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The effectiveness of ARISCAT Risk Index, other scoring systems, and parameters in predicting pulmonary complications after thoracic surgery

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Abstract

The Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) risk index, which is frequently used in nonthoracic surgery, may not be sufficient to predict postoperative pulmonary complications (PPCs). We aimed to evaluate the effectiveness of the ARISCAT risk index, ASA, preoperative albumin level, neutrophil/lymphocyte ratio (NLR), and other parameters in predicting PPCs after thoracic surgery.

Patients undergoing elective thoracic surgery with 1-lung ventilation (OLV) were prospectively analyzed. Demographic data, ARISCAT score, ASA, Nutritional Risk Score-2002, NLR, white blood cell counts, albumin, hemoglobin levels, intraoperative complications, postoperative average visual analogue scale (VAS) score for pain at the 24th-hour, the length of stay in the postoperative intensive care unit, chest tube removal time, postoperative complications, and discharge time were recorded. Patients were assessed for morbidity and mortality on the 90th-day.

120 patients' data were analyzed. PPCs developed in 26 patients. The development of PPCs was statistically significant in patients with high ARISCAT scores (P = .002), high ARISCAT grades (P = .009), and ASA III (P = .002). The albumin level was statistically significantly lower in patients who had mortality within 3 months (P = .007). When scoring systems and laboratory parameters were evaluated together, patients with high ARISCAT grade, Albumin < 35g/L, and ASA III had significantly higher development of PPCs (P = .004).

ARISCAT risk index and ASA were found to be significant in predicting PPCs after thoracic surgery. They were also valuable when evaluated in combination with preoperative albumin levels. Additionally; age, male gender, duration of surgery, and duration of OLV were also found to be associated with PPCs.

Abbreviations: ARISCAT = The Assess Respiratory Risk in Surgical Patients in Catalonia, ASA = American Society of Anesthesiologists, BMI = Body mass index, COPD = Chronic obstructive pulmonary disease, NLR = Neutrophil/lymphocyte ratio, NRS-2002 = Nutritional risk score, OLV = One-lung ventilation, PCA = Patient-controlled analgesia, PONV = Postoperative nausea and vomiting, PPCs = Postoperative pulmonary complications, SD = Standard deviations,VAS = Visual analog scale, VATS = Video-assisted thoracoscopic surgery.

Keywords: American Society of Anesthesiologist (ASA), albumin, postoperative pulmonary complications, The Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT), thoracic surgery

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

IRB: Keçioren Training and Research Hospital Ethical Committee; ID: 2012-KAEK-15/2230 Date: 03.09.2021.

Compliance with Ethical Standards: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration (as revised in 2013) and its later amendments or comparable ethical standards.

Ethical Statement: The study was performed in agreement with the approval of the Ethics Committee (Date: 03.09.2021, number: 2012-KAEK-15/2230).

Clinical trial number and registry URL: This "The Effectiveness of ARISCAT Risk Index, Other Scoring Systems, and Parameters in Predicting Pulmonary Complications after Thoracic Surgery" trial was registered on www.clinicaltrials.gov under the identifier NCT04995939. This manuscript adheres to the applicable Consolidated Standards of Reporting Trials (CONSORT) guidelines.

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1. Introduction

Postoperative pulmonary complications (PPCs) include complications affecting the respiratory system after anesthesia and surgery. These complications are common, difficult to predict, and have significant effects on patients.[1] PPCs emerge as a major risk. It affects the morbidity and mortality of patients and is effective in the length of hospital stay and hospital costs.[2] The incidence of PPCs in the general population undergoing surgery varies between 2% and 5.6%.[3] This rate was 19–59% after thoracic surgery, 16–17% after upper-abdomen surgery, and 0–5% after lower-abdomen surgery.[4,5] Because of the high incidence and risks, it is important to predict PPCs before surgery and take the necessary precautions according to the surgical methods.

The American Society of Anesthesiologists (ASA) physical status assessment is used to subjectively predict the health status of patients before surgery. Although it was originally a scoring system created for statistical data collection and reporting for anesthesiology, it is now used to predict perioperative risk.[6,7] However, ASA physical status assessment may not be sufficient to predict complications that may develop in certain surgical groups.[8] Therefore, many different scoring systems are used during the preoperative period to determine the risk status of patients. There are also studies on scoring systems that can be effective in predicting PPCs. The Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) risk index is a frequently used scoring system. The ARISCAT risk index is derived using many variables such as age, oxygen saturation, previous respiratory infection, anemia, abdominal or thoracic surgery, duration of operation, and emergency surgery.[9] The ARISCAT risk index was developed to predict the risk of PPCs and has shown promising results.[10]

The ARISCAT risk index is mostly used in operations other than thoracic surgery. Since the thoracic wall, mediastinum, or lungs are directly intervened in thoracic surgery cases, the expected PPCs in these patients may be different from those expected in other surgical groups. Therefore, the ARISCAT risk index may be insufficient to evaluate PPCs in thoracic surgery.

