Validation of Thoracic Surgery Scoring System (Thoracoscore) in Turkish Population

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ABSTRACT

Objective: To validate the Thoracoscore, a scoring system designed to predict 30-day mortality in patients undergoing thoracic surgery in the Turkish population.

Study Design: Observational study.

Place and Duration of the Study: Department of Thoracic Surgery, Ondokuz Mayıs University, Medical School, from January 2015 to June 2022.

Methodology: Patients who underwent thoracic surgery under general anaesthesia were evaluated. Thoracoscore was calculated using the online calculator located at https://www.samiuc.es/thoracoscore-thoracic-surgery-scoring-system/. Using the area under the ROC curve (AUC), the sensitivity and specificity of the Thoracoscore in predicting morbidity and mortality were assessed.

Results: The study included 745 patients (67.5% males and 32.5% females) with a mean age of 57.23±14.68 years. Nearly all of the patients underwent elective surgery (99.5%). In 56.9% of cases, the indication for thoracic surgery was malignancy. The 30-day and 90-day mortality rates of patients included in the study were 1.9% and 4.8%, respectively. The mean Thoracoscore was calculated to be -4.79±2.2 (Range: -7.37 to 7.37). In predicting morbidity, Thoracoscore had a sensitivity of 60.83% and a specificity of 73.12%. The sensitivity and specificity of Thoracoscore for predicting 30-day and 90-day mortality were calculated as being 85.7% and 68.7% for 30-day and 69.4% and 67.0% for 90-day, respectively.

Conclusion: Although Thoracoscore's AUC had sufficient discrimination capacity, its sensitivity and specificity was found to be limited. In order to fully comprehend its limitations and accuracy, the authors believe that multicentric studies involving a greater number of patients and a control group of equal size are necessary.

Key Words: *Morbidity*, *Mortality*, *Surgery*, *Thoracic*, *Thoracoscore*, *Validation*.

How to cite this article: Celik HK, Celik B. Validation of Thoracic Surgery Scoring System (Thoracoscore) in Turkish Population. *J Coll Physicians Surg Pak* 2023; **33(10)**:1165-1170.

INTRODUCTION

The decisions regarding a patient's preoperative evaluation and surgery are made after consideration of a variety of factors. The potential risks and benefits must be weighed together when deciding whether to operate or not. While the risk is generally estimated based on the results of the published surgical series and algorithms, if available, the risk is also determined by the surgeon's personal experience.[1,2] Patients undergoing thoracic surgery are classified according to their risk of postoperative complications or mortality using a variety of scoring models that have been developed for this purpose. The European Society Objective Score (ESOS.01), the EuroLung1, the EuroLung2, and the Thoracoscore are a few of the available scoring models used in thoracic surgery.[2-4]

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Received: April 10, 2023; Revised: May 26, 2023;
Accepted: August 28, 2023
DOI: https://doi.org/10.29271/jcpsp.2023.10.1165

Thoracoscore is a scoring system developed by Falcoz *et al*. in 2007 to predict 30-day mortality in patients following general thoracic surgery.[2] Thoracoscore has been used in studies outside of France, and the methodology's suitability has been confirmed.[5] With C-indices of 0.85 for the training set and 0.86 for the test set, the model has been demonstrated to be reliable and accurate. The correlation between the predicted and actual number of fatalities is 0.99.[6-8] The scale has been integrated into the British Thoracic Society and National Institute of Health and Clinical Excellence guidelines.[9,10]

Due to alterations in population characteristics, surgical indications and techniques, the predictive accuracy of scoring models for morbidity and mortality may deteriorate over time. The outdated use of these models may result in an overestimation or underestimation of the surgical risk of the patient. Loucou *et al*. revised and validated the Thoracoscore in 2020, improving its performance and calibration and making it more suitable for use in the current clinical practice.[11] With these modifications, Thoracoscore is now easily applied at the bedside and as a standard component of the medical history and physical examination. In addition, the Thoracoscore has become useful for comparing actual mortality to expected mortality and monitoring the early outcomes in surgical intervention.[10,11]

Thoracoscore has been translated into multiple languages to assess the preoperative mortality risk of patients undergoing thoracic surgery in diverse populations and cultures.[5-7] However, the authors did not find any validation of Thoracoscore for the Turkish population in the literature. This study aimed to validate the Thoracoscore for the Turkish population.

