EGYPTIAN JOURNAL OF ANAESTHESIA
2023, VOL. 39, NO. 1, 557–562
https://doi.org/10.1080/11101849.2023.2235148

Role of Thoracoscore and ESOS in Prediction of Outcomes after Thoracic Surgeries

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ABSTRACT

Background: The use of scores in thoracic surgery has been done recently. European Society Objective Score (ESOS) and Thoracoscore are the most popular scores used in thoracic operations. This work aimed to compare ESOS and Thoracoscore's ability in predicting the mortality after thoracic surgery.
Methods: This retrospective study involved 282 cases who were admitted to thoracic surgery unit, Tanta University Hospitals and other hospitals whose Thoracoscore and ESOS were calculated from January 2017 to December 2022.
Results: Mortality rate at 30 days postoperative was 7.44% in our study. Pneumonectomy and MV (mechanical ventilation) were significantly associated with mortality (P value < 0.001). Thoracoscore can predict mortality (P value = 0.004 and AUC = 0.629) with 61.9% sensitivity, 56.70% specificity, 10.3% positive predictive value (PPV), and 94.9% negative predictive value (NPV). ESOS can predict mortality (P value = 0.006 and AUC = 0.662) with 85.71% sensitivity, 37.55% specificity, 9.9% PPV and 97% NPV. ESOS was an independent significant predictor for mortality while Thoracoscore was not.
Conclusions: ESOS and Thoracoscore are applicable tools in predicting the mortality after thoracic surgeries. However, ESOS is more sensitive and more specific.

ARTICLE HISTORY
Received 9 May 2023
Accepted 6 July 2023

KEYWORDS
Thoracoscore; ESOS; thoracic surgeries; mortality

1. Introduction

Risk prediction assists in determining the potential risks with a certain patient undergoing a specific surgery [1]. Risk stratification in the preoperative phase improves the prognosis of individual cases, hence facilitating counselling. It can also assist enterprises with resource allocation planning. In cardiac surgery, there is a great deal of literature and focus on prior risk prediction scores [2]. However, risk scoring methods in thoracic surgery are relatively recent and less frequently employed [3]. The recommendations of the British Thoracic Society now mandate preoperative risk evaluation through the adoption of a score system for effective patient identification and giving risk-adjusted in-hospital death rates for specific thoracic surgery cases [4]. The use of scores in thoracic surgery has been done recently. European Society Objective Score (ESOS) and Thoracoscore are the most popular ones used in thoracic operations. This allows surgeons to assess the risk of death as long as medical conditions of the patient [5]. Falcoz et al. established the Thoracoscore to predict 30-day mortality in cases undergoing thoracic surgery [6]. It was evaluated in 2006 utilising the French Thoracic Surgery Database of more than 15,000 cases registered in the national Epithor database [7]. It is a logistic model that includes nine pre-operative and operational variables. The correlation between the predicted and actual number of fatalities was 0.99. Then, in 2007 and 2009, it was internationally verified using individuals from the United States and again proved to be accurate and reliable [8,9]. Thoracoscore was demonstrated to be a substantial predictor of hospital death in thoracic surgery procedures [8].

European Society of Thoracic Surgery produced the ESOS.01. Project for the Thoracic Surgery Database. It simply has two variables: age and expected postoperative FEV1 [10]. ESOS.01 has been demonstrated to be significant predictor for mortality [11].

Typically, risk stratification techniques are developed in a large population cohort in one nation and then verified in other nations. Countries vary in terms of the racial composition of their populations, the nature of their diseases, the treatment methods they employ, and their surgical expertise. Therefore, risk stratification algorithms must be validated in

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a specific nation prior to clinical application [12]. Therefore, the aim of this work was to compare the ability of Thoracoscore and ESOS in predicting the mortality after thoracic surgery in our center.

2. Materials and methods

This retrospective study involved 282 cases who were admitted to thoracic surgery unit of the Cardiothoracic Surgery Department – Tanta University Hospitals and other hospitals whose Thoracoscore and ESOS were calculated from January 2017 to December 2022. The research was conducted with the approval of the Tanta University Hospitals Ethical Committee (approval code: 36264PR66/1/23). Cases with many missing data were excluded.

