JOURNAL OF CLINICAL MEDICINE OF KAZAKHSTAN (E-ISSN 2313-1519)
Original Article DOI: https://doi.org/10.23950/jcmk/12663

Prediction of pulmonary complications following spine surgery: The ASA and ARISCAT risk indexes

Ayse Neslihan Balkaya, Asiye Demirel

Department of Anesthesiology and Reanimation, Yuksek Ihtisas Training and Research Hospital, University of Health Sciences, Bursa, Turkey

Received: 2022-05-27.
Accepted: 2022-10-26

J Clin Med Kaz 2022; 19(6):32-37

Corresponding author:
Ayse Neslihan Balkaya.
E-mail: aynesbalkaya@gmail.com;
ORCID: 0000-0001-8031-6264

Abstract

Objective: We aimed to evaluate the effectiveness of predicting postoperative pulmonary complications (PPCs) following spine surgery, comparing American Society of Anesthesiologist (ASA) and Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) risk scoring systems.

Material and methods: We reviewed 377 patients aged≥18 years who had undergone vertebral surgery. Demographic data, comorbidities, ASA classification, body mass index, ARISCAT risk score, pulmonary complications developing with in the postoperative 1st month were assessed.

Results: A total of 377 patients, 221 (58.6%) women and 156 (41.4%) men, mean age of 59±11.8 years were evaluated. Out of the 377 patients, 73 (19.4%) patients were ASA I, 235 (62.3%) patients were ASA II, 69 (18.3%) patients were ASA III, and the mean ARISCAT score was 22.51±8.38. In the postoperative period, PPC was identified in 30 (8%) patients, with atelectasis in 15 (4%), pneumothorax in 4 (1.1%), pneumonia in 4 (1.1%), respiratory failure in 4 (1.1%), bronchospasm in 2 (0.5%) patients, and pulmonary embolism in 1 (0.3%) patient. There was a statistically significant correlation between the presence of PPC and ASA score, and between the presence of PPC and the ARISCAT levels (p=0.000, p=0.000). The incidence of PPC increased with increasing ASA scores. The ARISCAT scores were higher in patients who developed PPC. The hospital stay of patients with PPCs were longer than other patients (p=0.000).

Conclusion: In our study, in which ASA classification and ARISCAT risk index were compared as a means to predict PPC, both scores were found to be effective.

Key words: ASA, postoperative complications, spine, surgery

Introduction

Postoperative pulmonary complications (PPCs) are postoperative complications occurring in 2–70% of patients, which are associated with increased postoperative morbidity, mortality, and prolonged hospital stays, resulting in increased patient care costs. PPCs are important determinants of 30-day mortality [1,2].

Common PPCs include atelectasis, bronchospasm, pneumonia, pleural effusion, pulmonary edema, hypoxemia, and respiratory failure. The patient's general health status is an important determinant of pulmonary risk [3]. The American Society of Anesthesiologists (ASA) physical status classification is a classification system used by anesthesiologists and surgeons to describe overall health status of the patient. The ASA is used to estimate patients' perioperative risk. Patients are classified according to functional limitations created by existing medical problems. A high ASA score is associated with increased functional dependence, increased risk of complications, need for postoperative intensive care unit (ICU), prolonged hospital stays, and increased mortality [4]. The Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) risk index is a classification system used to predict PPCs. The ARISCAT risk index is calculated by assessing the patient's history, physical examination, monitoring, laboratory results, and information about the surgical procedure performed [5].

Due to degenerative vertebral pathologies such as spinal stenosis and degenerative spondylolisthesis that have been increasing with the increase in the elderly population, spine surgery has become one of the frequently performed surgeries worldwide [6]. Despite technological developments and modern surgical techniques, PPCs are common after spine surgery due to conditions such as prolonged surgery, large elderly patient population, presence of comorbidities, underlying pulmonary diseases, smoking, and blood transfusion. Given the incidence of postoperative pulmonary complications, risk estimation should be prioritized and be a standard element of preoperative medical assessments. The present study hypothesized that both the ARISCAT risk index and ASA score would be predictors of pulmonary complications following spine surgery. The aim of our study is to compare the efficacy of the ASA classification and the ARISCAT risk index in predicting PPCs following posterior spine surgery.

