Predictive Factors Involved in Development of Postoperative Pulmonary Complications

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Objective: In the present study, we applied the method of the multi-center Prospective Evaluation of a Risk Score for postoperative pulmonary Complications in Europe (PERISCOPE) study, which was designed to predict postoperative complications and funded by the European Society of Anaesthesiology, to patients in our institution with the aim of prospectively analyzing the postoperative risk factors of pulmonary complications.

Methods: One hundred patients over 18 years of age who had emergency or elective non-thoracic or non-obstetric surgery under general anaesthesia or neuraxial blocks were included in the study. Collected data regarding the preoperative and postoperative period were filled in separate forms for all patients.

Results: A total of 11 patients developed pulmonary complications. We observed respiratory failure in 8 patients, pleural effusion in 3 patients, atelectasis in 5 patients, bronchospasm in 3 patients, and pneumothorax in 1 patient. In the univariate logistic regression model, patient age, gender, weight, rate of preoperative respiratory symptoms, cough test results, American Society of Anesthesiology (ASA) score, and the duration of surgery did not significantly increase the complication risk ($p>0.05$). However, in the univariate logistic regression model, the presence of respiratory symptoms increased the risk for complications approximately 5.34-fold ($p=0.014$). There was an increase in the possibility of complications in parallel with the increase in the duration of postoperative hospital stay ($p=0.012$). More respiratory symptoms ($p=0.019$) and longer hospital stay (6.5 vs. 3.5 days respectively, $p=0.029$) were recorded in patients with postoperative pulmonary complications.

Conclusion: Considering patients undergoing non-thoracic or non-obstetric surgery, the prevalence of postoperative pulmonary complications is higher in patients diagnosed with respiratory symptoms in the preoperative period. These complications significantly extend the length of hospital stay.

Key Words: Postoperative pulmonary complications, risk factors, comorbidity

Introduction

Pulmonary complications (PPCs) that are frequently seen in the postoperative period are an important cause of morbidity and mortality among patients (1, 2). The reasons for the occurrence of these complications are multifactorial. The surgery, anaesthesia method that is applied and preoperative risk factors of the patients play an important role. Obesity, smoking, age, current chronic lung diseases and other comorbidities are patient risk factors. Apart from these, whereas anaesthesia type, duration, use of different agents and efficacy of postoperative pain treatment are anaesthesia-related risk factors, intervention time, surgical techniques and incision size represent surgical risk factors. Atelectasis, pneumonia, respiratory failure and tracheobronchial infection can be listed among the main PPCs. The most common postoperative complication is atelectasis. Pneumonia, on the other hand, is reported as the primary reason of mortality (3). In addition, presenting the potential risk factors associated with pulmonary complications ensures the anticipation of complications by determining preventive strategies. In previous studies, for specific surgical groups, like upper abdominal interventions (4), oesophagectomy (5), total knee arthroplasty (6) or coronary artery bypass surgery (7), preoperative risk factors in the development of PPCs were investigated. The European Society of Anaesthesiology (ESA) performed a multinational, multicentre study called PERISCOPE (Prospective Evaluation of a Risk Score for postoperative pulmonary Complications in Europe), which our clinic also attended. In this study, the protocol of PERISCOPE is applied as a single-centre study, and our aim is to analyse preoperative risk factors prospectively for postoperative complications in our own patient population.

Methods

Following Istanbul University Faculty of Medicine Ethics Committee approval for our request concerning the changes in the “single-centre study” for the Periscope OPA, which had been approved by the very same committee (no: 2011/1188-631, dated: 05/04/2013), written informed consent of all patients was obtained; 100 patients over the age of 18 and undergoing urgent or elective surgery were included in the study. Patients undergoing surgeries with general anaesthesia or neuraxial block were included in the study. Obstetric and thoracic surgeries, patients in the gestational period and under 18 years of age, outpatient interventions, surgical interventions for postoperative complications, intubated patients and outpatient surgeries were excluded. For all patients, forms containing demographic characteristics and medical history were filled. Patients’ demographic data, queries related to surgical admission and discharge and preoperative, intraoperative, and postoperative data results were recorded. The analysed PPCs are shown in Table 1. For each PPC, the date of diagnosis was recorded.