2.1. The following data were collected

2.1.1. Preoperative data

Full history was taken involving demographic data, special habits, and comorbidities (history of congestive heart failure, hypertension, DM, hepatic diseases, chronic obstructive pulmonary diseases, tuberculosis or other malignancy). Clinical examination, laboratory investigations, and additional staging techniques (invasive staging procedures, brain magnetic resonance imaging and PET scan) were done. In addition, pulmonary function tests were carried out for the assessment of potential peak exercise and estimation of ESOS.

2.1.2. Intraoperative data

Surgical procedure (video-assisted thoracoscopic surgery or open thoracotomy), lung ventilation type (single or double lumen tube), type of operation (pneumonectomy, lobectomy and wedge resection), epidural analgesia, duration of surgery and mode of ventilation upon discharge from operating room (extubated or mechanically ventilated) were recorded.

2.1.3. Postoperative data

All cases were on a regimen for routine postoperative physiotherapy consisting of comprehensive breathing exercises, incentive spirometry, coughing and mobilization. Thirty-day mortality was recorded. Cases were stratified into survivor and non-survivors and the data were tabulated and compared.

2.1.4. Risk scores

Thoracoscore were calculated according to Table 1 [6]. ESOS variables are age and predicted postoperative FEV1 (ppoFEV1). The postoperative expected FEV1 (ppoFEV1), whether by considering the activity of the compromised lung (perfusion lung scan) or utilising the formula ppoFEV1= preoperative FEV1 − (1 − $S \times$ 0.0526) where S = amount of pulmonary resected segments [13].

Table 1. Thoracoscore.

Variable	Value	Code
1. Age (years)	<55	0
	55–65	1
	≥65	2
2. Sex	Male	0
	Female	1
3. ASA Classification	≤2	0
	≥3	1
4. Performance Status Classification	≤2	0
	≥3	1
5. Dyspnea score	≤2	0
	≥3	1
6. Priority of surgery	Elective	0
	Urgent or emergency	1
7. Procedure class	Other	0
	Pneumonectomy	1
8. Diagnosis group	Benign	0
	Malignant	1
9. Comorbidity score #	0	0
	≤2	1
	≥3	2

ASA: American Society of Anesthesiologist, #**Comorbidity score**: smoking, history of cancer, COPD, arterial hypertension, heart disease, diabetes mellitus, peripheral vascular disease, obesity and alcoholism.

Sample size calculation was done by MedCalc Software Ltd v. 20. With 95% power, 5% confidence limit, expected AUC of ROC curve of ESOS in the prediction of mortality is at least 0.7 in previous study [14] and null hypothesis AUC of ROC curve is 0.5. Therefore, at least 100 patients should be included in the study.

2.1.5. Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro–Wilks test and histograms were used to estimate the normality of the distribution of data. Quantitative parametric variables were presented as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student’s *t*-test. Non-parametric quantitative data were displayed as median and interquartile range (IQR) and were tested by Mann–Whitney test. Qualitative variables were displayed as frequency and percentage (%) and were analyzed utilizing the Chi-square test or Fisher’s exact test when applicable. ROC curve was used to show the role of Thoracoscore and ESOS as predictor for mortality through the evaluation of sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). Multivariate regression analysis was used for the prediction of factors affecting mortality. A two-tailed P value < 0.05 was judged significant.

3. Results

The study enrolled 282 cases who were stratified into survivor group (n = 261) and non-survivors’ group (n =

Table 2. Comparison between survivors and non-survivors regarding the preoperative parameters.

