Original Article

The value of preoperative pulmonary assessment in predicting postoperative pulmonary complications

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Abstract:

OBJECTIVE: We aimed to determine the preoperative parameters that may predict postoperative pulmonary complications (POPCs) and the value of some current practical indexes in predicting POPCs.

MATERIALS AND METHODS: Our study is a retrospective cohort study carried out in 9 different centers. Patients admitted to the chest diseases outpatient clinic for preoperative evaluation were followed up during the 6-month study period. Patients with or without postoperative complications were evaluated retrospectively, and the effect of some parameters and indexes recorded during the preoperative evaluation of chest diseases on POPC development was investigated statistically.

RESULTS: A total of 307 patients were included in the study. POPCs were observed in 100 patients (32.6%). About 13% of these complications were respiratory tract infections, 59% were respiratory failure, 45% were pleural effusion, and 42% were atelectasis, which were the most common pulmonary complications. The probability of experiencing POPCs by patients with chronic obstructive pulmonary disease (COPD) is 2.5 (1.18–5.67) times more than those without COPD. We determined that patients with the history of upper respiratory tract infection during the preoperative period are 5.3 times more likely to have POPCs; similarly, the number was 4.7 for patients undergoing cardiac operation and 3.3 for patients with interstitial infiltration.

CONCLUSION: The risk of pulmonary complications was higher for those with the history of upper respiratory tract infection during the preoperative period, those undergoing cardiac surgery, those with the shortness of breath, those with the history of COPD, and those with the reticular/interstitial infiltrations in the chest X-ray. These parameters should be examined carefully in the preoperative period and should be careful in terms of pulmonary complications that may develop during the postoperative period.

Keywords:

Postoperative assessment, preoperative assessment, pulmonary complications

Introduction

A detailed preoperative assessment allows a good risk analysis. Anticipating the risks after the operation, informing the patient and surgeon, and a better and standard preoperative evaluation can reduce postoperative pulmonary complications (POPCs). POPCs result in prolonged hospitalization and increased mortality after surgery. The lack of viable models that can be accepted as valid and that can predict POPCs has led to the need for new studies. For this purpose, "the Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT)" study[1] proposed a scoring system and "Prospective evaluation of a risk score for POPCs in

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Europe (PERISCOPE)" study reviewed the validity of the ARISCAT scoring system.[2] These studies are preoperative evaluation of anesthesia physicians and surgical physicians. In addition to these parameters, a more practical and helpful evaluation protocol for chest physicians is needed to be used for preoperative evaluation in the chest diseases polyclinic. For example, respiratory function test and radiological examination are some parameters that the chest diseases physicians frequently need in preoperative evaluation but not examined in their evaluation scores.

The aim of the present study was to determine the parameters that could predict the POPCs in the chest diseases clinic, to examine the effect of these parameters and POPCs on hospitalization and mortality, and to determine the value of some practical indexes in predicting POPCs. A secondary aim is to contribute to the formation of standard protocols for the practice of chest diseases to be able to predict POPCs.

Methods

The present study is a retrospective, multicentered, and observational cohort study carried out in various provinces (Corum, Kayseri, Ankara, Istanbul, Erzurum, Zonguldak, Balıkesir, Kocaeli, and Canakkale) between the date of January 2017 and June 2017, in which the patients who admitted to the chest diseases polyclinics and who meet the criteria for inclusion in the study were included. Preoperative, postoperative, and operation-related data were recorded. Patients who develop and do not develop POPCs during the study were retrospectively evaluated in terms of preoperative parameters.

Some practical index records such as STOP-BANG, Canet risk score, American Society of Anesthesiologists (ASA) classification, multifactorial pneumonia, and respiratory failure risk score, as well as detailed history, physical examination, chest X-ray, and respiratory function test results were recorded. POPC, hospitalization duration, and mortality were also recorded, then compared with the preoperative evaluation.

Except for the preoperative evaluation, the researchers did not intervene to the surgeon; so, the routine protocols were applied by the surgeon. If necessary, the surgeon was consulted with chest diseases department and asked for postoperative complications. Patients were also monitored by the chest diseases physician in accordance with the study protocol for postoperative complications, and if necessary, postoperative complications were intervened.