METHODOLOGY

The study included 745 patients who underwent surgery under general anaesthesia for mediastinal, pleural, chest wall, esophageal, or lung diseases at Department of Thoracic Surgery, Ondokuz Mayıs University, Medical School, Samsun, Turkey, between 1st January 2015 and 30th June 2022. The study only included the patients whose data could be accessed from the hospital database.

The criteria for exclusion was being aged either <18 years or >85 years, patients undergoing cardiac surgery, patients with thoracic trauma or those undergoing orthopaedic surgery, patients with intraoperative mortality, and those with missing data.

Age, gender, American Society of Anesthesiologists (ASA) classification, performance status, dyspnea score, the priority of surgery, class of the procedure, diagnosis group, and comorbidities score were used to calculate the Thoracoscore. Hospital mortality, morbidity, and length of stay (LOS) were also recorded. With the aid of an online Thoracoscore calculator (http://www.samiuc.es/thoracoscore-thoracic-surgery-scoring-system/), the predicted mortality and Thoracoscore were calculated.

The sample size analysis using 95% confidence (1-α), 95% test power (1-β), sensitivity of 0.89, and specificity of 0.79 revealed a minimum number of samples required for the study to be 500. The data were analysed using IBM SPSS V23. The cut-off value for predicting morbidity, 30-day and 90-day mortality with the Thoracoscore was determined by ROC analysis. The area under the receiver operating characteristic curve (AUC) was utilised for model discrimination. AUC >0.7 indicated a good capacity and AUC >0.8 indicated a strong capacity for discrimination. The risk factors for 30-day and 90-day mortality as well as morbidity were analysed using binary logistic regression. For quantitative data, the results were presented as mean ± standard deviation and median (minimum – maximum). On the other hand, the categorical data was presented as frequency (percent). The significance threshold was set at $p<0.050$.

RESULTS

Data of 786 patients who underwent thoracic surgery during the study period were evaluated. Forty-one patients were excluded due to lack of data, leaving 745 patients for analysis. Of these patients, 67.5% were males and 32.5% were females, with an average age of 57.23±14.68 years. Surgeries were elective in 99.5% of the patients and 56.9% had a diagnosis of malignancy. The patients had a median performance score of 1 (0-3), a median dyspnea score of 1 (0-3), and a median hospital stay of 5.55±4.74 days. The overall morbidity rate was 16.1%, while the 30-day and 90-day mortality rates were 1.9% and 4.8%, respectively. The average Thoracoscore was -4.79±2.2 (range: -7.37 to 7.37, Table I).

Thoracoscore was found to predict morbidity (AUC: 0.707, $p<0.001$). The sensitivity and specificity at a cut-off value of -4.168 was 60.83% and 73.1%, respectively. Furthermore, the Thoracoscore successfully predicted 30-day mortality (AUC: 0.784, $p<0.001$). Using a cut-off value of -4.168, the sensitivity and specificity were calculated to be 85.71% and 68.67%, respectively. The Thoracoscore also successfully predicted 90-day mortality (AUC: 0.784, $p<0.001$). With a cut-off value of -4.379, the sensitivity was 69.44% and the specificity was 67.0% (Figure 1).