		Survivors ($n=261$)	Non-survivors ($n=21$)	P value
Age (years)		45.72 ± 17.54	54.52 ± 26.17	0.035*
Sex	Male	154 (59%)	18 (85.71%)	0.016*
	Female	107 (41%)	3 (14.29%)	
BMI (kg/m^2)		28.4 ± 9.68	25.53 ± 6.86	0.185
Smoker		125 (47.89%)	7 (33.33%)	0.198
Comorbidities	Congestive heart failure	39 (14.94%)	6 (28.57%)	0.101
	Hypertension	39 (14.94%)	2 (9.52%)	0.498
	DM	74 (28.35%)	10 (47.62%)	0.063
	Hepatic disease	55 (21.07%)	3 (14.29%)	0.459
	TB	22 (8.43%)	2 (9.52%)	0.863
	COPD	49 (18.77%)	6 (28.57%)	0.276
	Other malignancy	24 (9.2%)	0 (0%)	0.146
Preoperative diagnosis	Benign	179 (68.58%)	10 (47.62%)	0.05
	Malignant	82 (31.42%)	11 (52.38%)	
ASA physical status	ASA I	49 (18.77%)	5 (23.81%)	0.655
	ASAII	112 (42.91%)	10 (47.62%)	
	ASA III	100 (38.31%)	6 (28.57%)	
Performance status score		0.99 ± 0.83	1.24 ± 0.89	0.194
Dyspnea score		1.23 ± 1.08	1 ± 0.89	0.344
Respiratory rate		22.06 ± 3.7	25.81 ± 4.08	<0.001*
FEV$_1$ (%)		66.2 ± 20.82	59.45 ± 13.35	0.145
ppoFEV1 (L)		1.56 ± 0.69	1.41 ± 0.61	0.316
FVC (L)		2.37 ± 0.96	1.86 ± 0.63	0.018*

Data are presented as mean ± SD or frequency (%). BMI: body mass index, DM: diabetes mellitus, TB: tuberculosis, COPD: chronic obstructive pulmonary disease, ASA: American Society of Anesthesiologists, TLC: total leukocyte count *: Significant when P value ≤ 0.05.

21). Mortality rate at 30 days postoperative was 7.44% in our trial.

Age, male sex and respiratory rate were higher significantly in non-survivors compared to survivors (P value < 0.05), while FVC was significantly lower in non-survivors than survivors (P value < 0.05). BMI, smoker, ASA, performance status score, dyspnoea score, FEV1, ppoFEV1, congestive heart failure, hypertension, DM, hepatic disease, TB, COPD, other malignancy and preoperative diagnosis were matched between both groups (Table 2).

Surgical approach, type of ventilation, epidural analgesia, and operative duration were insignificantly different between both groups. Operation type were significantly different as pneumonectomy was higher significantly in non-survivors than survivors and discharge from OR was significantly different as MV significantly higher in non-survivors than survivors (P value < 0.001) (Table 3).

Thoracoscore and ESOS were higher significantly in non-survivors than survivors (P value = 0.031 and 0.003, respectively) (Table 4).

Thoracoscore can predict mortality (P value = 0.004 and AUC = 0.629) with 61.9% sensitivity, 56.70% specificity, 10.3% PPV and 94.9% NPV. ESOS can predict mortality (P value = 0.006 and AUC = 0.662) with 85.71% sensitivity, 37.55% specificity, 9.9% PPV and 97% NPV (Figure 1).

ESOS was an independent significant predictor for mortality while Thoracoscore was not (Table 5).

Table 3. Comparison between survivors and non-survivors regarding the operative parameters.

		Survivors ($n=261$)	Non-survivors ($n=21$)	P value
Surgical approach	Thoracotomy	204 (78.16%)	18 (85.71%)	0.416
	VATS	57 (21.84%)	3 (14.29%)	
Type of ventilation	Single	115 (44.06%)	7 (33.33%)	0.340
	Double	146 (55.94%)	14 (66.67%)	
Operation type	Lobectomy	165 (63.22%)	11 (52.38%)	<0.001*
	Wedge resection	81 (31.03%)	2 (9.52%)	
	Pneumonectomy	15 (5.75%)	8 (38.1%)	
Epidural analgesia		74 (28.35%)	3 (14.29%)	0.164
Operative duration (h)		3.12 ± 1.53	3.72 ± 1.19	0.081
Discharge from OR	Extubated	250 (95.79%)	16 (76.19%)	<0.001*
	MV	11 (4.21%)	5 (23.81%)	

Data are presented as mean±SD or frequency (%), OR: operating room, VATS: video-assisted thoracoscopic surgery, *: Significant when P value ≤ 0.05.

