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SURGICAL MEDICAL SCIENCES / CERRAHİ TIP BİLİMLERİ

Predictive Value of ARISCAT Risk Index in the Development of Postoperative Pulmonary Complications After Major Abdominal Cancer Surgery

Majör Abdominal Kanser Cerrahisi Sonrası Postoperatif Pulmoner Komplikasyon Gelişmesinde ARISCAT Risk İndeksinin Prediktif Değeri

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Abstract

Objectives: The ARISCAT risk assessment score is a seven-variable regression model that divides patients into low, moderate, and high-risk groups in terms of developing postoperative pulmonary complications (PPC). In this study, we aimed to assess the predictive value of the ARISCAT score in major abdominal cancer surgery patients since they are considered to be vulnerable to postoperative complications.

Materials and Methods: A total of 410 patients aged >18 years old with American Society of Anesthesiologists (ASA) I-IV were included. Demographic data, body mass index, smoking status, ASA scores, preoperative hemoglobin levels, pulmonary disease history in the last 30 days, location of surgical incision (lower-upper abdominal), type of surgery (laparoscopic or open), emergency or elective, and operation times of patients were recorded.

Results: Age, smoking, higher ASA score, type of operation, preoperative pulmonary dysfunction, and higher ARISCAT scores were found to be related with PPC ($p<0.05$). A positive correlation was found between ARISCAT score and PPC ($p<0.05$). Elderly, lower preoperative SpO_2, surgeries with upper incision site, emergency surgeries were found to be associated with increased risk of developing PPC. Age was found to have the strongest relationship among the variables.

Conclusion: We found that the ARISCAT risk score was a strong predictor of the development of PPC after major abdominal cancer surgery.

Keywords: Complications, postoperative, pulmonary, scoring methods

Öz

Amaç: ARISCAT risk skoru, postoperatif pulmoner komplikasyon (PPK) gelişimi açısından hastaları düşük, orta ve yüksek riskli gruplara ayıran yedi değişkenli bir regresyon modelidir. Bu çalışmada, ARISCAT risk skorunun majör abdominal kanser cerrahisi geçiren hastalarda prediktif değerini araştırmaktır.

Gereç ve Yöntem: On sekiz yaş üstü, Amerikan Anestezistler Derneği (ASA) I-IV olan toplam 410 hasta çalışmaya dahil edildi. Demografik veriler, vücut kitle indeksi, sigara öyküsü, ASA skorları, ameliyat öncesi hemoglobin düzeyleri, son 30 gün içindeki akciğer hastalığı öyküsü, cerrahi insizyonun yeri (alt-üst karın), ameliyatın türü (laparoskopik veya açık), acil veya elektif ve hastaların operasyon süreleri kaydedildi.

Bulgular: Yaş, sigara kullanımı, yüksek ASA skoru, operasyon tipi, preoperatif akciğer fonksiyon bozukluğu ve yüksek ARISCAT skorlarının PPK ile ilişkili olduğu belirlendi ($p<0.05$). ARISCAT puanı ile PPK arasında pozitif korelasyon bulundu ($p<0,05$). Yaşlılarda, ameliyat öncesi SpO_2'nin düşük olması durumunda, üst kesi yeri olan ameliyatlarda, acil ameliyatlarda PPK gelişme riskinin arttığı gözlenmiştir. Değişkenler arasında PPK gelişmesiyle en güçlü ilişki hastanın yaşı olduğu tespit edilmiştir.

Sonuç: ARISCAT risk skorunun majör abdominal kanser cerrahisi sonrası PPK gelişmesini tahmin etmede güçlü bir öngörücü olduğunu tespit ettik.