The inclusion criteria in the study consisted of patients who were consulted for preoperative chest diseases and who did not have a restriction for general, neuraxial, and regional anesthesia. Exclusion criteria from the study were as follows:[1] patients under 18 years of age, patients with obstetric operations or pregnancy interventions, patients who will receive only local or peripheral nerve anesthesia, patients with previous postoperative complication procedures, patients with procedures outside the operating room, patients with transplantation, patients with preoperative intracranial tracheostomy, patients whose hospitalization period was <24 h, and patients who were reoperated in 90-day follow-up period.

The pathologies evaluated within the scope of POPC are described as follows:

- Respiratory infection: When the patient receives antibiotics due to suspected respiratory infection and meets at least one of the other criteria: new or changing phlegm, leukocytosis.
- Respiratory failure: When PaO_2 is below 60 mmHg in postoperative room air, the PaO_2/FiO_2 ratio is below 300 or 90% of saturation is below and oxygen therapy is needed.
- Pleural effusion: If the sinuses closed on chest X-ray, loss of net appearance of unilateral hemidiaphragm in a vertical position, the opacity where vascular shadows are protected in single hemithorax.
- Atelectasis: The opacity causing a shift of mediastinum, hilus, and hemidiaphragm to the affected area and an increase in compensatory inflation in the nonatelectatic lung.
- Pneumothorax: Air in the pleural space without a vascular bed.
- Bronchospasm: A newly identified expiratory wheezing treated with a bronchodilator.
- Aspiration pneumonitis: Acute lung injury due to inhalation of returned gastric contents.
- Pulmonary embolism: The diagnosis of embolism in the postoperative period.
- Extended Mechanical Ventilation: The requirement for mechanical ventilation of 24 h and more.[3]
- Continued positive airway pressure/Bilevel positive airway pressure (CPAP/BIPAP) requirement: The need for CPAP/BIPAP administration to the patient due to the shortness of breath in the postoperative period.

Statistical method

Statistical analyzes were performed with SPSS (version 22.0, SPSS Inc., Chicago, IL, USA, licensed to Hitit University). The normality distribution was assessed by the Shapiro–Wilk test. Descriptive statistics was presented as a mean ± standard deviation, median (min-max), number and percentage for categorical data, based on distributional assumptions for continuous variables. The effect of variables collected in our study on POPC was investigated by Multiple Binary Logistic Regression analysis. The Student's *t*-test and Mann Whitney U test for continuous data and Pearson Chi-square and Fisher's exact test for categorical data were used to determine the variables before multiple logistic regression analysis. $P < 0.05$ was considered as statistically significant.

Results

Nine centers participated in the study. 307 patients were included in the study. Some of the findings that may affect postoperative complications are shown in Table 1. There are 63 (20.5%) patients with ASA Class 1, 167 (54.4%) patients with Class 2, 67 (21.8%) patients with Class 3, and 7 (2.3%) patients with Class 4. There were 123 (40.1%) patients with Canet risk Score 1, 100 (32.6%) patients with Score 2, and 82 (26.7%) patients with Score 3. There were 127 (41.4%) patients with STOP-BANG Score 1, 129 (42%) patients with Score 2, and 51 (16.6%) patients with Score 3. General anesthesia was performed in 273 (88.9%) patients, neuraxial anesthesia in 22 (7.2%) patients, and regional anesthesia in 12 (3.9%) patients. 17 (5.5%) patients underwent emergency operations. The surgical incision was the peripheral and mediastinoscopic in 141 (45.9%) patients, upper abdominal in 61 (19.9%) patients, and thoracic in 103 (33.6%) patients. Surgical type was thoracic in 42 (13.7) patients, cardiac in 61 (19.9%), vascular in 5 (1.6%) (cardiovascular in 66 [21.5%]), mediastinoscopic in 44 (14.3%), gynecologic in 16 (5.2%), urological in 10 (3.3%), on breast in 42 (13.7%), conventional abdominal surgery in 20 (6.5%), endoscopic abdominal surgery in 24 (7.8%), and orthopedics in 35 (11.4%) patients. 182 (59.3%) patients were monitored in the service while 124 (40.4%) patients were monitored in the intensive care unit. 77 (25.1%) patients had continuous oxygen demand. 105 (34.2%) patients did not need oxygen. For the other patients, intermittent oxygen was used.