Table 4. Thoracoscore and ESOS of the studied groups.

	Survivors ($n=261$)	Non-Survivors ($n=21$)	P value
Thoracoscore (%)	2 (1–3)	3 (2–3)	0.031*
ESOS	0.78 (0.3–2.15)	1.5 (0.5–6.38)	0.003*

Data are presented as median (IQR). *: Significant when P value ≤ 0.05.

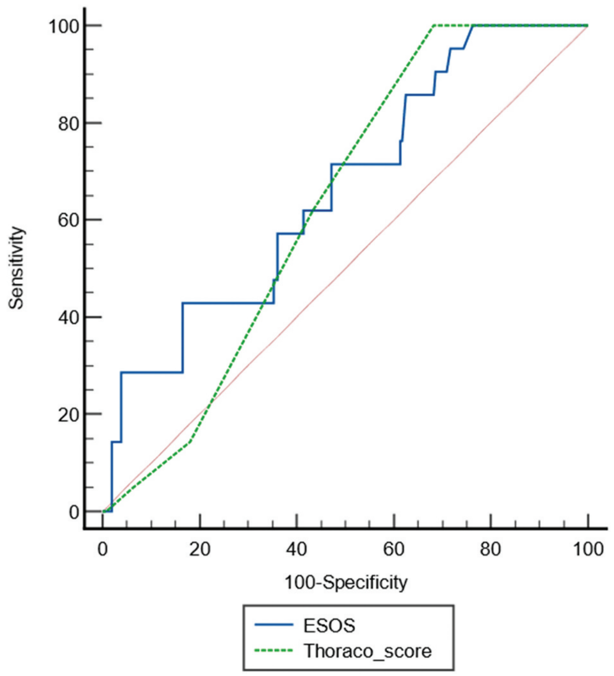

Figure 1. ROC curve of Thoracoscore and ESOS in the prediction of mortality rate.

4. Discussion

Risk prediction scores are utilised increasingly in all surgical subfields for predicting postperative mortality [15]. To simplify the consent procedure and to enable risk-adjusted surgery and mortality at a central location assessment, a precise evaluation of in-hospital mortality risk is necessary [16].

Our results revealed that 21 cases died (mortality rate of 7.44%). A 30-day mortality rate was obtained in Rosen et al. [17], Sharkey et al. [18] and Manlhiot [19] studies. Rosen et al. [17], reported overall 30-day mortality rate was 3.4% utilizing The National Cancer Database (NCDB) which is the world's largest cancer registry catching 67% of recently diagnosed non-small cell lung cancer in the United States. Sharkey et al. [18] documented that the observed in-hospital mortality was 31 cases (1.38%) utilizing data of cases experiencing lung resection at six UK centres. Also, Manlhiot [19] highlighted that the observed mortality was 1.96% and the Canadian Institute of Health Information's collection of discharge abstracts was the primary source of administrative data for their analysis.

Our results revealed that operation type were significantly different as pneumonectomy was significantly higher in non-survivors than survivors and discharge from operating room was significantly different as MV higher significantly in non-survivors than survivors.

Similary, Rosen et al. [17] reported that the 30-day mortality rate differed by operation: (2.6%) in lobectomy/bilobectomy, (4%) in extended lobectomy/bilobectomy, (4.2%) in wedge resection, and (8.5%) in pneumonectomy.

According to our findings, age, male sex and respiratory rate were significantly elevated in non-survivors than survivors.

In Shapiro et al. [20] study, several patient variables linked with a higher incidence of serious side effects were revealed by multivariable regression analysis. It was found that patients aged greater than 65 years was an independent predictor of side effects following pneumonectomy. This influence of ageing conforms to data reported by the National Veterans Affairs Surgical Quality Improvement Program and the Lung Cancer Study Group, both of which discovered an increase in the risk of perioperative death for all lung resections among geriatrics [21,22].