Anahtar Kelimeler: Komplikasyon, postoperatif, pulmoner, skorlama yöntemi

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Introduction

Postoperative pulmonary complications (PPC) are quite common and one of the important causes of postoperative morbidity and mortality (1). While the rate of mortality and morbidity is 14-30% in patients with PPC, it is 0.2-3% in patients without PPC. The incidence of PPC in non-cardiac surgery has been reported between 2% and 19%, and it is more common than cardiac complications (2,3). PPCs continue to be an important cause of unexpected intensive care admissions and long-term hospital stays (4).

Major abdominal cancer surgery is a very common type of surgery, and the rate of PPC development is expected to be higher due to the immunodeficiency of the cancer itself, decreased physiological reserve or complicated long surgical procedures. In the literature, the incidence of PPC development after major abdominal surgery has been reported as 5.8% (5).

In this study, our primary aim was to investigate the effectiveness of the ARISCAT risk scoring index in predicting the development of PPC in patients undergoing major abdominal cancer surgery. Secondary purposes were to show the relationship of PPCs with parameters such as radiotherapy/chemotherapy history, operation type and duration, demographic characteristics, pulmonary function status, length of hospital stay and 30-day mortality.

Materials and Methods

After ethical approval from University of Health Sciences Türkiye, Ankara Dr. Abdurrahman Yurtaslan Oncology Training and Research Hospital Clinical Research Ethics Committee (approval no.: 2019-11/459, date: 20.11.2019, trial registry: NCT04663958), between December 2020-June 2021, 420 patients over the age of 18 with an American Society of Anesthesiologists (ASA) score of 1-4, who were planned for major abdominal cancer surgery in the general surgery, urology and gynecological oncology departments with general anesthesia were included in the study prospectively and observationally, and informed consent forms were signed by all patients. Pregnant patients, patients with acute or chronic respiratory disease, previously intubated patients, patients who underwent surgery due to previous surgical complications, patients with severe cardiovascular disease or severe hemodynamic instability, and patients given regional anesthesia were excluded from the study. The study was conducted in accordance with the Helsinki Declaration-2013.

ARISCAT risk assessment scores were calculated by evaluating the patients preoperatively. ARISCAT risk scoring system is one of the most important measurement tools which is simple to implement, inexpensive, and widely used in the evaluation of PPC at the bedside (4). The ARISCAT risk assessment score (The Assess Respiratory Risk in Surgical Patients in Catalonia: Evaluating respiratory risk in surgical patients in Catalonia) has seven variables (age, preoperative SpO_2, preoperative anemia, lung infection presence in the last month, duration of operation, operation procedure, surgical incision site) that divides patients into low, medium and high risk groups, which is a risk scoring tool. A score of <26 is considered low risk, a score of 26-44 is considered medium risk, and a score >45 is considered high risk (Table 1) (2).

The patients were followed during the post-anesthetic care unit and hospital stay, and the presence of PPC was evaluated, and the time to discharge was recorded. On the 30th day after discharge, the patients were called by phone and the presence of mortality was questioned.

PPC are defined by the development of one of the following novel findings. This definition is based on the

Table 1: The ARISCAT risk assessment score

Risk factors	Risk score	
Age		
≤50	0	
51-80	3	
>80	16	
Preoperative O_2 saturation		
≥96	0	
91-95	8	
≤90	24	
Respiratory infection in the last month	17	
Preoperative anemia (hemoglobin≤10 g/dL)	11	
Surgical incision		
Peripheric	0	
Upper abdominal	15	
Intrathoracic	24	
Duration of surgery		
≤2 hours	0	
2-3 hours	16	
>3 hours	23	
Operation procedure		
Elective	0	
Emergency surgery	8	
Risk class	**Total risk score**	**Pulmonary complications rates**
Low	**<26**	**1.6%**
Intermediate	**26-44**	**13.3%**
High	**≥45**	**42.1%**

European Perioperative Clinical Outcome Definitions (EPCO) (6). Unscheduled emergency re-intubation and previously intubation before intensive care unit admission, which are not included in the EPCO definitions, are also included in this classification (Table 2).