POPC was observed in 100 patients (32.6%). Respiratory tract infection was observed in 16 patients, respiratory failure in 59, pleural effusion in 46, pulmonary embolism in 2, atelectasis in 43, pneumothorax in 1, bronchospasm in 24, prolonged mechanical ventilation in 10, and CPAP/BIPAP requirement in 28 patients. Postoperative complications were observed at 0.61 ± 1.41 days after surgery, and the mean hospitalization duration was 6.97 ± 7.81 during the postoperative period. Postoperative mean intensive care hospitalization duration was 1.62 ± 5.51 days. Mortality was observed in only 3 patients. Mortality was observed in 1 endoscopic abdominal surgery, 1 breast, and 1 gynecologic operation ($P = 0.18$). There was no difference in mortality in terms of surgical incision ($P = 0.78$). Mortality was observed in 2 patients

Table 1: The descriptive parameters which may have influence on postoperative complications

	n (%)
Gender	
Male	171 (55.7)
Female	136 (44.3)
Smoking	
None	137 (44.6)
Former	94 (30.6)
Active	76 (24.8)
Presence of symptoms	214 (69.7)
Cough	98 (31.9)
Sputum	76 (24.8)
Dyspnea	131 (42.7)
Snoring	107 (34.9)
Apnea (proofed)	31 (10.1)
Daytime napping	56 (18.2)
Cough test	38 (12.4)
Rales	35 (11.4)
Rhonchus	28 (9.1)
Pulmonary function test	
Normal	136 (44.3)
Obstructive	58 (18.9)
Restrictive	60 (19.5)
Pathologic findings on Chest X-ray	127 (41.4)
Consolidation	6 (2)
Pleural fluid, blunted costophrenic angle	21 (6.8)
Increased aeration	35 (11.4)
Reticular, interstitial changes	55 (17.9)
Nodule, mass	8 (2.6)
Increased cardiothoracic ratio	13 (4.2)
Comorbidity	233 (75.9)
COPD	39 (12.7)
Respiratory failure	6 (2)
Bronchiectasis	4 (1.3)
Asthma	45 (14.7)
HT	150 (48.9)
DM	96 (31.3)
CHF	16 (5.2)
Liver disease	3 (1)
Cerebrovascular disease	3 (1)
CAD	38 (12.4)
CRF	4 (1.3)
AF	6 (2)
Sleep apnea, documented by polysomnography	7 (2.3)
Presence of oxygen concentrator at home	6 (2)
Presence of BIPAP/CPAP at home	3 (1)
Upper respiratory tract infection, preoperative last 1 month	20 (6.5)
Preoperative anticholinergic usage	90 (29.3)
Preoperative B2 agonist drug usage	128 (41.7)
Preoperative inhaled steroid usage	115 (37.5)
Preoperative systemic steroid usage	41 (13.4)
Preoperative theophylline usage	11 (3.6)
Postoperative incentive spirometry	108 (35.2)
Postoperative pulmonary exercise	124 (40.4)
Postoperative pulmonary drainage	104 (33.9)

Contd...

Table 1: Contd...

	n (%)
Postoperative opioid usage	141 (45.9)
Total parenteral feeding	30 (9.8)
Enteral feeding	30 (9.8)
Postoperative prophylaxis for thromboembolism	244 (79.5)

CPAP: Continuous positive airway pressure, COPD: Chronic obstructive pulmonary disease, BIPAP: Bilevel positive airway pressure, HT: Hypertension, AF: Atrial fibrillation, DM: Diabetes mellitus, CHF: Congestive heart failure, CAD: Coronary artery disease, CRF: Chronic renal failure

with pathological symptoms observed in chest X-ray ($P = 0.57$).

