city of Denizli, Turkey, between January of 2006 and August of 2008. We collected data regarding gender, age, reason for admission, invasive interventions and operations, invasive mechanical ventilation, infections, and length of ICU stay. **Results:** Of the 141 patients, 103 (73.0%) were male, and 38 (23.0%) were female. The mean age was 52.1 years (range, 12-92 years), and the mortality rate was 16.3%. The most common reason for admission was trauma. Mortality was found to correlate with advanced age ($p < 0.05$), requiring invasive mechanical ventilation (OR = 42.375; $p < 0.05$), prolonged ICU stay ($p < 0.05$), and specific reasons for admission—trauma, gunshot wound, stab wound, and malignancy ($p < 0.05$ for all). **Conclusions:** Among patients in a thoracic surgery ICU, the rates of morbidity and mortality are high. Increased awareness of mortality risk factors can improve the effectiveness of treatment, which should reduce the rates of morbidity and mortality, thereby providing time savings and minimizing costs.

Keywords: Intensive care units; Thoracic surgery/mortality; Hospital mortality; Risk factors.

Resumo

Objetivo: Determinar a mortalidade e identificar fatores de riscos associados em pacientes em uma UTI de cirurgia torácica. **Métodos:** Foram avaliados retrospectivamente 141 pacientes admitidos na UTI de cirurgia torácica do Hospital Estadual de Denizli, localizado na cidade de Denizli, Turquia, entre janeiro de 2006 e agosto de 2008. Foram coletados dados sobre gênero, idade, causa de admissão, intervenções invasivas e operações, status de ventilação mecânica invasiva, infecções e tempo de permanência na UTI. **Resultados:** Dos 141 pacientes, 103 (73,0%) eram do sexo masculino e 38 (23,0%) do sexo feminino. A média de idade foi de 52,1 anos (variação: 12-92 anos), e a taxa de mortalidade foi de 16,3%. A causa de admissão mais frequente foi trauma. A mortalidade correlacionou-se com idade avançada ($p < 0,05$), uso de ventilação mecânica invasiva (OR = 42,375; $p < 0,05$), longa permanência na UTI ($p < 0,05$) e causas de admissão específicas — trauma, injúria por arma de fogo, injúria por arma branca e malignidade ($p < 0,05$ para todos). **Conclusões:** Os pacientes em uma UTI de cirurgia torácica têm alta morbidade e mortalidade. Um conhecimento maior dos fatores de risco de mortalidade pode melhorar a eficiência do tratamento, resultando em diminuição da morbidade e mortalidade, o que gerará economia de tempo e reduzirá os custos financeiros.

Descritores: Unidades de terapia intensiva; Cirurgia torácica/mortalidade; Mortalidade hospitalar; Fatores de risco.

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Financial support: None.
Submitted: 5 December 2010. Accepted, after review: 9 May 2011.
** A versão completa em português deste artigo está disponível em www.jornaldepneumologia.com.br

Introduction

Mortality rates are high in ICUs. Therefore, it is important for physicians working in ICUs to understand the factors that affect mortality, in order to improve their approach to and observation of patients.

Patients in a thoracic surgery ICU present with pronounced respiratory and hemodynamic instability. Patients who undergo elective surgery are admitted to the thoracic surgery ICU for postoperative follow-up. Trauma patients are admitted to these ICUs because of respiratory and hemodynamic instability. The European Thoracic Surgery Association endorses a high dependency unit (HDU) structure and recommends that patients submitted to major elective thoracic surgery undergo postoperative follow-up in such units.[1] Data in the literature indicate that the risk of mortality after major surgical procedures is high in ICUs, and it has been suggested that HDUs would be more suitable.[2,3] Lung injury after lung resection is associated with high mortality; preoperative and postoperative risk factors are significant predictors of postoperative lung injury.[4]

Thoracic surgery ICU patients present with a wide range of conditions and circumstances, ranging from elective surgery patients to trauma victims. Consequently, there are no standard algorithms for ICU admission or follow-up. The Acute Physiology and Chronic Health Evaluation II score is an objective method that is widely used to determine severity and prognosis.[5] However, the Mortality Prediction Model II score appears to be a more versatile tool for use in the thoracic surgery ICU, because it is based on admission values. The vital parameters at admission are important because they show rapid changes at a time when the mortality risk is high. There is an evident need for intensive care in trauma cases, in order to ensure that the multidisciplinary approach is timely and effective. In addition, in most ICU patients with acute respiratory failure, complex trauma, or malignancy, emergency intervention is necessary.