Statistical Analysis

Research data was uploaded to the computer and evaluated by means of "SPSS (Statistical Package for Social Sciences) for Windows 20.0 (SPSS Inc, Chicago, IL)". Mean, standard deviation, ratio and frequency values were used in the descriptive statistics of the data. The distribution of variables was checked with the Kolmogorov-Smirnov test. Mann-Whitney U test and independent samples t-test were used to analyze quantitative data, chi-square test was used to analyze qualitative data, and Fisher's exact test was used when chi-square conditions could not be met. Logistic regression was performed to investigate the effect level, odds ratios (OR), 95% confidence interval (CI), and receiver operating characteristic (ROC) analysis were used to estimate the relationship between PPC and other variables. P value <0.05 was considered statistically significant. In order to decide on the sample size, a literature review was conducted and power analysis was performed. The overall incidence of PPC was found to be 5.8% in previous studies (6). For the simplest within-group and between-group comparisons, the sample size with an effect value determined for a statistical power of 0.90 at the alpha=0.05 level was calculated as n=405 (G*Power 3.1.9.7). The n=410 patients collected for this study is more than sufficient for the purpose of the study.

Results

Of the 420 patients included in the study, 6 were excluded because they did not sign the written consent and 4 patients were excluded due to lack of data (Figure 1). Statistical analysis of a total of 410 patients was performed. PPC was detected in 12.4% (n=51) of 410 patients who underwent major abdominal cancer surgery, and PPC was not detected in 87.6% (n=359) (Table 3). According to these data, a significant difference was found between the patients with and without PPC in terms of age, smoking, ASA score, operation type, pulmonary function status and ARISCAT scores (p<0.05).

The mean ARISCAT score of 359 patients without PPC was 33.62, and of the 51 patients with PPC was 49.07 (Table 4). The most common complication was pneumonia, which was observed in 23 (5.6%) patients, and then atelectasis 19 (4.6%), respiratory failure 15 (3.6%), pleural effusion 14 (3.4%), ongoing postoperative intubation after surgery 6 (1.5%), pulmonary embolism 4 (1%), unplanned emergency reintubation 4 (1%), pneumothorax 3 (0.7%) and ARDS 2 (0.5%).

While the mean ARISCAT score of 12 (23.5%) patients with one PPC was 39.7±12.13, the mean ARISCAT score of the patients with four PPCs was 59.5±2.12. A positive statistical significance (p<0.005) was found between the development of more than one PPC in the same patient and the ARISCAT score (Table 4).

According to this study, ROC analysis was performed to determine the cut-off points in terms of low, medium and high