As the type of surgical incision was separated as cardiothoracic and noncardiothoracic to investigate the POPC among these subgroups, there was no difference in groups ($P = 0.25$). When the type of surgery was separated as thoracic and nonthoracic surgery to investigate the POPC among these subgroups, only one POPC (2.4%) was observed in thoracic surgery group ($P < 0.001$). When the type of surgery was separated as thoracic, cardiac, and noncardiothoracic surgery, there were 37 (60.7%) POPC in cardiac surgery group and 62 (30.4%) POPC in noncardiothoracic surgery group ($P < 0.001$).

The most frequent pulmonary complications in patients with POPC were respiratory tract infection (13%), respiratory failure (59%), pleural effusion (45%), and atelectasis (42%).

The effect of the variables on POPC was investigated by "Multiple Binary Logistic Regression. Before "Multiple binary logistic regression analysis," "Student's *t*-" and "Mann–Whitney U" test were used to identify candidate variables for continuous data. Preoperative saturation value which was statistically significantly different and preoperative blood glucose variable which was close to the statistically significant limit between the groups of POPC were decided to be taken into the model (P=0.023, P=0.057, respectively). Some variables that are not significantly different according to the POPC groups such as age, smoking (packet/years), body mass index, forced expiratory volume in 1 s percentage (FEV1%), preoperative albumin, preoperative urea, and preoperative hemoglobin value are not included in the model ($P = 0.375$, $P = 0.888$, $P = 0.332$, $P = 0.564$, $P = 0.147$, $P = 0.198$, and $P = 0.787$, respectively). For categorical data, some variables having significant differences according to Pearson's Chi-square and Fisher's exact test such as shortness of breath, snoring, rales, chest X-ray, reticular/interstitial (RI) density, mass, nodule, chronic obstructive pulmonary disease (COPD), preoperative upper respiratory infection (URI), surgical incision, thoracic operation, cardiac operation, and endoscopic abdominal surgery (P = 0.011, 0.006, <0.001, 0.004, <0.001, <0.001, 0.002, <0.001, <0.001, <0.001, <0.001, <0.001 and 0.029, respectively) and some variables which is close to the border of significance such as obstructive apnea, daytime sleepiness, cough test, respiratory failure, hypertension (HT), atrial fibrillation, emergency or elective surgery, mediastinoscopy, urological operation (P = 0.098, 0.098, 0.087, 0.091, 0.056, 0.091, 0.065, 0.064, and 0.084, respectively) were included in the model. Some parameters which is away from being significant such as gender, smoking, symptoms, cough, phlegm, rhonchus, pulmonary function test, consolidation, fluid sinus closure, increase in ventilation, increase in cardiothoracic ratio, presence of additional disease, bronchiectasis, asthma, diabetes mellitus (DM), congestive heart failure (CHF), liver disease, respiratory failure, coronary artery disease, chronic renal failure, other additional illnesses, diagnosed sleep apnea, the presence of O_2 concentrators at home, the presence of CPAP/BIPAP at home, operation anesthesia, vascular operation, gynecological operations, breast surgery, general surgery, conventional abdominal surgery, and orthopedics operation variables are not included in the model (P = 0.864, 0.977, 0.161, 0.185, 0.360, 0.959, 0.291, 0.395, 0.576, 0.319, 0.365, 0.799, 1.000, 0.250, 0.848, 0.666, 0.248, 0.554, 0.610, 1.000, 0.374, 1.000, 0.668, 0.640, 0.554, 0.211, 0.327, 0.342, 0.220, 0.818, respectively). Following univariate analysis, some variables were added to multiple binary logistic regression analysis to determine their effects on POPC. These 23 different variables are the preoperative saturation value, preoperative blood sugar, shortness of breath, snoring, rales, chest X-ray, RI changes, nodule/mass, COPD, preoperative upper respiratory tract history, surgical incision, thoracic, cardiac, endoscopic abdominal surgery, obstructive apnea, daytime sleepiness, cough test, Respiratuar Failure (RF) , HT, AF, emergency or elective surgery, mediastinoscopy, and urological operation. As a result of the analysis, nodule/mass variable whose confidence intervals could not be calculated (0: $n = 299$, 1: $n = 8$) was removed from the analysis. The final model was obtained using 8 of the 22 variable. These 8 variables were found to be significant as a result of forward stepwise Wald and backward stepwise Wald analysis, and the analysis results are given in Table 1. Logistic regression successful classification rate was determined to be 73.9%. Preoperative parameters which are determined to predict POPCs by "Multiple Binary Logistic Regression" analysis are given in Table 2.