In this study, we examined data regarding patient status during follow-up, as well as treatment outcomes and prognostic factors, the objective being to assess mortality and identify mortality risk factors, in patients admitted to a thoracic surgery ICU.

Methods

We retrospectively evaluated 141 patients admitted to the thoracic surgery ICU of the Denizli State Hospital, a large-scale regional hospital located in the city of Denizli, Turkey, between January of 2006 and August of 2008. Surgical patients who were not expected to have postoperative complications were followed in the postoperative ICU and were therefore excluded from the analysis. For all of the patients evaluated, we collected data regarding gender, age, reason for admission, invasive interventions, surgical procedures, the use of invasive mechanical ventilation (MV), infections, and length of ICU stay. These variables were investigated as possible prognostic factors. This study was approved by the local research ethics committee.

All of the patients received continuous oxygen therapy, the quantity of which depended on the status of the patient. Chest X-rays, blood counts, biochemical tests, and determination of the volumes of electrolyte solutions administered were carried out on a daily basis, or more often if necessary. When infection was suspected or diagnosed, blood and urine samples, as well as pleural fluid for culture, were collected. Antibiotic therapy regimens were selected by the infection committee of the hospital. The necessary follow-up procedures for trauma patients were discussed with the appropriate physicians; and their recommendations were registered in the treatment file before being applied. Postoperative patients, as well as patients without any signs of infection, received prophylaxis with intravenous cefazolin sodium. For those without active bleeding or hemothorax, low-molecular-weight heparin and H_2 receptor blockers were routinely used. For those who required invasive MV support, the treatment strategy, including the use of analgesia and sedation, was discussed with the attending anesthesiologist. Cases in which there were complications were discussed with the appropriate physicians.

In the patients who were unable to receive oral feedings, enteral nutrition was started by inserting a nasogastric tube on the second or third day, except in those who had undergone surgery or those who presented with abdominal obstructions.

The Statistical Package for the Social Sciences, version 11.5 (SPSS Inc., Chicago, IL, USA) was used for data processing. Statistical analyses were carried out using the chi-square test and Fisher's exact test. We used the Kolmogorov-Smirnov test in order to determine the normal distribution of the variables age and length of ICU stay. Independent tests and the Mann-Whitney U test were used for variables with normal distribution and for those without, respectively. We performed multivariate analysis with logistic regression and correspondence analysis. The level of statistical significance was set at $p < 0.05$.

Results

Between January of 2006 and August of 2008, 141 patients were admitted to the thoracic surgery ICU. Of the 141 patients, 103 (73.0%) were male, and 38 (23.0%) were female. Of the 141 patients, 23 (16.3%) died in the ICU: 15 (14.5%) of the male patients; and 8 (21.1%) of the female patients. There was no significant association between gender and ICU mortality ($p > 0.05$). The mean age of the male and female patients was 51.7 years (range, 12-92 years) and 53.4 years (range, 17-89 years), respectively. The overall mean age was 52.1 years (range, 12-92 years). A significant association was found between advanced age and ICU mortality ($p < 0.05$).

Of the 141 patients treated in the ICU, 53 (37.5%) had been admitted for trauma, chest trauma being prominent or involved in all of those cases. Of the 53 trauma patients, 7 (13.2%) died. The relationship between the reasons for ICU admission and mortality in patients receiving invasive MV is shown in Table 1. Of the 141 patients, 29 (32.1%) were admitted to the ICU for postoperative follow-up after moderate or major surgery and were therefore likely to have severe respiratory or hemodynamic problems. No mortality was observed in the follow-up of the patients who underwent elective surgery (resections, in 16 patients; emphysema, in 4; bullectomy, in 3; and esophagectomy, for lung abscess, in 6). Of the 141 patients, 19 (14.8%) had penetrating injuries (stab wounds), and 4 (21%) of those patients died. Respiratory diseases such as severe COPD, lung abscess, and empyema were the reasons for ICU admission in 12 patients (8.5% of the sample), and 1 (8%) of those patients died. In 11 patients (7.8% of the sample), the reason for ICU admission was inoperable primary or metastatic lung cancer, and 5 (45.4%) of those patients died. There were 11 patients (7.8% of the sample) who were admitted to the ICU for gunshot wound, and 6 (54.5%) of those patients died. Of the 6 patients (4.9% of the sample) admitted to the ICU for iatrogenic diseases (invasive MV-related pneumothorax, in 2; central catheterization-related hemopneumothorax, in 2; catheter-related hemothorax, in 1; and pneumomediastinum, resulting from a tracheostomy complication, in 1), none died. Among the various reasons for admission, gunshot wound, stab wound, and malignancy were found to be significantly associated with mortality ($p < 0.05$). Specific reasons for admission were the major factors found to affect mortality in the correspondence analysis ($p = 0.003$; Figure 1).