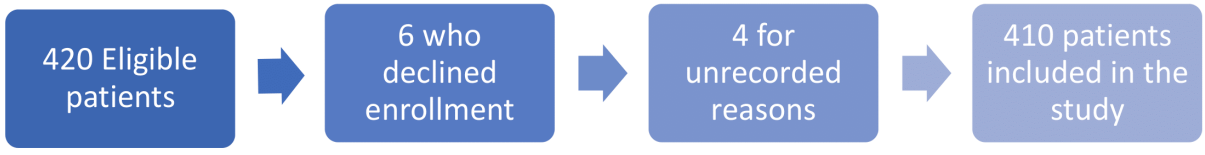

Figure 1: Recruitment flowchart

Table 2: Definitions of postoperative pulmonary complications	
Respiratory failure	When postoperative PaO_2^* <60 mmHg on room air, a ratio of PaO_2 to inspired oxygen fraction <300 or arterial oxyhemoglobin saturation measured with pulse oximetry <90% and requiring oxygen therapy
Respiratory infection	When a patient received antibiotics for a suspected respiratory infection and met at least one of the following criteria: new or changed sputum, new or changed lung opacities, fever, leukocyte count >12,000/μ
Aspiration pneumonitis	Acute lung injury after the inhalation of regurgitated gastric contents
Pleural effusion	Chest X-ray demonstrating blunting of the costophrenic angle, loss of the sharp silhouette of the ipsilateral hemidiaphragm in upright position, evidence of displacement of adjacent anatomical structures, or (in supine position) a hazy opacity in one hemithorax with preserved vascular shadows
Pneumothorax	Air in the pleural space with no vascular bed surrounding the visceral pleura
Atelectasis	Lung opacification with a shift of the mediastinum, hilum, or hemidiaphragm toward the affected area, and compensatory over inflation in the adjacent non atelectatic lung
Bronchospasm	Newly detected expiratory wheezing treated with bronchodilators
Acute respiratory distress syndrome	The presence of diffuse bilateral infiltrates on chest radiograph no signs of minimal left atrial overload within 7 days after surgery, $PaO_2^*/FiO_2^\dagger$: ≤300
*Partial pressure of oxygen, †Inspired oxygen concentration	

Table 3: Demographic characteristics and distribution of ARISCAT scores in patients with and without postoperative pulmonary complications

	Total n=410 (%)	PPC		p value
		Yes n=51 (12.4)	No n=359 (87.6)	
Age (years) Mean ± SD	60.69±11.9	66.4±11.98	59.9±11.7	**0.001***
Gender, n (%)				
Woman Man	225 (54.9) 185 (45.1)	n=29 (12.8) n=22 (11.9)	n=196 (87.2) n=163 (90.1)	0.440†
BMI (kg/m²) n (%)				
0-20 (kg/m²) 21-35 (kg/m²) >35 (kg/m²)	42 (10.2) 336 (82) 32 (7.8)	6 (14.2) 42 (12.5) 3 (9.3)	36 (85.8) 294 (87.5) 29 (91.7)	0.815†
Smoking, n (%)		Yes, n (%)	No, n (%)	
0 packs/year 1-20 packs/year 21-40 packs/year 41-60 packs/year 61-80 packs/year	218 (53.2) 62 (15.1) 94 (22.9) 35 (8.5) 1 (0.2)	19 (8.7) 9 (14.5) 12 (12.7) 11 (31.4) n <2	199 (91.3) 53 (85.5) 82 (87.3) 24 (68.6) n <2	**0.005†**
ASA scores (%)		**Yes, n (%)**	**No, n (%)**	
I II III IV	13 (3.2) 190 (46.3) 188 (45.9) 19 (4.6)	n <2 9 (4.7) 30 (15.9) 12 (63.1)	13 (100) 181 (95.3) 158 (84.1) 7 (36.9)	**<0.001†**
Type of operation n (%)		Yes, n (%)	No, n (%)	
Emergency Elective	38 (9.3) 372 (90.7)	18 (47.3) 33 (8.8)	20 (52.7) 339 (91.2)	**<0.001†**
Chemotherapy history in the last 1 year n (%)		**Yes, n (%)**	**No, n (%)**	
Yes No	92 (22.4) 318 (77.6)	9 (9.7) 42 (13.2)	83 (90.3) 276 (86.8)	0.381†
Radiotherapy history in the last 1 year n (%)		**Yes, n (%)**	**No, n (%)**	
Yes No	51 (12.4) 359 (87.6)	5 (9.8) 46 (12.4)	46 (90.2) 313 (87.2)	0.655†
Pulmonary function n (%)		**Yes, n (%)**	**No, n (%)**	
No dyspnea Dyspnea with exercise Resting dyspnea Always dyspnea	324 (79) 80 (19.5) 3 (0.7) 3 (0.7)	31 (9.5) 16 (20) 2 (66.6) 2 (66.6)	293 (90.5) 64 (80) n<2 n<2	**<0.001‡**
ARISCAT risk classification		**Yes, n (%)**	**No, n (%)**	
Low risk <26 Medium risk <26-44 High risk <44	91 (22.2) 214 (52.2) 105 (25.6)	2 (2.1) 18 (8.4) 31 (29.5)	89 (97.9) 196 (91.6) 74 (70.5)	**<0.001†**