Many parameters obtained from the blood count, such as the neutrophil/lymphocyte ratio (NLR), have prognostic value in cardiovascular and oncological diseases and can be a potential marker of systemic inflammation.[11–14] Many studies reported that high NLR, low hemoglobin, and low serum albumin levels show an unfavorable prognosis in lung cancer.[15–17] Additionally, many studies have shown that blood values such, as white blood cell count, neutrophil count, and NLR, are valuable in predicting prognosis, mortality, complications, and hospital stay in cardiovascular diseases.[18–20]

We hypothesize that various scoring systems and laboratory parameters may be more effective in predicting PPCs in patients undergoing thoracic surgery. In this study, we evaluated the effectiveness of the ARISCAT risk index, ASA physical status, nutritional risk score (NRS-2002), NLR, albumin, hemoglobin level, and the combined use of parameters in predicting PPCs after thoracic surgery.

2. Materials and Methods

2.1. Study design

After Ethics Committee approval was obtained for this prospective observational study (Date: 03.09.2021, number: 2012-KAEK-15/2230), it was performed in a tertiary thoracic surgery center between March 2021 and August 2021. The following patients were included in the study: those undergoing elective thoracotomy or video-assisted thoracoscopic surgery (VATS) under general anesthesia with 1-lung ventilation (OLV); those between the ages of 18–75, in the ASA physical status I-II-III risk group, with a body mass index (BMI) 18.5–35 kg/m^2, and with an expected operation time of more than 60 minutes. The study was registered to the Clinical Trial (clinicaltrials.gov Identifier: NCT04995939).

Patients who underwent bilateral thoracic surgery, those with chronic obstructive pulmonary disease (COPD) in class III and IV according to the GOLD classification, with advanced heart failure, coronary heart disease, sleep apnea syndrome, previous COVID-19 pneumonia, and previous lung surgery, with neuromuscular disease, and intracranial tumor, and those who had any of the PPCs before anesthesia induction were excluded from the study. The European joint task force published a guideline for the perioperative clinical outcome in 2015 and specified the definition of PPCs.[21] Later, Miskovic and Lumb revised this definition and stated that PPCs include complications such as aspiration, infiltration, pulmonary infection, atelectasis (required bronchoscopic intervention), cardiopulmonary edema, pleural effusion, pneumothorax, pulmonary embolism, empyema, and hemoptysis.[1] In the study PPCs also included prolonged air leakage which was a persistent air leak for more than 5 to 7 days after surgery.

Written informed consent was obtained from the patients 1 day before the operation. During the preoperative anesthesia evaluation, the following data were recorded: Gender, age, height, body weight, BMI, ARISCAT score, ARISCAT risk score classification, ASA physical status, and NRS-2002. ARISCAT risk score classification is shown in Table 1.[9] The NLR, white blood cell count, albumin, hemoglobin, preoperative oxygen saturation, pulmonary function test results, history of previous surgery, and concomitant diseases were also noted. The NLR was calculated by dividing the absolute neutrophil count by the absolute lymphocyte count.

During the intraoperative process; anesthesia duration, total OLV time, blood loss, urine output, regional anesthesia management, duration of operation, surgical procedure (VATS or thoracotomy), surgery performed, complications requiring intraoperative treatment, type of neuromuscular block antagonist applied at the end of surgery were recorded. The type and total amount of blood product and fluid administered were also noted.

The volumes of crystalloids, colloids, blood products, and the doses of vasoactive drugs administered within 24 hours after leaving the operating room were recorded. Additionally,

Table 1

Parameters of the ARISCAT score and risk classification.[9]

Score components		Risk score
Age	≤50 year	0
	51–80 year	3
	>80 year	16
Preoperative oxygen saturation	≥96%	0
	91–95%	8
	≤ 90%	24
Respiratory infection in past 1 month	No	0
	Yes	17
Preoperative hemoglobin < 10 g/dl	No	0
	Yes	11
Incision	Peripheral incision	0
	Upper abdominal incision	15
	Intrathoracic incision	24
Surgery duration	<2 hours	0
	2–3 hours	16
	>3 hours	23
Emergency procedure	No	0
	Yes	8
Risk		ARISCAT Score
Low		< 26 (1.6%)
Medium/Intermediate		26–44 (13.3%)
High		≥ 45 (42.1%)

oxygen saturation, mean arterial pressure, heart rate, white blood cell count, NLR, albumin, hemoglobin values, and average visual analog scale (VAS) score for pain at the 24th hour were recorded.