The probability of having POPC for those with COPD was observed as 2.5 (1.18–5.67) times higher than those without COPD. The probability of having POPC for those with a history of upper respiratory tract infection in the preoperative period was 5.3 times higher; similarly, we found these value as 4.7 times for those with the cardiac operations and 3.3 times for those with the reticular and the interstitial appearance in the chest X-ray.

POPC were seen in 58.2% of those with RI changes in the chest X-ray, in 53.8% of those with COPD, in 70.0% of those with a history of upper respiratory tract infection in the preoperative period, in 2.4% of those with thoracic surgery, in 59.1% of those with cardiac surgery, in 40.5% of those with shortness of breath, and in the 22.4% of those with snoring. Preoperative fasting blood glucose was seen as an average of 144 ± 77.58 in those with POPC and 127.94 ± 52.78 in those without POPC. In spirometry, obstructive pathology was seen in 58 (18.9%) patients and restrictive pathology in 60 (19.5%) patients.

Table 2: "Multiple binary logistic regression" analysis of preoperative parameters which predicted postoperative pulmonary complications

	P	OR	CI	
			Lower value	Upper value
Preoperative blood sugar	0.047	1.004	1.000	1.008
RI infiltration	0.000	3.334	1.699	6.542
COPD	0.018	2.586	1.179	5.673
Preoperative upper respiratory tract infection	0.003	5.321	1.792	15.799
Cardiac surgery	0.000	4.700	2.513	8.788
Dyspnea	0.036	1.828	1.041	3.210

COPD: Chronic obstructive pulmonary disease, OR: odds ratio, CI: Confidence interval, RI: Reticular/interstitial

Spirometry was not performed in 53 (17.3%) patients. SFT (obstructive/restrictive) and FEV1 reduction showed no correlation with POPC ($P = 0.27$, $P = 0.564$, respectively).

Table 3 shows the demographic characteristics of the patients with COPD (21), with RI infiltration in the chest X-ray (32), and with URTI history (14), as well as patients undergoing cardiac surgery (39), and patients with dyspnea (53), which were detected in the preoperative period.

Table 4 shows the postoperative hospitalization duration and its relationship with mortality according to the presence of COPD, RI infiltration in chest X-ray, URTI, cardiac surgery, and dyspnea in the preoperative period.

After the relationship between risk scores and POPCs was assessed, we found a significant correlation only between the ASA classification and POPC. The POPC was found in 43 of the patients with a low-risk score of STOP-BANG (33.9%), in 45 (34.9%) of the patients with a moderate risk score, and in 12 patients (23.5%) with the high-risk score ($P = 0.315$). The POPC was detected in 34 patients with a low-risk score of Canet risk assessment (27.6%), in 32 patients (32.0%) with a

Table 3: The relationship of preoperative pathologies with postoperative complications

	Respiratory tract infection (%)	Respiratory failure (%)	Pleural effusion (%)	PTE (%)	Atelectasis (%)	PNX (%)	Bronchospasm (%)	Prolonged mechanical ventilation (%)	Need for CPAP/BIPAP (%)
COPD (*n*=21)	2 (9.5)	11 (52.4)	11 (52.4)	-	9 (42.9)	-	3 (14.3)	-	6 (28.6)
Infiltration (*n*=32)	4 (12.5)	23 (71.9)	16 (50.0)	-	16 (50.0)	1 (3.1)	8 (25.0)	3 (9.4)	12 (37.5)
URTI (*n*=14)	1 (7.1)	9 (64.3)	7 (50.0)	-	6 (42.9)	-	4 (28.6)	1 (7.1)	4 (28.6)
Cardiac surgery (*n*=39)	3 (7.7)	27 (69.2)	25 (64.1)	2 (5.3)	18 (46.2)	-	3 (7.7)	-	10 (25.6)
Dyspnea (*n*=53)	6 (11.3)	28 (52.8)	28 (58.8)	1 (1.9)	22 (41.5)	1 (1.9)	13 (24.5)	3 (5.7)	14 (26.4)