Values are mean ± SD, PPC: Postoperative pulmonary complication, n: Number of patients, %: Column percentage, *Mann-Whitney U test, †Pearson chi-square test, ‡Fisher's Precision test (p<0.005)
SD: Standard deviation, BMI: Body mass index, ASA: American Society of Anesthesiologists Classification

risk according to the ARISCAT risk scores of patients with PPC, and ARISCAT scores were found to be 29 and 44 [77.6% (95% CI; 71%-85%)]. In this case, as a result of the analysis obtained, 0-29 low risk value; 29-44 were considered as medium risk factors and >44 as high-risk factors. In Figure 2, the ROC analysis graph for the sensitivity and specificity values of the cutoff notes was given. Logistic Regression analysis was performed to determine the effect power of the ARISCAT variables used to determine the risk of PPC in patients. The full model including the variables in the ARISCAT scale was found to be statistically significant (p<0.001).

Surgical incision site, preoperative SpO_2 value, the type of surgical procedure was found to be statistically significant (p<0.05) in the development of PPC (Table 5). The age was found to be the strongest predictor of the occurrence of PPC. When all other items in the scale were kept under control, it was observed

that 51-80 years of age increased the probability of PPC 3 times (OR=3.37) and that age >80 increased 14 times (OR=13.694).

The incidence of PPC was higher in emergency surgeries, open surgical procedures, upper abdominal incisions, and low preoperative SpO_2 and hemoglobin values. There was no statistically significant difference between the duration of surgery and PPC. While patients who did not develop PPC stayed in the hospital for 8.6±4.32 days, this period was found to be 12.9±9.22 days in patients who developed PPC. The duration of stay in the postoperative care unit was 17.9±5 and 82.7±147.6 hours, respectively (Table 6). A positive and significant relationship was found between the length of hospital stay-postoperative care unit stay and PPC (p<0.001).

Fourteen (3.4%) deaths were detected in the 30-day period in 410 patients included in the study. While there were 13

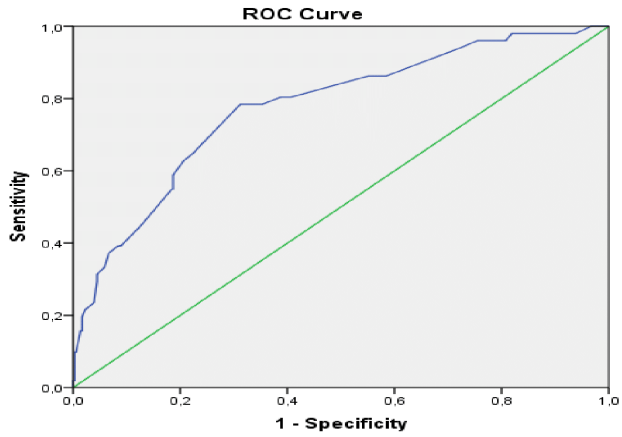

Figure 2: Receiver operating characteristic analysis result
ROC: Receiver operating characteristic

Table 4: Relationship between ARISCAT score and number of postoperative pulmonary complications			
Number of PPCs	**ARISCAT mean score ± SD**	**n (%)**	**p value**
1	39.7±12.13	12 (23.5)	0.008*
2	50.04±14.8	23 (45.2)	
3	54.07±17.6	14 (27.4)	
4	59.5±2.12	2 (3.9)	
Total	49.07±15.6	51 (100)	

Values are mean ± SD, *Spearman-rho test
SD: Standard deviation, n: Number of patients, PPC: Postoperative pulmonary complication