Applied analgesic method after surgery, need for noninvasive or invasive mechanical ventilation outside the operating room, indication, and duration if any, duration of stay in the postoperative intensive care unit, history of new or recurrent intensive care admissions in the postoperative period, fiber optic bronchoscopy application, the reason if applied, postoperative nausea and vomiting (PONV), time to chest tube removal, presence of postoperative extrapulmonary and pulmonary complications requiring treatment, and discharge time were recorded. The patients included in the study were called on the 90th day and assessed for morbidity and mortality.

2.2. General anesthesia

Patients were monitored in the operating room under the ASA standards and 0.03 mg/kg midazolam was administered intravenously to the patients for premedication. Following preoxygenation; anesthesia was induced with 2–2.5 mg/kg propofol, 1–1.5 mcg/kg fentanyl, and 0.1 mg/kg vecuronium intravenously. After the intubation with a left-sided double-lumen endobronchial tube, anesthesia was maintained by administering 2–3% sevoflurane in oxygen and air mixture. Intraoperative lung-protective ventilation (tidal volume 5–7 mL/kg, positive end-expiratory pressure 5–7 cmH_2O, and ventilatory plateau pressures below 30 cmH_2O whenever possible) was administered in all patients.[22] Furthermore, the shortest possible OLV duration was tried to be applied.

2.3. The block procedure

The block procedure was performed under general anesthesia before the skin incision to prevent the patient anxiety and ensure comfort. Thus, preemptive analgesia was also achieved. Following the anesthesia induction, the thoracic paravertebral block or erector spinae plane block was performed under ultrasonography guidance when the patients were in the lateral decubitus position. For both blocks, 20 ml of 0.25% bupivacaine was injected.

2.4. Analgesia protocol

Before the end of the surgical procedure; metoclopramide, to prevent PONV; dexketoprofen (50 mg), and tramadol (100 mg) were given to the patients intravenously. Intravenous morphine was administered via patient-controlled analgesia (PCA) pump for 24 hours in the postoperative surgical intensive care unit. The PCA pump's dose delivery was limited to administering a bolus dose of 1 mg morphine and delivering a maximum dose of 12 mg morphine in total within 4 hours with lockout intervals of 15 minutes. Paracetamol 1 g every 8 hours and dexketoprofen 50 mg twice daily were administered intravenously for multimodal analgesia. As a rescue analgesic agent, 0.5 mg/kg tramadol was given to patients intravenously when a score of VAS at coughing ≥ 4. Side effects such as allergic reactions, hypotension, PONV, and itching were recorded.

2.5. Statistical analysis

Data analyses were performed with SPSS for Windows, version 22.0 (SPSS Inc., Chicago, IL, United States). Whether the distribution of continuous variables was normal or not was determined by the Kolmogorov Smirnov test. Levene test was used for the evaluation of homogeneity of variances. Unless specified otherwise, continuous data were described as mean ± standard deviation (SD) for normal distributions, and median (interquartile range) for skewed distributions. Categorical data were described as the number of cases (%). Statistical analysis differences in normally distributed variables between 2 independent groups were compared by Student t-test. Mann-Whitney U tests were applied for comparisons of not normally distributed data. Categorical variables were compared using Pearson chi-square test or Fisher exact test. We evaluated the degrees of the relationship between variables with Spearman correlation analysis. The differences in not normally distributed variables among more than 2 independent groups were analyzed by the Kruskal-Wallis test. When the *P*-value from Kruskal-Wallis test statistics was statistically significant, the post hoc Conover-Inman test of multiple comparisons was used to know which group differed from which others. No specific adjustment was made for the *P*-value in multiple comparisons. When the Mann-Whitney-U tests are used, the Bonferroni correction is generally applied to reduce the risk of Type-1 error in multiple comparisons. However, we did not use the Mann-Whiney-U test with Bonferroni correction. Instead, we applied the Conover-Inman test, which can be used as a post hoc test for the Kruskal Wallis test and which is included in the SPSS 22 package program. P-value < 0.05 was accepted as a significant level on all statistical analyses.