Statistical analysis

In the analysis, SPSS (Statistical Package for the Social Sciences, Chicago, IL, USA) 21.0 software was used. For the descriptive statistics of the data, mean, standard deviation, rate and frequency values were used. Distribution of variables was checked via Kolmogorov-Smirnov test. In the analysis of quantitative data, the Mann-Whitney U-test and independent-samples t-test were used. In the analysis of qualitative data, when chi-square test conditions could not be provided, Fischer test was used. Effect level was analysed by logistic regression. Considering that the PPC incidence was 5% in previous studies and that the estimated sampling error was 5%, including 75 patients into the study was sufficient. Thus, we included 100 consecutive patients from the beginning of the study.

Results

The study included 100 patients who had general anaesthesia or neuraxial blocks; 54% was female and 46% was male. Also, 47 patients were in ASA 1 (American Society of Anaesthesiology), 45 were in ASA 2, and 8 patients were in ASA 3 risk groups. The patients’ demographic data are shown in Table 2. One of them was an urgent surgical intervention, and the others were elective surgeries. Fifteen out of 100 patients had neuraxial block, and none of them required postoperative intensive care. Five patients were monitored in the postoperative intensive care unit. Only 1 patient who was monitored in the postoperative intensive care unit for 24 hours had a 31.8 body mass index, and his functional capacity was 1, but the other patients were normal. All patients were healed and discharged home.

A total of 11 patients developed PPCs. We observed respiratory failure in 8 patients, pleural effusion in 3 patients,

atelectasis in 5 patients, bronchospasm in 3 patients and pneumothorax in 1 patient. Respiratory failure was observed in all patients who developed atelectasis. Whereas 1 patient had respiratory failure accompanied by pleural effusion, in addition, atelectasis was also observed in another patient. Aspiration pneumonia or pulmonary oedema was not observed.

The presence of respiratory system symptoms was significantly lower in patients who had PPCs after surgery than patients who did not ($p=0.019$). Length of hospital stay was significantly longer in patients who developed postoperative PPCs than in patients who did not develop PPCs ($p=0.029$) (Table 3).

In the univariate logistic regression model, patient age, gender, weight, rate of preoperative respiratory symptoms, smoking habit, cough test results, American Society of Anaesthesiology (ASA) score and the duration of surgery did not significantly increase the complication risk ($p>0.05$). However, in the univariate logistic regression model, the presence of respiratory symptoms increased the risk for PPCs approximately 5.3-fold (1.4-20.2) ($p<0.05$). There was an increase in the possibility of complications in parallel with the increase in the duration of postoperative hospital stay ($p<0.05$) (Table 4). The correct estimation rate of the model is 87%.

The type of surgery with the longest stay in the intensive care unit was glossectomy, with 72 hours (intervention time 245 min), and after that, it was intestinal resection, with 48 hours (intervention time 120 min). Eleven of the surgeries were upper abdominal surgeries. Fourteen patients underwent upper abdominal laparoscopic surgery (average length of hospital stay: 5 days), 1 patient had coronary artery bypass grafting (7 days), 1 patient had endoscopic intrathoracic surgery (2 days) and 73 patients underwent minor surgeries with a peripheral incision, such as inguinal hernia, breast surgery, shoulder fracture or varicose repair (1 day).

The relationship between the incidence of postoperative pulmonary complications and risk factors is shown in Table 5. The comparison of the characteristics between patients who developed PPCs and patients who did not is shown in Table 6. The only urgent intervention performed was evisceration in 11 patients who developed PPCs; the others were elective surgeries. All patients that had PPCs received general anaesthesia; 45% was female, and the others were male. The types of interventions and PPCs are shown in Table 6.

Seven patients had chronic obstructive pulmonary disease (COPD), and 3 of them were admitted to the intensive care unit (42.8%). Seventeen patients showed respiratory symptoms, like cough, wheezing, dyspnoea and sputum (17.6%). A total of 60% of those who received intensive care presented with respiratory symptoms. When evaluated in terms of heart failure, New York Heart Association (NYHA) score was 2 in 1 out of 5 patients; the others had 0. In total, 6 patients were NYHA 1, 6 patients were NYHA 2 and 1 patient was NYHA