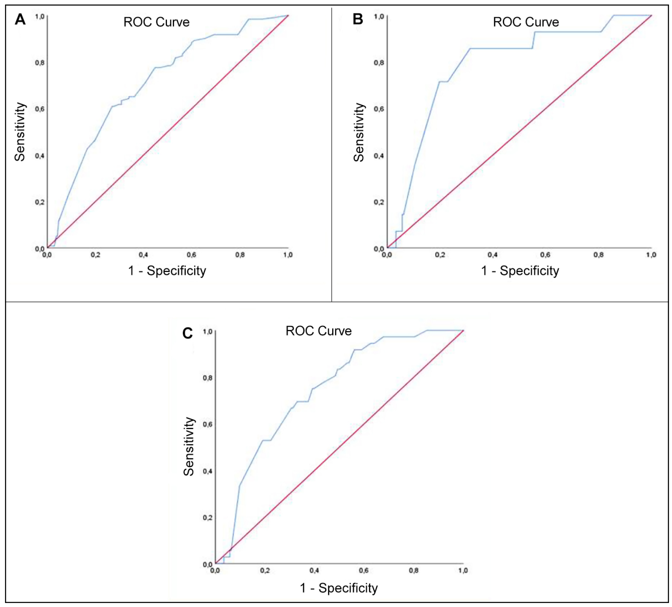

Figure 1: ROC curve for Thoracoscore in predicting (A) morbidity, (B) 30-day mortality, (C) 90-day mortality.

The univariate analysis revealed that age, gender, ASA status, performance score, dyspnea score, surgery priority, diagnosis group, comorbidity score, length of hospital stay, and Thoracoscore were significant predictors of morbidity. In multivariate analysis, significant predictors of morbidity were found to be severity of dyspnea and length of stay. The authors found that as length of the stay increases, morbidity risk multiplies by 1.873-fold. Furthermore, as dyspnea score increases, morbidity risk multiplies by 4.916-fold (Table II).

According to univariate analysis, age, performance score, dyspnea score, morbidity, and length of stay were significant in estimating 30-day mortality; however, according to multivariate analysis, only dyspnea score and morbidity status were significant. Consequently, as the dyspnea score increased, the risk of 30-day mortality increased 5.789-fold, while the risk of 30-day mortality increased 79.931-fold in the presence of morbidity. Moreover, according to the multivariate analysis, the longer the hospital stay, the lower the 30-day mortality risk (OR=0.876; $p=0.044$, Table III).

Table I: Comparison of the data of previous studies with the present study.

	Falcoz *et al.* (n = 10 122), n (%)	Loucou *et al.* (n = 56 279), n (%)	Present data (n=745), n (%)
Age			
<55	4541 (44.9)	17979 (31.9)	168 (22.6)
55-65	2342 (23.1)	16305 (29)	256 (34.4)
>65	3239 (32)	21995 (39.1)	321 (43)
Gender			
Male	6932 (68.5)	35631 (63.3)	503 (67.5)
Female	3190 (31.5)	20648 (36.7)	242 (32.5)
ASA			
≤2	6879 (71.5)	38318 (68.1)	651 (87.3)
≥3	2738 (28.5)	17961 (31.9)	94 (12.7)
Performance status			
≤2	7815 (82)	53611 (95.3)	721 (96.7)
≥3	1722 (18)	2668 (4.7)	24 (3.3)
Dyspnea score			
≤2	9054 (89.5)	50 607 (89.9)	679 (91.1)
≥3	1068 (10.5)	5672 (10.1)	66 (8.85)
Priority of surgery			
Emergency	1582 (15.6)	9495 (16.9)	4 (0.5)
Elective	8540 (84.4)	46784 (83.1)	741 (99.5)
Procedure			
Mediastinoscopy or mediastinal surgery	2642 (26.1)	19622 (34.9)	133 (17.9)
Wedge resection	4389 (43.4)	11397 (20.2)	149 (20.0)
Lobectomy or Bilobectomy	2484 (24.5)	17650 (31.4)	231 (31.0)
Pneumonectomy	607 (6)	1783 (3.2)	19 (2.5)
Diagnosis group			
Benign	4339 (42.9)	21496 (38.2)	321 (43.1)
Malignant	5783 (57.1)	34783 (61.8)	424 (56.9)
Surgical approach			
Thoracotomy	6357 (62.8)	20841 (37)	260 (34.9)
VATS	1792 (17.7)	26504 (47.1)	302 (40.5)
Cervicotomy or other	1973 (19.5)	8934 (15.9)	154 (20.7)
Comorbidities			
None	3333 (32.9)	26421 (47)	153 (20.5)
1-2	4852 (47.9)	19432 (34.5)	427 (57.3)
≥3	1937 (19.2)	10426 (18.5)	165 (22.2)
In-hospital mortality			
No	9904 (98)	55377 (98)	731 (98.1)
Yes	218 (2)	902 (2)	14 (1.9)

Table II: Examination of risk factors affecting morbidity with binary logistic regression analysis.