2.6. Sample size

The sample size was calculated using G*Power© software version 3.1.9.2 (Institute of Experimental Psychology, Heinrich Heine University, Dusseldorf, Germany). The sample size was calculated for the chi-square test, which was used for testing the main hypothesis of the present study. Depending on the results of previous research with 2-sided (two tails) Type-I error 0.05 and power of 80% ($1-\beta = 0.8$), effect size (d) factor 0.349, should involve at least 106 patients.[23].

2.7. Power analysis

The post hoc power was calculated using G*Power© software version 3.1.9.2 (Institute of Experimental Psychology, Heinrich Heine University, Dusseldorf, Germany). The power was calculated for the chi-square test, which was used for testing the main hypothesis of the present study (ARISCAT score in those with and without PPCs). Depending on the results of the previous research with 2-sided (two tails) Type-I error 0.05 and effect size (d) factor 0.619, post hoc power calculated as %77.2.[23].

3. Results

A total of 432 patients underwent thoracic surgery in the tertiary center between March 2021 and August 2021. 133 patients were eligible for the study. Among these patients, 120 patients were analyzed (Fig. 1). Demographic data and surgical characteristics of the patients are given in Table 2.

PPCs developed in 26 patients. Atelectasis was observed in 14 patients (46.6%), prolonged air leakage in 12 patients (40%), pulmonary embolism in 3 patients (10%), and pneumonia in 1 patient (3.3%). More than 1 complication was seen in 4 patients.

The development of PPCs has no statistically significant relationship with diagnosis, BMI, operation direction, and operation type. The age of the patients who developed PPCs was statistically significantly higher ($P = .008$). As patients' age increased, chest tube removal time ($P = .008$) and discharge time ($P = .005$) increased statistically significantly and there was a low positive correlation. The number of men who developed PPCs was statistically significantly higher ($P = .005$). The discharge time of male patients was statistically significantly higher ($P = .039$). The left-sided operation rate was statistically significantly higher in patients who had mortality within 3 months ($P = .045$). When the patients who developed PPCs,

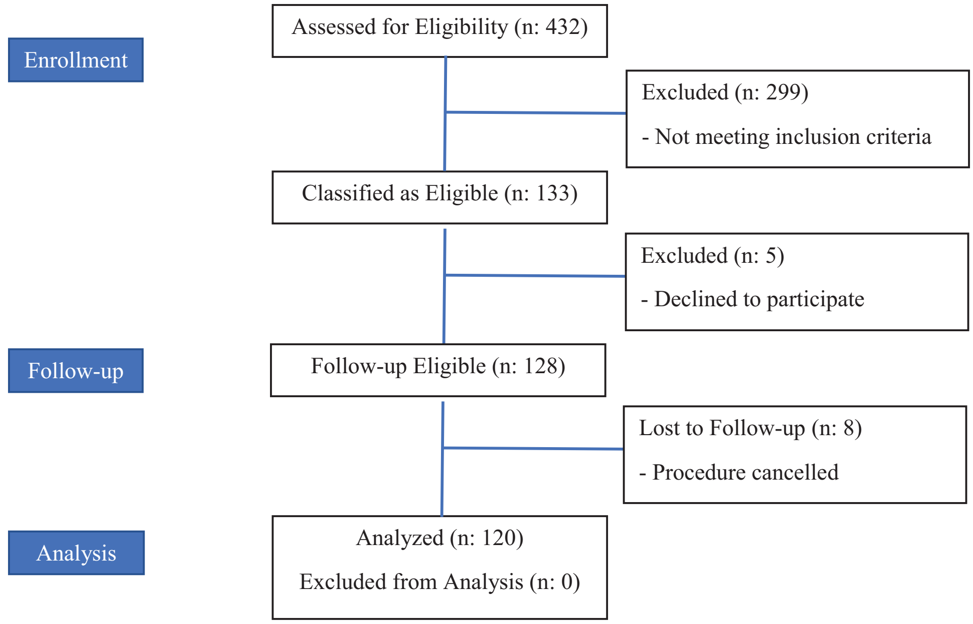

Figure 1. Flow chart.

Table 2

Demographic and surgical characteristics of the patients.