Table 5: Power of ARISCAT risk index to predict the development of postoperative pulmonary complications								
	S.E.	**Wald**	**p value**	**OR**	**B**	**Risk scores**	**95% CI for odds ratio**	
							Low	**High**
Age								
<50		10.050	**0.007**					
51-80	0.669	2.761	**0.009**	3.37	0.437	4	0.819	11.263
>80	0.853	9.403	**0.002**	13.694	1.706	17	2.571	72.934
Preoperative SpO_2								
>96		5.550	**0.005**					
91-95	0.456	0.088	**0.042**	1.145	0.673	7	0.468	2.797
<90	0.577	4.133	**0.027**	3.232	2.038	20	1.043	10.013
Pulmonary infection in the last month	1.106	0.152	0.697	0.650	0.431	4	0.074	5.676
Preoperative anemia Hb <10 g/dL	0.449	360	0.549	0.764	0.269	3	0.317	1.841
Surgical incision site Peripheral Upper abdominal	356	9.441	**0.002**	2.989	1.095	11	1.487	6.011
Operation time <2 hours	0.703	1.152	0.283	2.127	1.085	10	0.536	8.439
2-3 hours	0.742	2.141	0.143	2.960	0.331	3		
>3 hours								
Type of procedure Elective Emergent	0.439	17.497	**0.000**	6.263	1.835	19	2.651	14.797

SE: Standard error, Wald: Wald test, OR: Odds ratio, B: Beta, CI: Confidence interval, SpO_2: Peripheral oxygen saturation, Hb: Hemoglobin

(25.5%) deaths in 51 patients who developed PPC, 1 (0.2%) died in 359 patients who did not develop PPC. A statistically significant relationship (p<0.001) was found between PPC and 30-day mortality.

Discussion

This is the first observational study to investigate the effectiveness of ARISCAT in predicting the occurrence of PPC after major abdominal cancer surgery to our knowledge. PPC was detected in 12.4% of the patients, and a positive correlation was found between the increase in ARISCAT score and the development of PPC. Among the independent variables, age, preoperative SpO_2, surgical incision site and operation procedure (elective/emergency) were effective factors in predicting the development of PPC, and age was found to be the strongest variable.

Canet et al. (2) reported the rates of PPC development as 1.6% in the low-risk group, 13.3% in the intermediate-risk group, and 42.1% in the high-risk group according to the ARISCAT scores. In another study examining renal transplant patients, PPC was observed in 75% of the patients in the high-risk group and 19.5% of the patients in the intermediate-risk group (7). In our patient group, a significant positive correlation was found between the ARISCAT score and the development of PPC. The ARISCAT scores were found to be 29 and 44 as a result of the ROC analysis performed to determine the cut-off points of the patients in terms of low, medium and high risk, which is similar to other studies (2,8,9). Canet et al. (2) found the incidence of PPC development as 39.6% in cardiac surgery, 31.4% in thoracic surgery, 7.2% in abdominal surgery and 5.8% in vascular interventions. It has been shown that the incidence of PPC is inversely proportional to the distance of the incision line from the diaphragm, and a similar result was observed in our study (3,10).

Postoperative pneumonia is a common pulmonary complication after thoracic or non-thoracic surgery (11,12). Arozullah et al. (13) found the incidence of postoperative pneumonia to be 1.5% in their study in which they evaluated multifactorial risks to prevent postoperative pneumonia in patients who underwent non-cardiac surgery. In our study, the most common PPC was found to be pneumonia with a rate

Table 6: Relation of perioperative data with postoperative pulmonary complications