Material and methods

Patient population

The study was conducted in accordance with the Declaration of Helsinki. Following the approval of the study protocol by the Local Ethics Committee, patients who underwent spine surgery in our hospital between January 2019 and December 2020 were included in the study. The data of the patients were reviewed retrospectively using the hospital information system and archive records. Patients aged ≥18 years, who underwent posterior spine surgery were included in the study, and patients whose necessary medical information could not be accessed due to insufficient medical records were excluded. Patients' demographic data, comorbidities, ASA classification, body mass index (BMI), ARISCAT risk score (age, preoperative oxygen saturation and hemoglobin levels, type of incision, length of surgery, history of lower respiratory tract infection within one month prior to the surgery and emergency surgery, pulmonary complications within the postoperative one month and the time of complication development were recorded. Pulmonary complications such as atelectasis, lower respiratory tract infection, pneumonia, pulmonary embolism, pneumothorax, bronchospasm, and respiratory failure within the postoperative one month were examined. Postoperative pulmonary complications were determined by reviewing the hospital information system and patient medical records as well as by conducting patient phone interviews.

Assessment of postoperative pulmonary risk

The ASA scores that were determined by an anesthesiologist via preoperative patient assessment were recorded (Table 1). The ARISCAT risk indexes of the patients were calculated using age, preoperative oxygen saturation and hemoglobin levels, type of incision, length of surgery, history of lower respiratory tract infection one month before the surgery, and emergency surgery, which were retrieved from medical records of the patients (Table 2).

Table 1 The American Society of Anesthesiologists physical status classification system

ASA I: A normal healthy patient
ASA II: A patient with mild systemic disease
ASA III: A patient with severe systemic disease
ASA IV: A patient with severe systemic disease that is a constant threat to life
ASA V: A moribund patient who is not expected to survive without the operation
ASA VI: A declared brain-dead patient whose organs are being removed for donor purposes

Table 2 The assess respiratory risk in surgical patients in Catalonia Risk Index: Independent predictors of postoperative pulmonary complications

Risk Factor	Risk score
Age, years	
≤50	**0**
51-80	**3**
>80	**16**
Preoperative O2 saturation	
≥ 96%	**0**
91%-95%	**8**
≤ 90%	**24**
Respiratory infection in the last month	**17**
Preoperative anemia	
Hemoglobin >10 g/dL	**0**
Hemoglobin ≤ 10 g/dL	**11**
Surgical incision	
Peripheral	**0**
Upper abdominal	**15**
Intrathoracic	**24**
Duration of surgery	
≤ 2 hours	**0**
2-3 hours	**16**
> 3 hours	**23**
Emergency surgery	**8**
Risk class, No. of points in risk score (pulmonary complication rate)	
Low < 26 points	
Intermediate 26-44 points	
High > 44 points	

Definitions of PPC

Cough, sputum, fever (≥38°C) and leukocytosis, in addition to these symptoms, the presence of new infiltrates on chest X-ray was defined as pneumonia [7]. Suspicion of pulmonary embolism was confirmed by clinical and laboratory data (D-dimer, chest radiographs, arterial blood gases, and computed tomography. Atelectasis was evaluated as a decrease in breath sounds on physical examination and a shift of the mediastinum and hemidiaphragm towards the atelectatic area on chest X-ray in addition to the clinical picture. Pneumothorax lung air in the pleural space without a vascular bed on the X-ray, bronchospasm was evaluated as a newly detected wheezing and response to treatment with a bronchodilator. Respiratory failure was defined as oxyhemoglobin saturation measured by pulse oximetry <90%, PaO2<60 mmHg in arterial blood gas, and PaO2:FiO2 ratio < It was defined as 300 mmHg [8].