In all of the cases admitted to the ICU, minor surgical interventions performed by the thoracic surgeon were also examined, as were routine procedures, such as the use of oxygen

Table 1 - Gender, use of invasive mechanical ventilation, and mortality by reason for admission.

Reason for admission	Male		Female		IMV		Mortality		Total	
	n	%	n	%	n	%	n	%	n	%
Trauma	38	26.0	15	10.6	5	3.5	7	4.9	53	37.5
Inoperable malignancy	7	4.9	4	2.8	5	3.5	5	3.5	11	7.7
Postoperative follow-up	18	12.7	11	7.8	2	1.4	0	0.0	29	20.5
Lung disease	10	7.0	2	1.4	2	1.4	1	0.7	12	8.4
Stab wound	16	11.3	3	2.1	5	3.5	4	2.8	19	13.4
Iatrogenic	4	2.8	2	1.4	2	1.4	0	0.0	6	4.2
Gunshot wound	10	7.0	1	0.7	7	4.9	6	4.2	11	7.7
Total	103	73.0	38	27.0	28	19.8	23	16.3%	141	100.0

IMV: invasive mechanical ventilation.

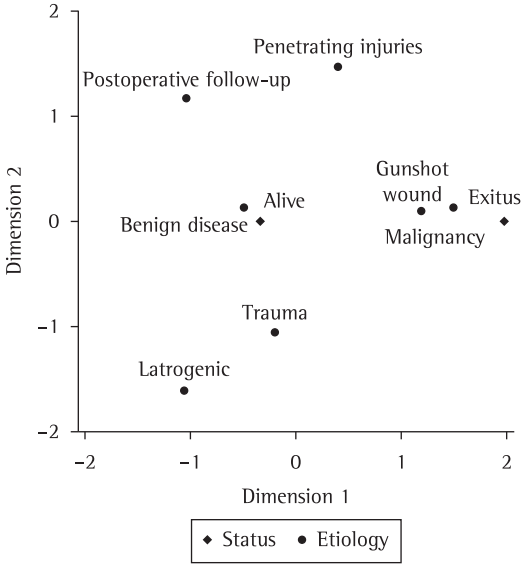

Figure 1 - Association between reason for admission and mortality.

therapy, intravenous catheters, and urinary catheters. Tube thoracostomy was performed in 21 (17.6%) of the patients. Those cases included the patients with postoperative (iatrogenic or non-iatrogenic) pneumothorax or hemothorax. Two of those patients had previously been treated but were admitted to the ICU after being submitted to tube thoracostomy due to pneumothorax. Minor surgical interventions were performed in 12 patients (9.9%). These were invasive interventions, including wound suture, debridement, and fasciotomy. Central venous lines were inserted in 46 patients, and tracheostomy was performed in 14. Four patients were submitted to rigid bronchoscopy because of foreign body aspiration, in 1; for removal of bronchial secretions, in 2; or because of hemorrhage, in 1. In our study, 22 patients required intra-arterial catheterization for blood gas monitoring. Cardiopulmonary resuscitation (CPR) was required in 20 (14.1%) of the patients and was performed twice in 2. All of the patients who required CPR died. In our study, 119 invasive interventions, divided into six groups, were performed in 81 patients (57.4%), and 13 of those patients died. There were 60 patients (42.6%) in whom no invasive intervention was required, and 10 of those patients died. No significant association was found between invasive interventions performed in the ICU and mortality ($p > 0.05$). The invasive interventions performed in the ICU were central catheterizations, in 46 patients; tube thoracostomy, in 21; minor surgical procedures, in 12; tracheostomy, in 14; and other interventions, in 26.