		PPC			
		Yes n (%)	No n (%)	Total	p value
Premedication	Yes	30 (9.6)	282 (90.4)	312 (100)	**0.002***
	No	21 (21.4)	77 (78.5)	98 (100)	
Incision site	Upper abdomen	31 (20)	124 (80)	155 (100)	**0.001***
	Lower abdomen	9 (7.1)	118 (92.9)	127 (100)	
	Laparoscopic	11 (8.5)	117 (91.5)	128 (100)	
Duration	<2 hour	4 (8.8)	41 (91.2)	45 (100)	0.746†
	2-3 hour	30 (12.9)	202 (87.1)	232 (100)	
	>3 hour	17 (12.7)	116 (87.3)	133 (100)	
Preoperative SpO_2 (mean ± SD)		91.9±4.53	94.01±2.3		**0.002‡**
Surgical Procedure	Elective	33 (8.9)	339 (91.1)	372 (100)	**0.000***
	Emergent	18 (47.4)	20 (52.6)	38 (100)	
Type of surgery	Open	40 (14.2)	243 (85.8)	283 (100)	0.146*
	Laparoscopic	11 (8.7)	116 (91.3)	127 (100)	
Hemoglobin (mean ± SD)		11.64±2.17	12.7±2.11		**0.004‡**
Total		51 (100)	359 (100)	410 (100)	

Values are mean ± SD, *Pearson chi-square, †Fisher's exact test, ‡Mann-Whitney U test
PPC: Postoperative pulmonary complication, n: Number of patients, %: Column percentage, SpO_2: Peripheral oxygen saturation, SD: Standard deviation

Table 7: Relationship between length of stay in hospital and postoperative care unit with postoperative pulmonary complications

	Total (n=410)	PPC Yes (n=51)	PPC No (n=359)	p value
Length of hospital stay (days) mean ± SD	9.15±5.37	12.9±9.22	8.6±4.32	**0.001***
Postoperative care (hours) mean ± SD	26±56	82.7±147.6	17.9±5	**0.000***

Values are mean ± SD, *Mann-Whitney U test
n: Number of patients, PPC: Postoperative Pulmonary Complication, %: Column percentage, SD: Standard deviation

of 5.6%. Some differences in the frequency of all PPCs in the literature might be related to the heterogeneity of the patient populations, the type of surgery and the variability of the definitions used in the studies (14).

Age is an important factor in the development of postoperative complications, and Canet et al. (2) determined the age of 80 as a deviation point at which PPCs increase significantly (9). In our study, we observed that the frequency of PPC increased significantly over the age of 80. It has been suggested that decrease in physiological reserve with advancing age, high airway closure capacity and low ventilation/perfusion ratios lead to hypoxia among the potential mechanisms.

The SpO_2 value is included in the ARISCAT risk score parameters as it may reflect both respiratory and cardiovascular functional status. In our study, we found that SpO_2 was also found to be an effective predictor. Many studies indicated that smoking was an important risk factor in the development of PPC (11). Although it is known that the risk of PPC increases 6 times in smokers compared to those who have never smoked before, it has been suggested in recent publications that this rate is lower in those who started smoking in the last year before surgery (15). In our study, a positive and significant correlation was found between the increase in the amount of smoking and PPC. Yang et al. (5), in their multicenter study, in which they retrospectively analyzed 165196 cases, reported that there was a positive correlation between the presence and severity of respiratory distress in patients and PPC. Although different results were reported in the studies (2,7,16,17), a positive and significant correlation was found between the ASA values of the patients and PPC in this study ($p<0.001$).

There is no conclusive level of evidence that obesity increases PPCs. In obese individuals, decreased chest wall and lung compliance and functional residual capacity are observed (18). Yang et al. (5) found a significant relationship between BMI and PPC. There were also several studies showing that the risk of PPC did not increase with obesity (19,20). In our study, no significant relationship could be demonstrated between BMI and PPC.

Preoperative anemia (hemoglobin<10 g/dL^{-1}) has been defined as a poor prognosis marker in postoperative and intensive care patients. It was reported that even mild anemia might cause an increase in 30-day mortality and cardiac complications (21). Canet et al. (2) found that preoperative anemia increased the development of PPC 3 times. In our study, in the logistic regression analysis used to determine the effects of the independent ARISCAT variables in the development of PPC, preoperative anemia could not be defined as a strong factor. However, there was a significant difference in hemoglobin levels between patients with and without PPC ($p<0.005$). For this reason, we think that preoperative anemia should be evaluated in the early period, especially in risky patient groups, and attention should be paid to its perioperative management.