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences IBM SPSS 23.0 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp). The Shapiro-Wilk test was performed to determine that the data is normally distributed. Descriptive statistics were expressed as mean and standard deviation or median (minimum–maximum) for quantitative

data, and frequency and percentage for qualitative data. The Mann-Whitney U test was used for the non-normally distributed variables. The Pearson's Chi-square, Fisher-Freeman-Halton and Fisher's Exact Chi-square tests were used to analyze categorical data. In case of significance, the Bonferroni test, one of the multiple comparison tests, was used. The Spearman's correlation coefficients were used to analyze the relationships among variables. The significance level was set at p=0.05.

Results

The study group consisted of 400 patients out of which 23 patients were excluded due to insufficient patient medical records. A total of 377 patients, 221 (58.6%) females and 156 (41.4%) males, with a mean age of 59±11.8 (18-86) years, were assessed. Demographic data of the patients are presented in Table-3. The ASA score was ASA I in 73 (19.4%) patients, ASA II in 235 (62.3%) patients, ASA III in 69 (18.3%) patients. The mean ARISCAT score was 22.51±8.38 (3–62).

Table 3 Demografic data and comorbidities

Gender (n, %)	
Male	156 (41.4%)
Female	221 (58.6%)
Age (years) (mean±sd)	59±11.8
Smoking History (n, %)	
Current	87 (23.1%)
Never	271 (71.9%)
Prior	19 (5%)
History of previous surgery (n, %)	
Yes	258 (68.4%)
No	119 (31.6%)
Diabetes Mellitus (n, %)	111 (29.4%)
Hypertension (n, %)	149 (39.5%)
Coronary Artery Disease (n, %)	40 (10.6%)
Asthma (n, %)	15 (4%)
COPD (n, %)	15 (4%)
Congestive Heart Failure (n, %)	6 (1.6%)
Cardiac Rythm Disorder (n, %)	8 (2.1%)
BMI (kg/m2) (n, %)	
<25 (Normal)	88 (23.3%)
≥25 & <30 (Overweight)	187 (49.6%)
≥30 & <35 (Obese)	76 (20.2%)
≥35 (Severely Obese)	26 (6.9%)

ASA: American Society of Anesthesiologist; COPD: Chronic Obstructive Pulmonary Disease
BMI: Body mass index

The surgery was elective in 348 (92.3%) patients and was performed under emergency conditions in 29 (7.7%) patients. Spine surgery was performed due to degenerative vertebral pathology in 352 (93.4%) patients, due to trauma in 24 (6.4%) patients and due to malignancy in 1 (0.3%) patient. Among the patients, 18 (4.8%) had cervical, 10 (2.7%) thoracic, 13 (3.4%) thoracolumbar, and 336 (89.1%) had lumbar spine surgery. Intraoperative blood product transfusion was used in 72 (19.1%) patients (Table-4). The mean surgical procedure time of the patients was 181.22±48.81 minutes. The mean length of hospital stay was 4.81±2.97 (2–28) days.

In the postoperative period, PPC was identified in 30 (8%) patients, with atelectasis in 15 (4%), pneumothorax in 4 (1.1%), pneumonia in 4 (1.1%), respiratory failure in 4 (1.1%), bronchospasm in 2 (0.5%) patients, and pulmonary embolism in 1 (0.3%) patient (Table-5). PPCs were detected between postoperative first 24 hours and day 10. It was observed that the age of the patient was not statistically effective on the development of PPC. Out of the patients who developed PPCs, 3 were operated at the cervical, 1 at the thoracic, 4 at the thoracolumbar, and 22 at the lumbar level. In the postoperative period, 2 (0.5%) patients were transferred to the postoperative intensive care unit (ICU) and 29 (7.7%) patients to the Postanesthetic Care Unit (PACU) for various reasons. After the operation, a total of 4 patients, 2 patients in the ICU and 2 patients in the PACU, were intubated from the operating room. The patients who were intubated at the time of ICU admission. The patients who were intubated at the time of ICU admission were put under observation due to having a prolonged need for mechanical ventilation and hospitalization.