	All patients (n:120)
Age (yr)	55.48 ± 12.76 58.00 (50.50–65.00)
BMI (kg/m²)	27.89 ± 5.03 26.45 (23.88–31.24)
Gender	
Women	42 (35.0%)
Men	78 (65.0%)
Diagnosis	
Mass, malignant	99 (82.5%)
Bronchiectasis	5 (4.1%)
Hydatid cyst	9 (7.5%)
Pleural thickening	2 (1.7%)
Interstitial lung disease	2 (1.7%)
Other	3 (2.5%)
Co-morbidity	
Hypertension	39 (32.5%)
Diabetes mellitus	28 (23.3%)
Coronary artery disease	18 (15.0%)
Chronic obstructive lung disease–asthma	13 (10.8%)
Goiter	5 (4.2%)
Rhythm disorders	1 (0.8%)
Extrapulmonary malignancy	5 (4.2%)
Cerebrovascular event	3 (2.5%)
Other	6 (5.0%)

Continuous variables are expressed as either the mean ± standard deviation or median (minimum-maximum) and categorical variables are expressed as either frequency or percentage.
BMI = body mass index.

were evaluated in terms of surgery, in those who had a lobectomy, wedge resection, and segmentectomy the PPCs were statistically significantly higher (P = .013), and chest tube removal time was statistically significantly higher in these patients (P < .001). Additionally, overall Chest tube removal time was found to be statistically significantly higher in patients who underwent thoracotomy (P = .037). As the duration of operation increased, PPCs incidence (P = .007), chest tube removal time (P < .001) and discharge time (P < .001) statistically significantly increased. PPCs incidence (P = .009), chest tube removal time (P < .001) and discharge time (P < .001) statistically significantly increased as OLV duration increased (Table 3 and Table 4).

There was no statistically significant correlation between the development of PPCs and preoperative NRS-2002, albumin, NLR, and hemoglobin. The ARISCAT score (P = .002) and the ARISCAT grade (P = .009) were found to be statistically significantly higher in patients who developed PPCs. Chest tube removal time (P = .004) and discharge time (P < .001) increased statistically significantly as ARISCAT score and grade increased. A low degree of positive correlation was found between the ARISCAT score and chest tube removal time (P < .001) and discharge time (P < .001). The development of PPCs was found to be statistically significantly higher in patients with ASA physical status class of 3 (P = .002). It was observed that the albumin level was statistically significantly lower in those with 3-month mortality (P = .007). When the patients were evaluated in terms of NRS-2002, it was observed that all patients had NRS-2002 scores below 3 (Table 5).

When scoring systems and laboratory parameters were evaluated in different combinations, the incidence of PPCs in combination-I was found to be statistically significantly higher (P = .004). Chest tube removal time (P = .002) and discharge time (P = .003) were also observed to be statistically significantly longer in combination-I (Table 6).

When the 3-month mortality, discharge time, and chest tube removal time of the patients who developed PPCs were evaluated, in the patients with PPCs discharge time and chest tube removal time were found to be statistically significantly higher (P < .001).

4. Discussion

According to the literature review, this is the first prospective observational study in which different scoring systems and laboratory parameters were evaluated together with the ARISCAT scoring system for predicting PPCs after thoracic surgery to our knowledge. The incidence of PPCs was 21.7% and the 3-month mortality rate was 3.3% in the present study. Study results showed that the incidence of PPCs is higher with advancing age and in men. Advancing age also prolonged the

Table 3

PPCs, chest tube removal time, discharge time, and three-month mortality characteristics by patients' demographic data and diagnosis.

	PPCs positive n:94 (78.3%)	PPCs negative n:26 (21.7%)	Chest tube removal time (Day)	Discharge time (Day)	3-Month mortality positive n:4 (3.3%)	3-Month mortality negative n:116 (96.7%)
Gender	56.5 (16)	62 (13)	r:0.243	r:0.256	55.5 (6)	58 (15.5)
P value	**.008**†		**.008**‖	**.005**‖	.95†	
BMI	26.99 (7.47)	26.12 (5.19)	r:-0.121	r:-0.094	23.72 (5.87)	26.75 (7.33)
P value	.631§		.19‖	.12‖	.18§	
Gender						
Female	39 (41.5%)	3 (11.5%)	4. (3)	5.5 (3)	-	42 (36.2%)
Male	55 (58.5%)	23 (88.5%)	5 (3)	7 (4)	4 (100.0%)	74 (63.8%)
P value	**.005**§		.11†	**.039**†	.296§	
Diagnosis						
Mass, Malignant	75 (79.8%)	24 (92.3%)	5 (3)	6 (3)	4 (100.0%)	95 (81.9%)
Bronchiectasis	4 (4.3%)	1 (3.8%)	7 (4)	8 (1)	–	5 (4.3%)
Hydatid cyst	8 (8.5%)	1 (3.8%)	5 (2)	5 (2)	–	9 (7.8%)
Pleural Thickening	2 (2.1%)	–	3 (2)	3 (2)	–	2 (1.7%)
Interstitial Lung Disease	2 (2.1%)	–	4.5 (3)	4.5 (3)	–	2 (1.7%)
Other	3 (3.2%)	–	6 (1)	8 (2)	–	3 (2.6%)
P value	.96§		.582‡	.075‡	.99§	