Emergency surgery is the independent risk factor that contributes most to the development of PPC (22). These patients are generally hypovolemic, have poor vital signs and need active resuscitation. Canet et al. (2) showed that the risk of PPC increased 2.2 times in patients who were operated on urgently (2). Perilli et al. (8) reported the incidence of PPC in patients undergoing major abdominal surgery as 7% in elective cases and 33% in emergency cases. In our study, these rates were found to be 8.9% and 47.4%, respectively. The fact that our patient population was cancer patients and the increased frailty levels and co-morbidities related to cancer might have caused the difference in the results. McAlister et al. (23) stated that the duration of the operation longer than 2.5 hours increased the incidence of PPC development 3.3 times. In our patients who underwent major abdominal cancer surgery, no significant relationship could be demonstrated between the duration of the operation and the development of PPC. It was thought that the fact that the time was evaluated in only three categories might have affected the difference between cancer surgeries that lasted much longer than 3 hours.

The surgical incision site plays an important role in the evaluation of PPCs. In ARISCAT risk scoring, the incision sites are defined as thoracic, upper abdominal and peripheral and do not contain information about laparoscopic methods. PPC most commonly develops after thoracic and upper abdominal surgeries. The incidence of PPC varies inversely with the distance of the incision site to the diaphragm (3). In our study, similar to the literature, PPC was mostly observed after upper abdominal incision.

It was shown that the duration of intensive care and hospitalization was significantly prolonged in patients with PPC ($p<0.001$). Smith et al. (24) reported that PPCs increased the length of hospital stay up to 17 days in patients who underwent laparotomy. Similar results have been shown in other studies (11,14,25). In our study, the group with the highest 30-day mortality was the group that developed PPC ($p<0.001$) and a similar result was observed by Canet et al. (2).

Study Limitations

The fact that there is no definition of ARISCAT score in laparoscopic interventions. Therefore, we scored laparoscopic procedures as peripheral surgeries and our definition of laparoscopic procedures might have an impact on the results. However, we thought that this effect would not cause a significant change in our results due to the absence of large abdominal incisions that caused postoperative pain and difficulty in mobilization and the speed of the healing process in laparoscopic procedures. We added emergency re-intubation and continuation of intubation after surgery to the EPCO criteria used in the evaluation of PPCs. Although this change

in definition might make a difference in developing PPC types, it did not affect the correlation between PPC frequency and ARISCAT scores. In addition, clinically insignificant atelectasis might have been overlooked, since routine chest radiographs were not requested from every patient who was operated on.

Conclusion

In our study, we found that the ARISCAT risk scoring index was significantly effective in predicting the development of PPC in patients undergoing major abdominal cancer surgery. Among the independent variables, age, preoperative SpO_2, surgical incision site and type of operation procedure were important factors, and age was found to be the strongest variable. Revealing the potential risk factors for the development of PPC will contribute to the early determination of preventive strategies and the effective use of health resources, especially in cancer patients with high frailty. In future studies, simple-to-use, bedside preoperative tests such as ARISCAT should be developed, and targets for identifying patient and surgical risk factors and improving perioperative care should be determined.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the University of Health Sciences Türkiye, Ankara Dr. Abdurrahman Yurtaslan Oncology Training and Research Hospital Clinical Research Ethics Committee (approval no.: 2019-11/459, date: 20.11.201).

Informed Consent: Informed consent forms were signed by all patients.

Authorship Contributions

Surgical and Medical Practices: M.K.Ş., S.A., Concept: M.K.Ş., S.A., G.O., S.Ü., Design: M.K.Ş., S.A., G.O., S.Ü., Data Collection and/or Processing: M.K.Ş., S.A., Analysis or Interpretation: M.K.Ş., S.A., G.O., S.Ü., Literature Search: M.K.Ş., S.A., G.O., S.Ü., Writing: M.K.Ş., S.A., G.O., S.Ü.

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