	Univariate		Multivariate	
	OR (95% CI)	p	OR (95% CI)	p
Age	1.032 (1.015 – 1.049)	<0.001	1.004 (0.967 – 1.043)	0.815
Gender (Reference: male)	0.154 (0.079 – 0.3)	<0.001	0.555 (0.209 – 1.477)	0.239
ASA (Reference: 1)				
2	8.485 (4.058 – 17.742)	<0.001	1.008 (0.29 – 3.507)	0.989
3	42.625 (13.482 – 134.769)	<0.001	0.75 (0.068 – 8.255)	0.814
Performance status	4.974 (3.433 – 7.207)	<0.001	1.221 (0.576 – 2.591)	0.603
Dyspnea score	9.386 (6.321 – 13.937)	<0.001	4.916 (2.381 – 10.152)	<0.001
Priority of surgery (Reference: Elective)	16 (1.65 – 155.145)	0.017	2.19 (0.067 – 71.092)	0.659
Diagnosis group (Reference: Benign)	3.232 (2.037 – 5.129)	<0.001	0.781 (0.309 – 1.974)	0.601
Comorbidity score (Reference: 0)				
1	2.865 (1.344 – 6.107)	0.006	2.516 (0.596 – 10.628)	0.209
2	5.11 (2.405 – 10.855)	<0.001	2.033 (0.447 – 9.237)	0.358
3	4.917 (2.196 – 11.008)	<0.001	1.401 (0.274 – 7.151)	0.685
4	5.704 (1.819 – 17.88)	0.003	1.328 (0.165 – 10.681)	0.789
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Hospital stay (day)	2.056 (1.805 – 2.341)	<0.001	1.873 (1.628 – 2.154)	<0.001
Thoracoscore	1.121 (1.043 – 1.204)	0.002	1.044 (0.846 – 1.289)	0.689

OR = Odds ratio, CI = Confidence interval.

Table III: Examination of risk factors affecting 30-day and 90-day mortality by binary logistic regression analysis.

	30-day Mortality				90-day Mortality			
	Univariate		Multivariate		Univariate		Multivariate	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Age	1.078 (1.019 – 1.141)	0.009	1.067 (0.991 – 1.149)	0.086	1.072 (1.035 – 1.11)	<0.001	1.06 (1.017 – 1.105)	0.006
Performance status	3.355 (1.563 – 7.198)	0.002	0.561 (0.17 – 1.846)	0.341	2.51 (1.51 – 4.173)	<0.001	1.177 (0.551 – 2.511)	0.674
Dyspnea score	9.874 (3.663 – 26.618)	<0.001	5.789 (1.146 – 29.238)	0.034	3.247 (1.971 – 5.351)	<0.001	1.846 (0.821 – 4.152)	0.138
Diagnosis group (Reference: Benign)	2.823 (0.781 – 10.205)	0.113	0.407 (0.078 – 2.112)	0.284	3.997 (1.643 – 9.724)	0.002	2.088 (0.745 – 5.856)	0.162
Morbidity (Reference: No)	75.813 (9.816 – 585.54)	<0.001	79.931 (7.527 – 848.838)	<0.001	5.951 (2.996 – 11.819)	<0.001	0.891 (0.804 – 0.988)	0.029
Hospital stay (day)	1.082 (1.017 – 1.151)	0.013	0.876 (0.77 – 0.997)	0.044	1.051 (0.999 – 1.106)	0.057	5.87 (2.076 – 16.597)	0.001
Thoracoscore	1.113 (0.948 – 1.307)	0.190	1.107 (0.758 – 1.619)	0.598	1.09 (0.973 – 1.221)	0.138	0.914 (0.663 – 1.261)	0.586

OR = Odds ratio, CI = Confidence interval.