In our sample, 28 patients (19.8%) were submitted to invasive MV. Anesthesiologists were previously consulted regarding the patients with respiratory issues and low oxygen saturation. Two patients required invasive MV support on two occasions. Tracheostomy was performed 7-8 days after invasive MV initiation. The mean duration of invasive MV was 6.1 days. However, 4 patients required long-term invasive MV support and were transferred to the anesthesia department. The type of invasive MV to be used and other parameters were decided together with the attending anesthesiologists.

Positive pressure ventilation was applied in 2 patients. Volume-controlled ventilation using low pressures was used in 4 patients with pneumothorax and massive air leakage. Ventilation with positive pressure was used in 3 patients with pulmonary contusion and in 2 with lung edema. Synchronized intermittent mandatory ventilation was used in 2 postoperative patients and in 2 with carcinoma of the terminal bronchioles. Of the 23 patients submitted to invasive MV, 21 (91.3%) died. There was a significant association between the use of invasive MV and mortality (OR = 42.375; 95% CI: 9.377-191.487; $p < 0.0005$).

The total number of days in the ICU was 586, and the mean length of ICU stay was 4.1 days. Figure 2 shows the association between the length of ICU stay and mortality.

Mortality increased in the ICU as the length of ICU stay increased. The median length of ICU stay was 7 days in the patients who died (interquartile range [IQR], 9). The median length of ICU stay was 3 days in the surviving patients (IQR, 4; Z, −3.38). There was a significant difference between these two groups ($p = 0.001$).

Infection was detected in 18 patients: pneumonia, in 6 (33.3%); wound infection, in 2 (11.1%); empyema, in 7 (38.8%); and other types of infection, in 3 (16.8%). Among those 18 patients, there were six cultures that were positive for infection. One patient developed sepsis, and the blood culture in that case was positive for *Staphylococcus aureus*. That patient died due to acute kidney injury during the treatment process. Of the 18 patients with

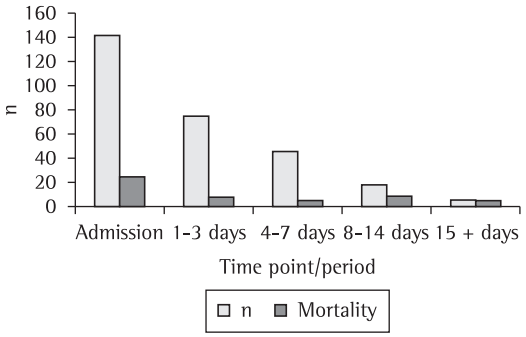

Figure 2 - Length of ICU stay and mortality.

infection, 3 (2.1%) died. Of the remaining 123 patients, 20 died. There was no significant association between infection and mortality (p = 0.254).

The most common morbidities were hemorrhage, in 18 patients (12.3%); atelectasis, in 11 (7.8%); pneumonia, in 6 (4.2%); and wound infection, in 2 (1.4%).

The overall mortality rate was 16.3% (23 patients), of whom 12 (51.6%) were in the 45-69 year age bracket and 7 (30.1%) were in the > 70 year age bracket. The most common causes were hypovolemic shock, in 5 (21.8%); and end-stage malignant disease, in 5 (21.8%). The causes of mortality and the corresponding rates are presented in Table 2.

In the present study, advanced age, invasive MV, prolonged ICU stay, and certain reasons for admission (trauma, malignancy, gunshot wound, and penetrating injury) were found to be prognostic factors of mortality (Table 3).

Discussion

The results of the present study clearly show that there is a variety of reasons for admission to a thoracic surgery ICU, ranging from postoperative follow-up to trauma and complex end-stage malignancies.

Table 2 - Causes of mortality.