COPD: Chronic obstructive pulmonary disease, URTI: Upper respiratory tract infection, PTE: Pulmonary thromboembolism, PNX: Pneumothorax, CPAP: Continued positive airway pressure, BIPAP: Bilevel positive airway pressure

Table 4: The relationship of preoperative pathologies with postoperative length of stay and mortality

	Length of stay (days)	*P*	ICU stay (days)	*P*	Mortality	*P*
COPD (+)	8.31±5.71	0.25	2.00±4.30	0.65	0.03±0.16	0.49
COPD (−)	6.77±8.07		1.57±5.67		0.01±0.09	
R/I infiltration (+)	10.98±13.22	0.01	3.55±11.64	0.15	0	0.42
R/I infiltration (−)	6.11±5.75		1.21±2.74		0.01±0.109	
Cardiac surgery (+)	8.35±6.40	0.108	1.73±1.78	0.86	0	0.36
Cardiac surgery (−)	6.59±8.13		1.59±6.17		0.01±0.11	
Dyspnea (+)	7.03±6.24	0.91	1.66±3.35	0.92	0.02±0.12	0.40
Dyspnea (−)	6.93±8.33		1.60±6.69		0.01±0.07	
URTI (+)	8.84±4.73	0.28	1.79±2.02	0.90	0	0.54
URTI (−)	6.85±7.97		1.61±5.67		0.01±0.10	
POPC (+)	11.20±9.98	<0.001	3.40±9.00	0.006	0.02±0.14	0.31
POPC (−)	4.99±5.56		0.80±2.12		0.00±0.07	

COPD: Chronic obstructive pulmonary disease, URTI: Upper respiratory tract infection, ICU: Intensive care unit, POPC: Postoperative pulmonary complication, R/I: Reticular/interstitial moderate risk score, and in 33 patients (40.2%) with high-risk scores ($P = 0.23$). POPCs were found to be 20.6% ($n = 13$) in those with ASA 1, 32.9% ($n = 55$) in those with ASA 2, 34.8% ($n = 30$) in those with ASA 3, and 14.3% ($n = 1$) in those with ASA 4 ($n = 0.02$). The risk index for multifactorial respiratory failure was 15.69 ± 10.97 in patients with POPCs and 16.52 ± 10.03 ($P = 0.42$) in patients without POPCs. The multifactorial pneumonia risk index was 12.76 ± 9.07 in patients with POPCs and 10.75 ± 7.99 ($P = 0.055$) in patients without POPCs.

Discussion

In the present study, POPC was found in 32.6% of the study group. The risk of pulmonary complications was higher for those with the history of upper respiratory tract infection during the preoperative period, those undergoing cardiac surgery, those with the shortness of breath, those with the history of COPD, and those with the RI infiltrations in the chest X-ray. In the previous studies, POPCs were reported as 2%–9%, while this rate was 10%–30% in those receiving general anesthesia.[4-6]

Most common POPC is respiratory failure characterized by impaired pulmonary gas change. Furthermore, respiratory failure is associated with the prolonged mechanical ventilation, the complications related to prolonged intensive care, and the increased mortality.[7-10] In our study, respiratory failure was the most frequent complication, comprising 59% of the patients with POPC.

Canet *et al*.[1] reported that the postoperative respiratory failure developed in 63 patients (2.6%), bronchospasm in 44 (1.8%), pleural effusion in 43 (1.7%), respiratory infection in 40 (1.6%), atelectasis in 35 (1.4%), aspiration pneumonitis in 9 (0.4%), and pneumothorax in 8 (0.3%). In PERISCOPE study, respiratory failure was the most frequent complication (241 patients, 4.7%), followed by pleural effusion (159, 3.1%), atelectasis (122, 2.4%), pulmonary infection (120, 2.4%), bronchospasm (42, 0.8%), pneumothorax (29, 0.6%), and aspiration pneumonitis (12, 0.2%).[2] In our study, the most common complications for the patients with POPC were respiratory failure (%59), pleural effusion (45%), atelectasis (42%), and respiratory tract infection (13%).