Continuous variables are expressed as either the mean ± standard deviation or median (interquartile range) and categorical variables are expressed as either frequencyorpercentage. It is evaluated the degrees of the relationship between variables with Spearman correlation analysis. r: correlation analysis. *P*-values marked with bold indicate statistically significant *P*-values.
*Student *t*-test.
†Mann-Whitney-U test.
‡Kruskal Wallis.
§Chi-square test.
‖Spearman correlation analysis.
BMI = body mass index, OLV = one lung ventilation, PPCs = postoperative pulmonary complications, VATS = video-assisted thoracic surgery.

Table 4

PPCs, chest tube removal time, discharge time, and 3-month mortality characteristics by patients' surgical characteristics

	PPCs positive n:94 (78.3%)	PPCs negative n:26 (21.7%)	Chest tube removal time (Day)	Discharge time (Day)	3-Month mortality Positive n:4 (3.3%)	3-Month mortality Negative n:116 (96.7%)
Operation side						
Left	43 (45.7%)	13 (50.0%)	5 (3)	7 (3)	4 (100.0%)	52 (44.8%)
Right	51 (54.3%)	13 (50.0%)	4.5 (4)	5.5 (3)	–	64 (55.2%)
P value	.70§		.18†	.098†	**.045**§	
Operation						
Lobectomy wedge, segment	69 (73.4%)	25 (96.2%)	5 (3)	6 (4)	4 (100.0%)	90 (77.6%)
P value	**.013**§		**<.001**†	.20†	.576§	
Pneumonectomy	8 (8.5%)	–	1 (0.5)	7 (6.5)	–	8 (6.9%)
P value	.199§		**<.001**†	.184†	.99§	
Decortication	4 (4.3%)	–	6.5 (2)	6.5 (2)	–	4 (3.4%)
P value	.576§		.385†	.99†	.99§	
Other	16 (17.0%)	1 (3.8%)	4 (3)	4 (3)	1 (25.0%)	16 (13.8%)
P value	.12§		.20†	**.009**†	.462§	
Operation type						
VATS	67 (71.3%)	17 (65.4%)	5 (3)	6 (3)	4 (100.0%)	80 (69.0%)
P value	.562§		.457†	**.001**†	.315§	
Thoracotomy	42 (44.7%)	12 (46.2%)	6 (3)	7 (2)	1 (25.0%)	53 (45.7%)
P value	.89§		**.037**†	**.001**†	.626§	
VATS + thoracotomy	6 (6.4%)	–	6 (2)	6.5 (1)	–	6 (5.2%)
P value	.338§		.637†	.683†	.99§	
Operation duration	186.5 (95)	236.5 (51)	r:0.499	r:0.473	241.5 (98.5)	204 (95)
P value	**.007**†		**<.001**‖	**<.001**‖	.421†	
OLV duration	150 (85)	200 (88)	r:**0.458**	r:**0.400**	222.5 (105)	155 (89)
P value	**.009**†		**<.001**‖	**<.001**‖	.24†	

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*Student *t* test.
†Mann-Whitney-U test.
‡Kruskal Wallis.
§Chi-square test.
‖Spearman correlation analysis.
BMI = body mass index, OLV = one lung ventilation, PPCs = postoperative pulmonary complications, VATS = video-assisted thoracic surgery.

Table 5

Correlation of patients' preoperative scores, NRS, NLR, albumin, and hemoglobin levels with PPCs, chest tube removal time, discharge time, and 3-month mortality.