Table 1. Postoperative pulmonary complication analysis

1. Has the patient experienced any PPC? 1- yes, 2- no (if no, go to question 21)
2. Respiratory syndrome 1- no, 2- mild: when breathing room air $\text{PaO}_2 < 60$ mmHg or $\text{SpO}_2 < 90\%$ but needs a facemask or nasal oxygen, 3- serious: depending on $\text{PaO}_2 < 60$ mmHg or $\text{SpO}_2 < 90\%$, needing non-invasive or invasive mechanical ventilation, 4- severe: need for invasive mechanical ventilation and $\text{PaO}_2/\text{FiO}_2 < 300$.
3. Date of respiratory failure diagnosis:
4. Pulmonary infection suspicion: 1- yes: If the patient is taking antibiotics and if there is at least one of the following criteria: sputum, opacity in PA chest film, fever over 38 degrees, leucocytosis over 12,000/mcl, 2- no.
5. The first date of postoperative pulmonary infection suspicion:
6. Pulmonary infiltration: 1- yes: unilateral or bilateral opacities in posteroanterior chest film, 2- no.
7. The first diagnosis date of postoperative pulmonary infiltration:
8. Pleural effusion: 1- yes: flattening on costophrenic angle on PA, 2- no.
9. The diagnosis date of pleural effusion:
10. Atelectasis: 1- yes: Lung opacities containing mediastinum, hilum or hemidiaphragm shifting towards affected area and compensatory overinflation in non-atelectasis lung, 2- no.
11. The first diagnosis date of atelectasis:
12. Aspiration pneumonia: 1- yes: respiratory failure following regurgitation of gastric contents, 2- no
13. Diagnosis date of aspiration pneumonia:
14. Bronchospasm: 1- yes: new expiratory wheezing requiring treatment with bronchodilator, 2- no
15. Development history of bronchospasm:
16. Pneumothorax: 1- yes: presence of air in the pleural space, 2- no.
17. Diagnosis date of pneumothorax:
18. Cardiogenic pulmonary oedema: 1- yes: dyspnoea identified as a result of echocardiography, pulmonary catheterisation or specific therapy and rales associated with left ventricular failure and diffuse alveolar interstitial infiltrates.
19. Diagnosis date of cardiogenic pulmonary oedema:
20. Postoperative intensive care unit stay (hours):
21. Discharge from the hospital: 1- lives, discharged home, 2- lives, discharged to another medical centre, 3- lives, discharged to a care centre, 4-exitus.
22. Date of discharge:
23. The cause of death:
PPC: postoperative pulmonary complication, PaO_2 : arterial oxygen pressure, SpO_2 : oxygen saturation, FiO_2 : percentage of inspired oxygen, PA: posteroanterior, mcl: microliter

Table 2. Demographic data and hospitalisation times (Mean $\pm$ SD)

Age (year)	51.4 $\pm$ 17.4
Body weight (kg)	73.8 $\pm$ 13.0
Height (cm)	167.2 $\pm$ 9.4
Postoperative hospitalisation time (day)	7.4 $\pm$ 4.9
Postoperative hospitalisation time in intensive care unit (hour)	37.0 $\pm$ 23.0
Mean $\pm$ SD: mean $\pm$ standard deviation	

3 (Class 1: symptoms with more than ordinary activity, Class 2: symptoms with ordinary activity, Class 3: symptoms with minimal activity, Class 4: symptoms at rest) (8).

The functional capacity of 13 of 100 patients was 2, and these 2 were monitored in the intensive care unit (15.3%). However, in terms of length of stay in the intensive care unit, there

was no statistically significant difference between patients who had functional capacity 1 and 2.

Discussion

In this study, the protocol of PERISCOPE was applied as a single-centre study, and our aim was to analyse preoperative risk factors prospectively for postoperative complications in our own patient population.

The presence of respiratory system symptoms was significantly lower in patients who had PPCs after surgery than in patients who did not. Length of hospital stay was significantly longer in patients who developed postoperative PPCs than in patients who did not develop PPCs. Patient age, gender, weight, rate of preoperative respiratory symptoms, smoking habit, cough test results, ASA score and the duration of surgery did not significantly increase the complication risk. The

Table 3. Comparison of data obtained from patients with and without postoperative pulmonary complications (mean±SD)