According to the univariate analysis, age, gender, ASA status, performance score, dyspnea score, diagnosis group, and morbidity were significant in estimating 90-day mortality. In multivariate analysis, only age, morbidity status, and length of stay were found to be significant. Consequently, the risk of 90-day mortality was found to increase 1.06-fold with the increasing age, 5.87-fold with the increasing length of hospital stay, and decrease 0.89-fold in the presence of morbidity (Table III).

DISCUSSION

In surgery, prediction models are frequently used to support the decision-making. A robustly developed and validated estimation model facilitates preoperative decision-making and provides an accurate estimate of the potential surgical risk. Patients may be incorrectly rejected or accepted for surgery if the model is inaccurate or incorrectly applied.[12,13] In recent years, numerous models for predicting the risk of perioperative mortality after thoracic surgery have been developed. The British Thoracic Society and the National Institute for Clinical Excellence both recommend using the Thoracoscore to estimate the risk of perioperative mortality.[2,9,10]

Although the Thoracoscore has been demonstrated to have good internal and external validity, a number of recent studies have cast doubt on its usefulness because it predicts risk using only nine variables, with unmeasured variables likely contributing to uncertainty. Therefore, Loucou *et al*. revised and validated the Thoracoscore in 2020, stating that it required improvement because the original model was obsolete and unsuitable for the clinical reality of the present day. This new risk model's C-index and calibration slope were robust and more applicable to a clinical practice.[11]

The majority of previous studies, including the original Thoracoscore, were conducted with a cohort of patients with cancer.[6,8,13,14] Malignant disease was present in 56.9% of the participants in the present study. Likewise, gender, age groups and procedures were similar to the previous studies. This is crucial for this study's accuracy and the reliable validation of its findings for the Turkish society.

Taylor *et al*. published a meta-analysis of studies describing risk prediction models designed to predict perioperative mortality in adult patients undergoing thoracic surgery. The authors concluded that there is no single model that is unambiguously appropriate for use in contemporary practice and emphasised the need to update these existing models with contemporary, multicentric studies employing robust statistical methodology.[12]

Taylor *et al*. validated six models, including the Eurolung model, the Brunelli model, the Thoracoscore, and the European Society Objective Score, for the purpose of estimating short-term mortality. They concluded that the Eurolung2 model had superior discrimination and calibration (AUC 0.73, p>0.05 for O:E), whereas the other models performed poorly. The authors attributed this to a significant change in the characteristics of patients undergoing thoracic surgery. In addition to a decrease in the number of patients undergoing open surgery for early-stage lung cancers, a net increase in parenchymal sparing procedures (such as segmentectomies and sleeve resections) and minimally invasive surgery rates had been observed, resulting in a decrease in morbidity and mortality rates. Therefore, the authors emphasised the urgent need to develop a precise model applicable to contemporary clinical practice.[5]

In a study conducted in India, Pathy *et al*. reported that Thoracoscore underestimates mortality, has poor calibration, and fair discriminant ability. The authors stated that Thoracoscore is not suitable for the Indian population due to the prevalence of tuberculosis in their country and the fact that the majority of thoracic surgeries are performed to treat tuberculosis-related complications.[15]

Dejan *et al*. reported good performance of the Thoracoscore in their clinic and reported that it could be used to predict in-hospital mortality for patients undergoing lung resection. In addition, they found that advanced age, male gender, and malignant pathology were the most accurate predictors of in-hospital mortality.[14]

Sharkey *et al*. analysed the ROC for Thoracoscore and ESOS.01 and reported an in-hospital mortality C-index of

0.705%. Although this is statistically significant, it demonstrates an ability to discriminate that is, at best, acceptable but by no means excellent. Consequently, it has not been demonstrated that both Thoracoscore and ESOS.01 are adequate for predicting in-hospital mortality. Both had a C-index below 0.75, indicating that they were unreliable predictors of mortality in this patient population. The authors attributed this improvement in patient outcomes to the use of minimally invasive surgical techniques and limited anatomical resections in this population.[8]