Preoperative scores	PPCs negative n:94 (78.3%)	PPCs positive n:26 (21.7%)	Chest tube removal time (day)	Discharge time (day)	3-Month mortality positive n:4 (3.3%)	3-Month mortality negative n:116 (96.7%)
ARISCAT risk score						
Low	4 (4.3%)	–	3 (1.5)	3 (2)	–	4 (3.4%)
Intermediate	41 (43.6%)	4 (15.4%)	4 (2)	5 (3)	1 (25.0%)	44 (37.9%)
High	49 (52.1%)	22 (84.6%)	6 (3)	7 (2)	3 (75.0%)	68 (58.6%)
P value	**.009**§		**.004**‡	**<.001**‡	.99§	
ARISCAT Score	47 (7)	50 (0)	r:0.320	r:0.377	54 (11.5)	47 (7)
P value	**.002**†		**<.001**‖	**<.001**‖	.13†	
ASA						
ASA II	47 (50.0%)	4 (15.4%)	4 (4)	6 (3)	1 (25.0%)	50 (43.1%)
ASA III	47 (50.0%)	22 (84.6%)	5 (3)	7 (4)	3 (75.0%)	66 (56.9%)
P value	**.002**§		.15†	.10†	.636 §	
NRS						
0	84 (89.4%)	23 (88.5%)	5 (3)	6 (4)	4 (100.0%)	103 (88.8%)
1	7 (7.4%)	2 (7.7%)	4 (2)	5 (3)	–	9 (7.8%)
2	3 (3.2%)	1 (3.8%)	4 (4)	6 (2.5)	–	4 (3.5%)
P value	.99§		.29‡	.397‡	.99§	
Albumin (g/L)	40.58 ± 4.47	40.00 ± 4.13	r:-0.015	r:-0.081	34.68 ± 3.68	40.65 ± 4.28
P value	.558*		.87‖	.382‖	**.007***	
NLR	2.38 (1.3)	2.24 (1.56)	r:0.018	r:0.032	2.94 (2.96)	2.34 (1.31)
P value	0.500†		0.847‖	0.725‖	0.456†	
Hemoglobin (g/dL)	14.0 ± 1.71	14.34 ± 1.72	r:0.035	r:-0.062	14.30 ± 1.35	14.11 ± 1.72
P value	.45*		.702‖	.50‖	.83*	

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*Student *t*-test.

†Mann-Whitney-U test.

‡Kruskal Wallis.

§Chi-square test.

‖Spearman correlation analysis.

ARISCAT = Assess Respiratory Risk in Surgical Patients in Catalonia, ASA = American Society of Anesthesiologists, NLR = Neutrophil -to-Lymphocyte Ratio, NRS = Nutritional risk screening, PPCs = Postoperative Pulmonary Complications.

Table 6

Association of different laboratory and scoring system combinations with PPCs, chest tube removal time, time to discharge, and 3-month mortality.

Preoperative combinations	PPCs negative n:94 (78.3%)	PPCs positive n:26 (21.7%)	Chest tube removal time (day)	Discharge Time (day)	3-month mortality positive n: 4 (3.3%)	3-month mortality negative n:116 (96.7%)
Combination-I (n:7) ARISCAT Grade High + Albumin<35g/L + ASA 3	3 (11.1%)	4 (80.0%)	7 (8)	8 (7)	1 (100.0%)	6 (19.4%)
Combination-II(n:9) ARISCAT Grade Low and Intermediate+ Albumin 35g/L and above + ASA 2	8 (88.9%)	1 (20.0%)	4 (2)	4 (2)	–	25 (80.6%)
P value	**.004**†		**.002***	**.003***	.219†	

Continuous variables are expressed as either the median (interquartile range), and categorical variables are expressed as either frequency or percentage. *P*-values marked with bold indicate statistically significant *P*-values.

*Mann–Whitney U test.

†Chi-square test.

ARISCAT = Assess Respiratory Risk in Surgical Patients in Catalonia, PPCs = Postoperative Pulmonary Complications, SA = American Society of Anesthesiologists.

time to discharge and chest tube removal. The increase in duration time of OLV and surgery was also related to a higher rate of PPCs, and they prolonged the time of discharge and chest tube removal time. While the rate of PPCs was found to be higher in patients who underwent lobectomy, wedge resection, and segmentectomy; the time of chest tube removal was also longer in these patients. We observed that the PPCs could be predicted with the ARISCAT risk index and ASA physical status classification. In patients with PPCs; the duration of surgery and the duration of OLV time were found to be longer. Low preoperative albumin levels were associated with 3-month mortality. In addition to ARISCAT scoring, using ASA physical status and albumin data in combination together can be efficient in predicting PPCs that may develop after thoracic surgery.

Due to the nature of thoracic surgery, intervention in the thoracic cavity is an important factor in the increase of PPCs. In addition, the current clinical status of these patients can frequently deteriorate, which causes many laboratory parameters to be unstable. Thoracic surgery itself is included in the ARISCAT parameters, causing the score to be higher. Therefore, the preoperative ARISCAT scores in thoracic surgery are usually intermediate and high grade. Based on this, we particularly evaluated the effectiveness of the ARISCAT scoring system together with ASA physical status, and albumin level which is an effective parameter in major surgeries such as thoracic surgery.