		Postoperative pulmonary complication				p
		Existent		Non-existent		
		n	%	n	%	
Age		58.4±15.8		50.6±17.5		0.162
Gender	Female	5	45.5	49	55.1	0.547
	Male	6	54.5	40	44.9	
Weight (kg)		73.7±17.4		73.9±12.5		0.970
Presence of preoperative respiration symptom	Existent	2	18.2	6	6.7	0.213
	Non-existent	9	81.8	83	3.3	
Respiration-related symptom	Non-existent	6	54.5	77	86.5	0.019
	1	1	9.1	4	4.5	
	2	3	27.3	6	6.7	
	3	0	0.0	2	2.2	
	4	1	9.1	0	0.0	
Smoking status	Never smoked	3	27.3	46	51.7	0.169
	Still smoking	3	27.3	24	27.0	
	Quit smoking 1 month ago and earlier	5	45.5	19	21.3	
Cough test	Presence of cough	2	18.2	18	20.2	0.677
	Absence of cough	6	54.5	68	76.4	
	Not tested	3	27.3	3	3.4	
ASA	I	4	36.4	43	48.3	0.454
	II	5	45.5	40	44.9	
	III	2	18.2	6	6.7	
Surgery duration (hour)		6.5±4.5		3.5±3.8		0.405
Hospitalisation after intervention (day)		6.5±4.5		3.4±3.8		0.029
Preoperative serum creatinine (mg dL ⁻¹)		0.8±0.1		0.87±0.1		0.068
Crystalloid infusion (mL)		1740±560.7		1296±669.2		0.036
Colloid infusion (mL)		227.2±261.1		150.8±310.9		0.078
Intervention duration (min)		131.8±95.6		94.3±53.3		0.042
Independent-samples t-test/Mann-Whitney U-test/chi-square test; Mean±SD: mean±standard deviation; ASA: American Society of Anesthesiology						

Independent-samples t-test/Mann-Whitney U-test/chi-square test; Mean±SD: mean±standard deviation; ASA: American Society of Anesthesiology

presence of respiratory symptoms increased the risk for PPCs approximately 5.34-fold. In the two studies previously conducted, it was reported that the presence of cough symptom in the preoperative phase increases the PPC risk (9, 10). While the only factor increasing PPC risk was purulent cough in the series mentioned before (respectively, 297 and 117 patients), in our study, in addition to cough symptom, the presence of dyspnoea, sputum and wheezing were evaluated, and the presence of a significant risk was determined. In addition, that the positivity in the patients' cough test results was not a PPC risk-increasing factor reveals the necessity to analyse the presence of respiratory symptoms in a more comprehensive way.

In our study, the patients' preoperative smoking habits did not increase the risk of postoperative pulmonary complications. In a meta-analysis in which 107 studies were included, whereas there was no increase in postoperative mortality in preoperative smokers, an increase in general morbidity, wound complications, infection, neurological complications, intensive care unit admission and pulmonary complication

rate was observed (11). It was reported that there was an approximately 2.5-fold increase of the PPC risk in smokers. In this meta-analysis, it was stated that smoking cessation 4-8 weeks prior to the surgery decreased the postoperative complication risk. On the other hand, as was the case with our study, there was no significant difference in postoperative pulmonary complication incidence or 1-year postoperative pulmonary function test results in patients who recently stopped smoking or still smoked (12). Therefore, it was reported that it was not necessary to postpone the surgery.

Mistiaen and Vissers (13) assessed the preoperative risk factors of 1000 patients who had undergone aortic valve replacement surgery and reported that the postoperative pulmonary or pleural complication rate in elderly patients is low. In this observational study, it was determined that the presence of lung diseases, such as chronic obstructive pulmonary disease, increases the complication rate. In our study, we found that age and chronic obstructive pulmonary disease do not increase the likelihood of PPCs. However, the average age of

Table 4. Distribution of patient and intervention data

Univariate model	O.R.	95% confidence interval		p
		Minimum	Maximum	
Age	0.973	0.937	1.011	0.165
Gender (F/M)	0.680	0.193	2.394	0.548
COPD (existent/non-existent)	3.074	0.539	17.547	0.206
Weight (kg)	1.001	0.954	1.051	0.969
Smoking (existent/non-existent)	2.853	0.710	11.459	0.140
Cough (existent/non-existent)	1.259	0.234	6.774	0.788
ASA (I/II/III)	0.572	0.220	1.487	0.252
Surgery duration (hour)	0.993	0.984	1.001	0.091
Hospitalisation after intervention (day)	0.867	0.762	0.985	0.028
Respiratory system problem (existent/non-existent)	5.347	1.409	20.291	0.014
Multivariate reduced model	O.R.	95% confidence interval		p
		Minimum	Maximum	
Respiratory system problem (existent/non-existent)	7.373	1.729	31.440	0.007
Postoperative hospitalisation (day)	0.839	0.731	0.962	0.012
Stable	0.616			0.683