Bradley *et al*. reported that the AUC value of Thoracoscore to predict mortality was 0.68 (95% CI: 0.56-0.80), which is considered an adequate but insufficient capacity for discrimination. In contrast to Thoracoscore, ESOS was found to be a more significant predictor of mortality in their study population, with poor predictive ability but excellent discrimination.[16]

The benefit of this study is that despite being conducted in a single centre involving a small number of patients, the study data are reliable because the same surgical team operated on all patients, and the same team handled postoperative follow-up. Again, when compared with other studies, it was found that the number of patients operated for malignancy and patients who underwent thoracotomy/VATS in the present study were similar. The mean Thoracoscore value in this study was found to be -4.79±2.2, with a sensitivity and specificity of 60.83% and 73.12% for morbidity, respectively. The sensitivity and specificity of 30-day mortality were 85.71% and 68.67%, respectively, while for 90-day mortality, they were 69.44% and 67.0% respectively. In light of these results, the Thoracoscore has an acceptable discriminative power in the patient population included in this study, but its sensitivity and specificity are limited. Furthermore, according to the multivariate analysis, dyspnea score and length of hospital stay were significant predictors of morbidity, with morbidity increased by 4.91-fold for each unit increase in dyspnea score. The presence of morbidity was a significant risk factor in predicting 30- and 90-day mortality. It was found that 30-day mortality increased 79.931 times and 90-day mortality increased 5.87 times in the presence of morbidity.

The most important limitation of this study was that it was based on a single-centre and included a small patient population. Despite the small number of patients included in the study, the majority of thoracic surgery procedures were included. In the future, a study limited to patients who have undergone lung resection could be conducted.

CONCLUSION

Although the AUC value of the Thoracoscore has acceptable discriminatory power in the patients included in this study, its sensitivity and specificity are limited. Therefore, even though it is safe to say that the Thoracoscore's validity has been established through this study, additional multicentre studies with as many patients and control groups as possible are required to fully comprehend the test's limitations and accuracy.

ETHICAL APPROVAL:
The study was carried out in accordance with the Declaration of Helsinki and approved by the Clinical Research Ethics Committee of Ondokuz Mayis University (Approval No. KAEK-2022/243).

PATIENTS' CONSENT:
Not applicable as the data were obtained retrospectively.

ACKNOWLEDGEMENT:
Thanks to Dr. Naci Murat from Department of Industrial Engineering, Ondokuz Mayis University Faculty of Engineering, for his contribution to the statistical evaluation of this study.

COMPETING INTEREST:
The authors declared no competing interest with respect to the authorship and/or publication of this article.

AUTHORS' CONTRIBUTION:
HKC, BC: Conception and design, drafting of the manuscript, material preparation, data collection and analysis, revision of the manuscript.
All authors approved the final version of the manuscript to be published.

REFERENCES

1. Taversky A, Kahnemann D. Judgement under uncertainty: Heuristics and biases. *Science* 1974; **185(4157)**:1124-31. doi: 10.1126/science.185.4157.1124.
2. Falcoz PE, Conti M, Brouchet L, Chocron S, Puyraveau M, *et al*. The thoracic surgery scoring system (Thoracoscore): Risk model for in-hospital death in 15,183 patients requiring thoracic surgery. *J Thorac Cardiovasc Surg* 2007; **133(2)**: 325-32. doi:10.1016/j.jtcvs.2006.09.020.
3. Berrisford R, Brunelli A, Rocco G, Treasure T, Utley M. Audit and guidelines committee of the European society of thoracic surgeons; European association of cardiothoracic surgeons. The European thoracic surgery database project: Modelling the risk of in-hospital death following lung resection. *Eur J Cardiothorac Surg* 2005; **28(2)**:306-11. doi: 10.1016/j.ejcts.2005.03.047.
4. Brunelli A, Salati M, Rocco G, Varela G, Van Raemdonck D, Decaluwe H, *et al*. European risk models for morbidity (EuroLung1) and mortality (EuroLung2) to predict outcome following anatomic lung resections: An analysis from the European society of thoracic Surgeons database. *Eur J Cardiothorac Surg* 2017; **51(3)**:490-7. doi: 10.1093/ejcts/ezw319.
5. Taylor M, Szafron B, Martin GP, Abah U, Smith M, Shackcloth M, *et al*. North West thoracic surgery collaborative (NWTSC). External validation of six existing multivariable clinical prediction models for short-term mortality in patients undergoing lung resection. *Eur J Cardiothorac Surg* 2021; **59(5)**: 1030-6. doi: 10.1093/ejcts/ezaa422.