Studies have shown that advancing age is an important factor in the development of PPCs.[1,21,23–26] Additionally, it has been stated that the male gender is a risk factor for the development of PPCs.[27] Another effective factor in the development of PPCs is the duration of surgery. The duration of surgery, which is also a parameter in ARISCAT scoring, especially over 2 hours has been stated as a significant factor in the development of PPCs.[9] In this study, the results are compatible with the literature; male gender, advancing age, and duration of surgery are among the predictable factors in the development of PPCs.

In a study by Kupeli et al[24] in which they investigated the relationship between PPCs and ASA physical status, they observed that ASA physical status was a weak modality in predicting the PPCs. At the same time, in their study, the relationship between ARISCAT and PPCs was also evaluated. They concluded that PPCs could be predicted more reliably with the ARISCAT risk index.[24] ASA physical status assessment is routinely used to subjectively predict preoperative health status. However, ASA physical status is not enough in estimating perioperative risk. Therefore, it raised concerns about the reliability of the scale.[28] This indicates that more comprehensive preoperative risk assessments are needed in surgeries such as thoracic surgery where perioperative complications are common. ARISCAT risk index can give a more comprehensive result by evaluating many parameters. However, to our knowledge, our study is unique in this regard, since studies on ARISCAT risk assessment generally cover heterogeneous surgical groups. In this study, both a high ASA physical status score and a high ARISCAT index were found to be significant in predicting PPCs and prolonged chest tube removal time and discharge time after thoracic surgery.

The effectiveness of albumin, an inflammatory factor, as an indicator of postoperative complications and the nutritional status is the subject of many types of research.[29–32] It has been shown that preoperative serum albumin is significantly associated with postoperative complications in malignancies.[30,31] However, it is still unclear whether perioperative albumin is associated with postoperative short-term morbidity after lung cancer resection.[32] Li et al [32] found that the decrease in serum albumin at postoperative day 1, predicted PPCs after lung cancer resection with VATS. Li et al[32] confirmed that a 14.97% reduction in albumin was a limit for predicting PPCs and found that patients with ≥ 14.97% reductions in albumin levels had a higher risk of developing PPC.[32] In our study, low preoperative albumin levels were independently associated with 3-month mortality. However, when albumin, ARISCAT score, and ASA physical status score are evaluated together; high ASA and ARISCAT scores and preoperative albumin levels below 35 g/dl adversely affect the development of PPCs, the chest tube removal time, and discharge time. This result shows that this combination may be more reliable in predicting PPCs.

OLV is frequently applied in thoracic surgery to reduce adverse events that may occur in the contralateral lung and to provide optimal surgical conditions.[33] However, OLV itself can lead to serious complications such as increased intrapulmonary shunt, decreased arterial oxygen pressure, and hypoxia.[34] These changes not only affect the intraoperative period but also contribute to the development of PPCs. Different OLV durations have different effects on lung damage, and the longer this period, the more complications increase.[35] It has been shown that short-term OLV does not affect the local inflammatory cytokine response in lung resections,[36] however, in a retrospective analysis, OLV duration is a risk factor for postoperative acute lung injury and acute respiratory distress syndrome.[37] A study conducted by Lai et al,[35] for patients who underwent OLV for esophageal surgery, stated that long OLV times were associated with PPCs, and they showed that OLV times below 150 minutes were associated with good outcomes [35]. In this study, it was also observed that PPCs increased as the OLV duration increased, by the literature. Therefore, keeping the OLV duration as short as possible with good cooperation with the surgical team may have a key role in preventing PPCs.

We have some limitations in this study. The study was conducted in a single center. In addition, although only thoracic surgery cases were included in the study, the presence of both thoracotomy and VATS cases caused heterogeneity. Although multimodal analgesia management including regional techniques determined in our department was performed in patients, a uniform regional block was not applied.

In conclusion, it was seen that the ARISCAT scoring system was more effective in predicting PPCs after thoracic surgery when used together with ASA physical status and preoperative albumin level. Age, male gender, duration of surgery, and duration of OLV were also associated with PPCs. We think that multicenter studies to be conducted in more specific patient groups can more clearly determine the parameters that are successful in estimating PPCs.

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Conceptualization: HS, GÜ, AA
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Formal analysis: GÜ, MZ, RB
Investigation: AA, MZ, Fİ
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Supervision: HS, AA, GÜ, RB
Visualization: AA, GÜ, MZ
Writing—original draft: All authors
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The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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