COPD: chronic obstructive pulmonary disease; F: female; M: male; ASA: American Society of Anesthesiology

Table 5. Relationship between development of postoperative pulmonary complications and preoperative risk factors

Risk factor	Frequency of postoperative pulmonary complication development (%)
Class 2 functional capacity	3/13 (23.0)
Class 1 functional capacity	8/87 (8.9)
(+) Cough test	2/20 (10)
(-) Cough test	6/80 (7.5)
(+) Respiratory symptom	5/17 (29.4)
Cessation of smoking	5/24 (20.8)
Active smoker	3/27 (11.1)
Never smoked	3/49 (6.1)
Blood transfusion	2/11 (18)
NYHA class 2	2/6 (33.3)
Hypertension	5/36 (13.8)
Coronary artery disease	2/10 (20)
Neurological disease	2/6 (%33.3)
ASA 3	11/45 (%24.4)
ASA 2	1/8 (%12.5)
ASA 1	4/47 (8.5)

NYHA: New York Heart Association; ASA: American Society of Anesthesiology

the patients in our study, being 51, restricts the reliability of the age-related risk analysis.

In this study, the PPC development was associated with prolongation of hospital stay. These results may show that PPC

Table 6. Developing postoperative pulmonary complication and operation type

Postoperative pulmonary complication	Operation
Pneumothorax	Laparotomy
Bronchospasm	Breast-conserving surgery Inguinal hernia Stoma closure
Atelectasis	Glossectomy Coronary artery bypass grafting Evisceration* Laparoscopic cholecystectomy* Breast-conserving surgery
Pleural effusion	Laparoscopic colectomy Lumbar instrumentation Coronary artery bypass grafting
Suspicious infection	Laryngectomy

*Operations in which PPC developed after the 2nd postoperative day (other complications developed within the first 24 postoperative hours)

development prolongs the length of hospital stay but may also show that prolongation of the hospital stay can lead to PPC development. However, we did not analyse a cause-and-effect relationship in this study. It was stated in previous studies that PPCs, like pulmonary embolism, atelectasis, pneumonia and respiratory failure, prolong the duration of hospitalisation (14). Postoperative complications, like pneumonia and atelectasis, lead to negative results, since they increase not only morbidity and mortality but also the length of hospital stay (15). Pulmonary complications increase the length of stay, since they trigger a reduction in effective coughing,

prolonged mechanical ventilation requirements or secondary infections. Patients' diaphragm movements are restricted, and bronchial mucociliary activity is reduced while they are intubated. Petri et al. (16) and Soga et al. (17) reported in their studies that PPCs prolong the duration of patients' hospital stays and increase the rate of intensive care admission. It was reported that atelectasis is the most common postoperative pulmonary complication (18). Our findings, in this respect, are consistent with earlier studies; 54.5% of the patients developed atelectasis. In one of these patients, bronchoconstriction was accompanied by the atelectasis. In our study, atelectasis was most commonly determined on the second day. A relationship between the use of crystalloid infusion and PPC development was detected in our study. However, here again, we did not analyse a cause-and-effect relationship in this study.

We also think that several limitations of this study are worth discussing. Patients in the postoperative period were monitored until they were discharged; 73% of the patients were discharged 1 day after they had minor surgeries. That is why we had the knowledge about early PPCs. If we had had a longer follow-up period, we could have recorded information on long-term complications. The patients' postoperative analgesia methods not being standardised was another limitation. The reason for this was to evaluate major with minor surgeries and open or laparoscopic surgeries together. Postoperative analgesia of the patients was performed by the consulting anaesthetist. We also think that including patients who had undergone coronary artery bypass grafting surgeries into the studies might be interpreted as another limitation. The incidence of atelectasis complications was higher in patients who had undergone this surgery.

Conclusion

Considering patients undergoing non-thoracic or non-obstetric surgery, the prevalence of postoperative pulmonary complications is higher in patients diagnosed with respiratory symptoms in the preoperative period. These complications significantly extend the length of hospitalisation.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of İstanbul University Faculty of Medicine.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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