Smoking history has been reported as an independent risk factor for POPC.[11,12] However, in our study, smoking history is not associated with POPC. Similarly, Saracoglu *et al*. reported that there is no relationship between these two parameters.[6] We report that the presence of COPD disease known to be associated with smoking increases the risk of POPC to 2.5 (1.18–5.67) fold. The COPD can be alleviated due to increased bronchospasm and hyperreactivity during surgery.[13] COPD is a well-known risk factor for the development of POPC.[14] In patients with COPD, respiratory insufficiency, pleural effusion, and atelectasis were the most common POPC. Gupta *et al*.[8] reported that COPD had a relationship with postoperative pneumonia and respiratory failure.

Many studies indicated that POPC such as postoperative pneumonia and prolonged mechanical ventilation is more common in patients receiving general anesthesia.[15] In our study, we did not find an anesthetic-type POPC development relationship. 88.9% patients received general anesthesia, and the number of patients with neuraxial and regional anesthesia was very few. The absence of statistical difference was not considered clinically insignificant. However, patients receiving general anesthesia are expected to have more risk of developing POPC through many mechanisms.[16-19] As in most studies, POPC was observed more in patients undergoing abdominal surgery. The mechanism is explained through which surgical incision affects the diaphragm and causes superficial respiration. Many studies suggest that laparoscopic techniques reduce the risk.[11,20] Although surgical incision may seem to be associated with POPC, statistical analysis revealed that this effect was not independent.

ASA level is routinely used in preoperative evaluation.[11] In our study, a relationship between ASA classification and POPC was determined. The higher the ASA classes, the greater the risk of POPC. However, it was not determined as an independent variable in regression analysis. This assessment, which shows the overall health status, cannot be expected to be an independent effective factor. Therefore, we believe that ASA classification is more valuable than the other risk scores used in this study.

Although the routine use of preoperative spirometry and lung radiology to predict POPC is not recommended in the 2006 ACP guideline, SFT and radiology are used together in preoperative assessment of chest disease practice. In the present study, there was no correlation between the presence of obstruction or restriction in SFT and the presence of POPC. However, the presence of RI infiltration in the radiological appearance of lung increased the risk of POPC up to 3.3-fold. Respiratory failure, atelectasis, and postoperative use of NIMV were most frequent POPC. Postoperative hospitalization duration is also higher in these patients. Therefore, lung radiology is important in preoperative evaluation. There is still insufficient evidence for the use of preoperative spirometry.[21,22] Although some studies show that asthma increases the risk of POPC, recent studies have shown that asthma does not increase this risk.[5] In the present study, asthma was not determined as a risk factor for POPC. Lawrence *et al*.[23] indicated that POPC was associated with abnormal chest X-ray, decreased respiratory sounds, and prolonged expiration or rales, rhonchus sounds. In our study, although we found higher POPC in patients with rales, it was not detected as an independent risk factor. It is known that spirometry and lung radiography may be used in patients with the chronic cardiopulmonary disease. In our study, the relationship between spirometry and POPC was not determined, but a relationship between the presence of RI infiltration in the pulmonary radiology and the presence of POPC was observed.

Heart surgery is a high-risk surgical operation for POPC development. Maneuvers such as the dissection of the internal thoracic artery in the case of myocardial revascularization, the application of topical ice, and the dissection of the pericardium may increase the risk of phrenic nerve damage. Although the mechanism of pulmonary dysfunction after cardiopulmonary bypass is unclear, the immunogenic factors depending on the nonbody circulation, frequent blood transfusion, and massive fluid shifts can cause damage. Mortality is high after cardiopulmonary bypass. During bypass, the lungs become collapsed, and the development of postoperative atelectasis is frequent. The longer the period, the greater the risk of POPC development.[24,25] In our study, there was a 4.7-fold increased risk of POPC in cardiac surgery patients.