Table 4 Intraoperative Data

	Frequency [n (%)]
Diagnosis group	
Degenerative	352 (93.4%)
Trauma	24 (6.4%)
Neoplasm	1 (0.3%)
Diagnosis level	
Cervical	18 (4.8%)
Thoracic	10 (2.7 %)
Thoracolumbar	13 (3.4%)
Lumbar	336 (89.1%)
Intraoperative transfusion	
ES	54 (14.3%)
ES&FFP	18 (4.8%)

ES: Erythrocyte suspension, FFP: Fresh Frozen Plasma

The relationship between the presence of PPC and ASA scores was significant (p=0.000). The incidence of PPC increased with increasing ASA scores. Of the 30 patients with PPCs, 15 (50%) were scored as ASA III, 12 (40%) as ASA II, and 3 (10%) as ASA I. There was a statistically significant correlation between the presence of PPCs and ARISCAT scores (p=0.000). The ARISCAT scores were higher in patients who developed PPCs (p=0.000). The ARISCAT score was 34.13± 2.14 in the presence of PPCs, and 21.51±7.16 in patients without PPC. The mean ARISCAT score of 4 patients who were intubated during postoperative follow-up was higher than those who were extubated when the surgical procedure was completed (p=0.000). The ARISCAT score was 52.75±7.54 (42–58) in patients who were postoperatively intubated compared to 22.19±7.78 (3–62) in extubated patients. Out of the 4 patients who were postoperatively intubated, 2 were scored as ASA II, and the other 2 as ASA III (p=0.23).

In the postoperative period, one of the patients hospitalized in the intensive care unit was ASA II and the other was ASA III; these patients were in the high ARISCAT score group (ARISCAT scores: 53, 58). The ASA scores of the patients admitted to the PACU were higher than the scores of other patients. The rate of PACU admission increased with increasing ASA scores (p=0.000). Of the 29 patients admitted to the PACU, 22 were scored as ASA III, 5 as ASA II, and 2 as ASA I. The ARISCAT scores (30±12.20) of the patients in the postoperative PACU were higher than the scores of those who were postoperatively transferred to the ward (19±7.12) (p=0.000).

In the patient group with PPCs, there was a negative correlation between the ARISCAT score and the time of PPC development (p=0.169, r= -0.258). Similarly, the ASA score was negatively correlated with the time of PPC development

Table 5 Distribution of postoperative pulmonary complications according to ASA classification and ARISCAT risk index [n, (%)]

Complications	ASA I (n=73)	ASA II (n=235)	ASA III (n=69)	Low ARISCAT (n=249)	Intermediate ARISCAT (n=118)	High ARISCAT (n=10)
Atelectasis	3	5	7	4	9	2
Pneumonia	0	2	2	2	2	0
Pulmonary embolism	0	1	0	0	1	0
Respiratory Failure	0	2	2	0	1	3
Pneumothorax	0	1	3	0	3	1
Bronchospasm	0	1	1	1	1	0
Total	3(4.1%)	12 5.1%)	15(21.7%)	7 (2.8%)	17 (14.4%)	6 (60%)

ARISCAT: The Assess Respiratory Risk in Surgical Patients in Catalonia

(p=0.605, r= -0.098). Patients with PPCs were found to stay longer in the hospital than those without PPCs (p=0.000). The length of hospital stay was 9.77±5.16 days in the presence of PPCs and 4.37±1.98 days in the absence of PPCs.

There was no mortality due to the development of PPCs among the study patients.