Cause of mortality	n	%
Hypovolemic shock	7	40.4
End-stage malignant disease	5	21.7
COPD	4	17.3
ARDS	3	12.9
Pulmonary embolism	1	4.3
Myocardial infarction	1	4.3
Disseminated intravascular coagulation	1	4.3
Uremia	1	4.3
Total	23	100

Our study highlights the fact that, in the thoracic surgery ICU, male patients tend to be younger, which is probably due to their active lifestyle. Schönhofer et al.[5] and Lesauskaite[6] both reported that advanced age increases mortality. As age increases, there is a decrease in lung elastic recoil, as well as in chest wall compliance and respiratory muscle strength. In addition, older patients present with greater smoking histories and longer periods of exposure to environmental contaminants.[7] In a multicenter study involving 1,231 patients from 132 ICUs, Luhr et al.[8] reported a 41% mortality rate and found that advanced age was associated with mortality. In a study involving 357 patients submitted to invasive MV, Kollef et al.[9] concluded that being female, being older, having multiple organ deficiency, and having ARDS were factors that influenced mortality. In our study, 15 of the 103 male patients and 8 of the 38 female patients died. However, there was no significant association between gender and mortality (p > 0.05). The mean age of our patients was 52.1 years (range, 12-92). Although the majority of the cases had specific reasons for admission, such as trauma, postoperative complications, and malignancy, we observed that morbidity and mortality increased in parallel with advancing age.

The reason for admission is one of the basic factors influencing mortality in ICU patients. It is closely associated with the approach taken and with morbidity. In a study involving 5,030 medical or surgical ICU patients, the reported annual mortality rate was ≥ 40%.[6] Considering the cases admitted to our ICU, the most common reason for admission was chest trauma. Traffic accidents accounted for the majority of the cases, and there was secondary trauma in 34 cases due to penetrating chest injury. Of the 53 trauma patients, 38 (26%) were male. However, no significant association could be detected between male gender and mortality due to trauma. In one study investigating COPD and ARDS patients,[10] the mortality rate was 34%, increasing to 46% when invasive MV was also considered.

It is known that mortality is high in patients with recognized COPD or other chronic respiratory diseases.[11] In our sample, 12 patients

Table 3 - Prognostic factors and mortality.

Factor	Total	Mortality	p
Gender			
Male, n (%)	103 (73.0)	15 (65.2)	> 0.05
Female, n (%)	38 (27.0)	8 (34.8)	
IMV			
Yes, n (%)	28 (19.8)	21 (91.4)	< 0.0005
No, n (%)	113 (80.2)	2 (8.6)	
Invasive intervention			
Yes, n (%)	81 (57.4)	13 (57.0)	> 0.05
No, n (%)	60 (43.6)	10 (43.0)	
Infection			
Yes, n (%)	18 (85.6)	3 (13.0)	> 0.05
No, n (%)	123 (14.4)	20 (87.0)	
Reason for admission			
Trauma, n (%)	53 (37.5)	7 (29.2)	0.003
Gunshot wound, n (%)	11 (7.8)	6 (25.8)	< 0.05
Stabbing injury, n (%)	16 (11.3)	4 (17.2)	< 0.05
Malignancy, n (%)	11 (7.7)	5 (21.5)	< 0.05
Lung disease, n (%)	12 (8.4)	1 (4.3)	> 0.05
Iatrogenic, n (%)	4 (4.2)	0 (0.0)	> 0.05
Postoperative follow-up, n (%)	29 (20.5)	0 (0.0)	> 0.05
Age, mean ± SD (range)	47.2 ± 12.6 (12–92)		< 0.05
ICU stay (in days), median (IQR)	7 (9)		0.001

IMV: invasive mechanical ventilation; and IQR: interquartile range.

had COPD or similar respiratory diseases or complications thereof, and 1 of those patients died.

One group of authors[12] concluded that mortality is higher in patients admitted to the ICU a few days after being admitted to the hospital or being transferred from other hospitals than in those admitted directly to the ICU. This difference was attributed to the different characteristics of the patients. In our study, 17 patients had been referred from surrounding hospitals to our hospital, which is a regional hospital.

None of the 29 patients admitted to the ICU for postoperative follow-up died. Markos et al. [3] reported a similar result, showing that there were no deaths among postoperative follow-up patients.

Mortality was observed in 6 of the 11 cases of gunshot injuries, as well as in 7 of the 53 trauma cases and in 5 of the 11 cases of respiratory problems due to malignancy. The reason for admission was one of the prognostic factors that influenced mortality in the ICU.