Type of surgical incision site has an important role on POPCs. No difference was observed in terms of postoperative complications between cardiothoracic and noncardiothoracic surgery subgroups (36.9%, 30.4%; $P = 0.25$). Nonetheless, as we separated the type of surgery as thoracic, cardiac, and noncardiothoracic surgery, there were 37 (60.7%) POPCs in cardiac surgery group and 62 (30.4%) POPCs in noncardiothoracic surgery group ($P < 0.001$). In the previous studies, the frequency of pulmonary complications and their severity in clinical practice were not clearly documented. Variations in the reported occurrence of pulmonary complications after cardiac surgery range from 8% to 79%.[26] The findings of this study similarly reveal higher POPCs following cardiac surgery.

The overall incidence of POPC following thoracic surgery varies from 15% to 37.5%.[27] In our study, the low incidence of POPC (2.4%) in thoracic surgery group may be explained with close follow-up of patients during postoperative course. Furthermore, preoperative selection of the patients and treatment of underlying pulmonary pathology with thoracic surgery may also have a role on these results.

Mortality was observed in 2% of the patients with POPC. Canet *et al*. reported that 30-day mortality was observed in 19% of the patients with POPC.[1] In the present study, mortality was observed in only 3 patients, being a low number compared to the literature. Therefore, the comparisons of mortality are not clinically relevant in our study. Canet *et al*. revealed that the hospitalization duration was 12 days on average for the patients with POPC and 3 days for the patients without POPC. Similarly, we found that the duration of hospitalization for those with POPC increased.

Since 2000, multiple assessment scoring systems for the development of POPC have been developed by defining risks in preoperative period.[9,28] Patients with a cough and shortness of breath should be evaluated carefully. The risk factors for POPC were reported as cardiac insufficiency, functional restriction, COPD, current smoking status ASA level, and age.[29] ASA classification is used as a useful and widely accepted risk assessment tool.[22] Most OSAS patients are not diagnosed during the preoperative period. Patients with sleep apnea have a high risk for perioperative complication such as hypoxemia, pneumonia, difficult intubation, myocardial infarction, pulmonary embolism, atelectasis, and arrhythmia.[30-32] OSAS is present in about 22% of the adult patients to be surgically treated. However, almost 70% of them have not yet been diagnosed in preoperative evaluation.[31-33] Many questionnaires have been developed to determine high-risk patients for OSAS during surgery assessment, such as the Berlin questionnaire, ASA checklist, and the Stop-Bang questionnaire.[34-36] Stop-Bang questionnaire has a high sensitivity, specificity, and negative predictive value in detecting moderate and severe sleep apnea.[28] ACP also suggests some scaling indices for specific complications such as respiratory failure and pneumonia.[28,37] These indices were used in the present study, but they were not found to be valuable in predicting POPC.

Canet *et al*.[1] mentioned that, as a limitation in their study, spirometry was not used. Preoperative evaluations were guided by anesthesia physicians in the literature, but spirometry was not sufficiently evaluated. In our study, the effect of spirometry was investigated, but it did not have any significant effect on the POPC.

The first limitation of our study was that the number of patients was not sufficient to form an index. Second, the fact that very few mortalities were observed did not allow to compare the effect of risk factors on mortality and to examine the value of risk indexes foreseeing mortality. The other limitation of our study is the fact that POPC and mortality were recorded during hospitalization. Third, because of the fact that the researchers who performed the operation were physicians in chest diseases, they did not see the patients during the perioperative period and did not completely eliminate the effective factors. This period was only determined from nursing records. We think that the joint studies evaluated by both chest disease physicians in the preoperative period and anesthesia physicians in perioperative period may be more valuable in predicting which parameters will be evaluated in risk indexes. In addition, it will be more valuable to have more patients from multicenter, as in our study.

Conclusion

In the present study, we observed that there was a higher risk of pulmonary complications for patients who had a history of upper respiratory tract infection during the preoperative period, patients who underwent cardiac surgery, patients who had shortness of breath, a history of COPD, and a RI infiltration in the chest X-ray. These parameters should be examined carefully in the preoperative period, and physicians should be careful in terms of pulmonary complications that may develop during the postoperative period.

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Conflicts of interest
There are no conflicts of interest.

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