Discussion

Spine surgery is one of the most frequently performed surgeries in the world. There are several studies in the literature on the rate of pulmonary complication development and risk factors for pulmonary complications following spine surgery, but there is no study comparing the ASA classification and the ARISCAT risk index in predicting pulmonary complications. Our study found that both the ASA classification and the ARISCAT risk index were effective in predicting PPCs. The PPC development rate was observed to be high in the presence of increased ASA score and high ARISCAT risk scores.

The development of PPCs worsens the prognosis in postoperative patients [9]. In the literature, the incidence of PPCs in surgical patients shows a wide variation, considering race, geographical region, level and quality of healthcare, current diagnoses and comorbidities of patients, and the diversity of surgical procedures [2]. Studies on patients undergoing noncardiac surgery, in turn, found the incidence of PPC to be 2–19% [10,11]. It has been reported in the literature that the rates of pulmonary complications after spine surgery range from 0.9% to 5%, but the rate may differ between studies according to the method of current surgeries, surgical incision site, and the definition of pulmonary complications [12]. The rate of PPCs in patients undergoing spinal surgery were reported as 9% by Imposti et al., 15.56% by Weinberg et al., and 10.3% by Balci et al. [12-14]. In our study, an 8% incidence of PPC was found within 30 days postoperatively. This result was consistent with the incidence of pulmonary complications observed in both non-cardiac and spine surgery [11].

One of the most common causes of death following spine surgery is respiratory failure. Therefore, pulmonary complications and associated risk factors are important for preoperative planning and identification of patients at risk [15]. Various risk indexes have been proposed in the literature to estimate the risk of PPCs. The ARISCAT risk index is a scoring system easy to calculate based on seven simple variables of the patient and the surgical procedure, that provides objective results [10]. It has been reported that the ARISCAT risk index, which is also referred to as the Catalonia risk index in the literature, is effective in identifying the risk of pulmonary complications [16-18]. Our study found the ARISCAT risk index to be effective in predicting PPCs, and patients with low ARISCAT risk scores had fewer PPCs than those with medium and high-risk scores. The PPC development rate was observed to increase with increasing pulmonary risk scores.

The ASA physical status classification is an easy scoring system that has been used for a long time to estimate perioperative morbidity and mortality [19]. By providing a simple categorization of the physiological status of patients, it helps clinicians in estimating the surgical risk and it is important in predicting morbidity and mortality [20]. The ASA classification is not specific, which may cause subjective assessment and uncertain clinical interpretations among clinicians [21]. The study by Sankar et al., indicated that this scoring system had a moderate level of reliability among clinicians using the ASA scoring; although there are discussions about its reliability, it is the scoring system most frequently used by anesthesiologists to identify the perioperative risk [4,22]. Studies reporting an association between the ASA scoring system and the development of PPCs are limited, and such studies obtained different results [3,18]. Some studies in the literature emphasize the absence of a significant relationship between the ASA scoring system and the development of PPCs [5,8,23,24]. On the other hand, there are various studies indicating that the ASA classification is an important factor in the prediction of PPCs, and that there is an increase in PPCs with increasing ASA scores [16,25,26]. Our study determined that the ASA classification was important in predicting PPCs, and the PPC development rate was higher in patients with high ASA scores.

The ARISCAT risk index consists of seven independent variables: blood oxygen saturation level, recent history of upper respiratory tract infection, presence of preoperative anemia, surgical incision site, length of surgery, emergency surgery, and patient age. The blood oxygen saturation level is an objective risk indicator for cardiopulmonary function [27]. The presence of upper respiratory tract infection within the last month is a condition that may pose a risk for PPCs; the surgical procedure can be delayed in patients scheduled for elective surgeries, but care should be taken in case of pathologies requiring an emergency surgery. Preoperative anemia is a risk factor that increases perioperative mortality and morbidity rates in patients [28]. The surgical incision site is one of the two independent variables related to the surgical procedure in the ARISCAT risk index, and it is believed that the closer the incision site to the diaphragm, the greater the pulmonary risk [18]. Prolonged surgery is another factor that increases the pulmonary risk [29]. Since spine surgery was performed with a posterior approach

in our study, it was classified as a peripheral incision surgically according to ARISCAT and the incision was considered as the lowest risk. Preoperative anemia was not observed in patients undergoing elective surgery, while blood product transfusion was used in patients undergoing emergency surgery in the presence of perioperative anemia.