Invasive interventions performed within the ICU did not affect mortality. Iatrogenic pneumothorax developed in 1 of the 46 catheterized patients. Tube thoracostomy was used in 16 patients and was a relevant factor, increasing morbidity and mortality. Pneumothorax, albeit rare, is important in the ICU. Small pneumothorax can increase acutely in patients receiving invasive MV, causing patient health status to deteriorate.[13] Pneumothorax occurred in 8 patients in whom tube thoracostomy was required. Pleural fluid collection is routine in the ICU, and it has been reported that up to 62% of patients require this procedure.[13] Abnormal pleural fluid buildup can be a sign of disease, such as complicated empyema or silent embolism. Excess pleural fluid can increase the mechanical load on the respiratory muscles, causing respiratory distress. In our study, pleural effusion was detected in 7 patients (5%), 5 of whom required tube thoracostomy and 2 of whom were submitted to thoracocentesis. In 1 patient, drainage was not discontinued and empyema developed.

In our study, tracheostomy was performed in 14 patients (9.9%). As a rule of thumb, tracheostomy was used in cases in which invasive MV was required for more than one week. The

reported proportion of patients who required such prolonged ventilatory support ranges from 3.0% to 23.9%.[10,14]

Liu et al.[14] suggested that the duration of invasive MV has a direct impact on mortality. Vasilyev et al.[15] investigated 1,416 patients; the most important factors influencing survival at the ICU were reported to be the severity of lung injury, the etiology of acute respiratory failure, the duration of invasive MV, the presence and severity of hypoxemia while receiving invasive MV, and the presence of multiple organ failure. One of the patients on invasive MV was submitted to tube thoracostomy due to iatrogenic pneumothorax, and 1 patient developed pneumonia, which was deemed to be due to invasive MV. Ventilator-associated pneumonia is commonly observed (in 9-68%) and is a serious condition.[16] Cunnion et al.[17] reported that the major risk factor for nosocomial pneumonia in surgical and medical/respiratory ICUs is prolonged MV, resulting in a 12 times higher risk for ventilated patients than for nonventilated patients. This is in agreement with the findings of the present study.

It has been shown that the risk of sepsis is 5-7 times higher in ICU patients than in the normal population.[18] Weiss and Hudson showed that sepsis increases ICU mortality.[19] Kollef et al.[9] stated that one of the risk factors influencing in-hospital mortality in severe patients is the inefficient treatment of infections.

The implementation of guidelines for the treatment of nosocomial pneumonia in the ICU can be key to decreasing mortality rates.[20] The presence of problems that greatly affect the prognosis, such as infectious complications, makes it difficult to use respiratory parameters alone in evaluating the prognosis of these patients.[21] In the present study, we found no significant association between infection and mortality. Infection due to thoracic surgery affects mortality at a lower rate. The main reason for this is that emergent surgical pathologies are prominent and that the duration of stay in the ICU is typically short. In addition, the use of prophylactic antibiotic therapy in postoperative patients is effective in controlling empyema and other symptoms of postoperative infection.

The length of stay in the ICU varies from facility to facility.[14] At larger facilities, the mean length of ICU stay has been reported to be as short as 4.64 days.[5] It has been suggested that mortality is directly proportional to the length of stay in the ICU and in the hospital.[5] Rapoport et al.[12] found the mortality of patients admitted to the ICU after cardiac arrest to be 59%. Because our hospital is a large regional hospital, 17 patients had been referred from surrounding hospitals. The mean length of ICU stay in our study was 4.0 days, and mortality increased with this stay. The fact that the mean length of ICU stay was short was due to the number of postoperative follow-up patients.

It is mandatory that thoracic surgery ICUs be effective in performing curative invasive interventions, such as open tracheostomy, tube thoracostomy, central catheterization, and bronchoscopy. In addition, respiratory problems and postoperative complications, such as iatrogenic issues, including intrathoracic/extrathoracic hemorrhage, as well as foreign body aspiration and respiratory complications, such as pneumothorax, hemothorax, and pleural effusion, need to be considered. However, in various cases investigated in the present study, the emergency intervention required was identified after physical examination within a matter of minutes, and, therefore, insufficient data could be obtained for the scoring system.

Patients in a thoracic surgery ICU present with a wide range of severe conditions, with high mortality and morbidity. If we understand the risk factors for and mechanisms of mortality in thoracic surgery ICU patients, sufficient and appropriate follow-up care can be provided in order to significantly reduce morbidity and mortality, thereby providing time savings and minimizing costs.

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