6. Chamogeorgakis T, Toumpoulis I, Tomos P, Ieromonachos C, Angouras D, Georgiannakis E, *et al*. External validation of the modified Thoracoscore in a new thoracic surgery program: prediction of in-hospital mortality. *Interact Cardiovasc Thorac Surg* 2009; **9(3)**:463-6. doi: 10.1510/icvts.2008.201178.
7. Chamogeorgakis TP, Connery CP, Bhora F, Nabong A, Toumpoulis IK. Thoracoscore predicts midterm mortality in patients undergoing thoracic surgery. *J Thorac Cardiovasc Surg* 2007; **134(4)**:883-7. doi: 10.1016/j.jtcvs.2007.06.020.
8. Sharkey A, Ariyaratnam P, Anikin V, Belcher E, Kendall S, Lim E, *et al*. Thoracoscore and European society objective score fail to predict mortality in the UK. *World J Oncol* 2015; **6(1)**:270-5. doi: 10.14740/wjon897w.
9. Lim E, Baldwin D, Beckles M, Duffy J, Entwisle J, Faivre-Finn C, *et al*. Guidelines on the radical management of patients with lung cancer. *Thorax* 2010; **65(Suppl 3)**:iii1-27. doi: 10.1136/thx.2010.145938.
10. The diagnosis and treatment of lung cancer (update of NICE clinical guideline): CG 121. Lung Cancer: Diagnosis and management. NICE Guideline, 2019. Available from: http://www.nice.org.uk/guidance/ng122.
11. Loucou JD, Pagès PB, Falcoz PE, Thomas PA, Rivera C, Brouchet L, *et al*. Validation and update of the thoracic surgery scoring system (Thoracoscore) risk model. *Eur J Cardiothorac Surg* 2020; **58(2)**:350-6. doi: 10.1093/ejcts/ezaa056.
12. Taylor M, Hashmi SF, Martin GP, Shackcloth M, Shah R, Booton R, *et al*. A systematic review of risk prediction models for perioperative mortality after thoracic surgery. *Interact CardioVasc Thorac Surg* 2021; **32(3)**:333-42. doi: 10.1093/icvts/ivaa273.
13. Qadri SS, Jarvis M, Ariyaratnam P, Chaudhry MA, Cale AR, Griffin S, *et al*. Could Thoracoscore predict postoperative mortality in patients undergoing pneumonectomy? *Eur J Cardiothorac Surg* 2014; **45(5)**:864-9. doi: 10.1093/ejcts/ezt517.
14. Dejan D, Gorica M, Ljiljana G. Thoracoscore: Predicting risk of in-hospital mortality for patients undergoing pulmonary resection. *Vojnosanit Pregl* 2018; **75(3)**:297-300. doi: 10.2298/VSP160228333D.
15. Pathy A, Kar P, Gopinath R, Gubba D, Soujanya Rani N, Kanimozhi A. Thoracoscore: Does it predict mortality in the Indian scenario? A retrospective study. *Indian J Anaesth* 2022; **66(Supply 5)**:257-63.
16. Bradley A, Marshall A, Abdelaziz M, Hussain K, Agostini P, Bishay E, *et al*. Thoracoscore fails to predict complications following elective lung resection. *Eur Respir J* 2012; **40(6)**:1496-501. doi: 10.1183/09031936.00218111.