Age is one of the independent variables in ARISCAT risk scoring. For the ASA classification, in turn, there is no consensus on the inclusion of patient age in the scoring system. Advanced age is considered a risk factor for the development of PPC. Lung functions may deteriorate depending on age due to deterioration in lung elasticity, decrease in alveolar area and increase in dead space [16,26,30]. In contrast to studies that considered age an independent risk factor for PPCs, our study found no association between age and PPC development, similar to the result of the study by Kara et al. [18].

The Post-Anesthesia Care Unit (PACU) is a space that provides post-operative intensive care to high-risk surgical patients. The aim in PACU is to provide postoperative care, to follow the development of complications and to intervene early if they occur. The PACU is an area in which all postoperative complications, including PPCs, are common [31]. High ASA and ARISCAT scores at patient follow-ups may also be used as predictors of PPCs in PACUs. Our study determined that the ASA and ARISCAT risk scores of the patients admitted to the PACU were higher than the scores of other patients, and 75.8% of the patients admitted to the PACU were scored as ASA III. PPC development was observed in 9 patients with high ASA and ARISCAT scores among 29 PACU patients.

While ASA is a general classification system that assesses the overall health status of patients, the ARISCAT risk index is a pulmonary system-specific assessment system that produces a pulmonary risk score. In our study, both ASA classification and ARISCAT risk index were found to be effective in predicting postoperative PPCs.

The small number of patients in our retrospective and single-center study is among our limitations. Due to the absence of ASA IV and V patients in the study, the rates of pulmonary complications in patients with high ASA scores were not included in the study.

The PPC development rate is high after spine surgery. Identification of patients with risk factors for the development of PPCs is important to reduce postoperative morbidity and mortality rates. Our study, which assessed the ASA classification versus the ARISCAT risk index in the prediction of PPCs, established that both scores were effective in predicting PPCs. Since the ARISCAT index is a classification system specific to the pulmonary system, we believe that using the ASA classification together with the ARISCAT risk index would be more effective in predicting PPCs.

Disclosures: There is no conflict of interest for all authors.

Acknowledgements: None.

Funding: None.