Several single-institution studies and meta-analyses have revealed an increased incidence of serious adverse events with advancing age [23–25]. In this investigation, male sex was also observed to be related with significant perioperative mortality. Unknown is the rationale for this intriguing observation.

In Shapiro et al. [20] study, congestive heart failure was a rare comorbidity among cases experiencing pneumonectomy, with just 24 of the 1267 cases studied (1.9%) having this ailment. However, it was proven to be a significant predictor of unfavourable outcome. Given the appropriate cardiac dysfunction that pneumonectomy can generate [26], It is not unexpected that pre-existing heart failure is accompanied by an increased risk of significant morbidity and mortality following pneumonectomy. Comparable to our findings, Rosen et al. [17] reported that aging, male sex, and rising comorbidities, were related with a higher incidence of longer duration of stay in multivariable analyses. In their systematic review, Taylor et al. [27] analysed models of perioperative mortality prediction following thoracic surgery. Age, sex, and pneumonectomy were the most common predictors considered which came in line with our findings. Our results demonstrated that Thoracoscore can predict mortality (*P* value = 0.004 and AUC = 0.629) with 61.9% sensitivity, 56.70% specificity, 10.3% PPV and 94.9% NPV. ESOS can predict mortality (*P* value = 0.006 and AUC = 0.662) with 85.71% sensitivity, 37.55% specificity, 9.9% PPV and 97% NPV. ESOS was an independent significant predictor for mortality, while Thoracoscore was not. Our findings agreed with Pathy et al. [12] who concluded that

Table 5. Multivariate regression analysis for prediction of mortality rate.

Variable	Coefficient	Std. Error	Wald	Odds ratio (95% CI)	*P*
Thoracoscore	0.151	0.185	0.670	1.16 (0.81–1.67)	0.413
ESOS	0.198	0.093	4.527	1.22 (1.02–1.46)	0.033*

Significant when *P* value ≤ 0.05, CI: confidence interval.

Thoracoscore possessed mediocre calibration and discrimination capabilities. In the Indian population, Thoracoscore failed for mortality prediction. Also, Bradley et al. [28] reported that ESOS predicted mortality (OR 1.43, 95% CI 1.11–1.83; $p = 0.006$).

However, a validity of Thoracoscore as clinical mean for mortality risk prediction in-hospital mortality in 15,183 cases considering a thoracic operation was confirmed by Falcoz et al. [6] in France. In New York, Chamogeorgakis et al. [29] also suggested Thoracoscore as a valuable clinical tool for predicting in-hospital and midterm mortality in cases following routine thoracic surgery. Also, our results are in contrast of Sharkey et al. [18] who investigated that both thoracoscore and ESOS.01 overemphasized mortality among cases undergoing general thoracic surgery Therefore, there is an ongoing need to design an acceptable risk predictive model for the UK population. Poullis et al. [14] reported that ROC values of 0.69, 0.70, and 0.61 for the Thoracoscore, ESOS.01, and STS risk models, respectively, indicate that none of these models is particularly accurate.

The present study is limited by a relatively small sample size and retrospective design. Consequently, additional prospective studies with larger sample sizes are necessary to generalize our results.

5. Conclusions

ESOS and Thoracoscore are applicable tools in predicting the mortality after thoracic surgeries. However, ESOS is more sensitive and more specific.

Acknowledgments

Nothing to declare.

Disclosure statement

None of the authors has a conflict of interest.

Funding

No funding was obtained for this investigation.

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Availability of data and material

The datasets utilized and/or analyzed for this work are accessible as MS Excel files (.xlsx) from the corresponding author upon reasonable request.

Sponsors and funding sources

There are none to be declared.

Ethical approval and protocol registration

The study was done after approval by the Faculty of Medicine's Ethical Committee at Tanta University (approval code: 36264PR66/1/23) and all cases provided informed consent.

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