References

1. Smetana GW: Preoperative pulmonary evaluation. N Engl J Med. 1999; 340:937–944. https://doi.org/10.1056/NEJM199903253401207
2. Fisher BW, Majumdar SR, McAlister FA. Predicting pulmonary complications after nonthoracic surgery: A systematic review of blinded studies. *Am J Med.* 2002; 112:219–225. https://doi.org/10.1016/s0002-9343(01)01082-8
3. Smetana GW, Lawrence VA, Cornell JE. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. *Ann Intern Med.* 2006;144(8):581. https://doi.org/10.7326/0003-4819-144-8-200604180-00009
4. Sankar A, Johnson SR, Beattie WS, Tait G, Wijeysundera DN. Reliability of the American Society of Anesthesiologists physical status scale in clinical practice. *Br J Anaesth*. 2014;113(3):424. https://doi.org/10.1093/bja/aeu100
5. Kupeli E, Dedekarginoglu B, Ulubay G, Eyuboglu FO, Haberal M. American Society of Anesthesiologists Classification Versus ARISCAT Risk Index: Predicting pulmonary complications following renal transplant. *Exp Clin Transplant.* 2017;1:208-213. https://doi.org/10.6002/ect.mesot2016.P89
6. Mathiesen O, Dahl B, Thomsen BA, Kitter B, Sonne N, Dahl JB et al. A comprehensive multimodal pain treatment reduces opioid consumption after multilevel spine surgery. *Eur Spine J.* 2013;22:2089-2096. https://doi.org/10.1007/s00586-013-2826-1
7. Carratala J, Fernandez-Sabe N, Ortega L, Castellsague X, Roson B, Dorca J, et al. Outpatient care compared with hospitalization for community-acquired pneumonia: a randomized trial in low-risk patients. *Ann Intern Med*. 2005;142:165–172. https://doi.org/10.7326/0003-4819-142-3-200502010-00006
8. Tilak KM, Litake MM, Shingada KV. Study of risk, incidence and mortality associated with postoperative pulmonary complications using assess respiratory risk in surgical patients in catalonia score. *Int Surg J*. 2019;6(9):3215-3222. https://doi.org/10.18203/2349-2902.isj20194054
9. Patel K, Hadian F, Ali A, Broadley G, Evans K, Horder C, et al. Postoperative pulmonary complications following major elective abdominal surgery: A cohort study. *Perioper Med (Lond).* 2016;5:10. https://doi.org/10.1186/s13741-016-0037-0
10. Canet J, Gallart L, Gomar C, Paluzie G, Vallès J, Castillo J, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. *Anesthesiology*. 2010;113:1338-1350. https://doi.org/10.1097/ALN.0b013e3181fc6e0a
11. Mazo V, Sabaté S, Canet J, Gallart L, de Abreu MG, Belda J, et al. Prospective external validation of a predictive score for postoperative pulmonary complications. *Anesthesiology*. 2014;121:219-31. https://doi.org/10.1097/ALN.0000000000000334
12. Imposti F, Cizik A, Bransford R, Bellabarba C, Lee MJ. Risk factors for pulmonary complications after spine surgery. *Evid Based Spine Care J.* 2010;1(2):26-33. https://doi.org/10.1055/s-0028-1100911
13. Weinberg DS, Hedges BZ, Belding JE, Moore TA, Vallier HA. Risk factors for pulmonary complication following fixation of spine fractures. *Spine J.* 2017;17(10):1449-1456. https://doi.org/10.1016/j.spinee.2017.05.008
14. Balci A, Usame R, Akın C. Preoperative pulmonary evaluation and evaluation of postoperative pulmonary complications in geriatric patients undergoing spinal surgery. *JHMN*. 2020; 78:27-35.
15. Stundner O, Taher F, Pawar A, Memtsoudis SG. Pulmonary complications after spine surgery. *World J Orthop*. 2012;3(10):156-161. https://doi.org/10.5312/wjo.v3.i10.156

16. Gupta S, Fernandes RJ, Rao JS, Dhanpal R. Perioperative risk factors for pulmonary complications after non-cardiac surgery. *J Anaesthesiol Clin Pharmacol.* 2020;36(1):88-93. https://doi.org/10.4103/joacp.JOACP_54_19
17. Mazo V, Sabaté S, Canet J, Gallart L, de Abreu MG, Belda J, Langeron O, Hoeft A, Pelosi P. Prospective external validation of a predictive score for postoperative pulmonary complications. *Anesthesiology*. 2014(8);121(2):219-31. https://doi.org/10.1097/ALN.0000000000000334
18. Kara S, Küpeli E, Yılmaz HEB, Yabanoglu H. Predicting pulmonary complications following upper and lower abdominal surgery: ASA, ARISCAT risk index. *Turk J Anaesthesiol Reanim.* 2020;48(2):96-101. https://doi.org/10.5152/TJAR.2019.28158
19. Wolters U, Wolf T, Stützer H, Schröder T. ASA classification and perioperative variables as predictors of postoperative outcome. *Br J Anaesth*. 1996;77(2):217-222. https://doi.org/10.1093/bja/77.2.217
20. Daley J, Khuri SF, Henderson W, Hur K, Gibbs JO, Barbour G, et al. Risk adjustment of the postoperative morbidity rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. *J Am Coll Surg.* 1997;185:328–340. https://doi.org/10.1016/S1072-7515(97)00090-2
21. Mak PH, Campbell RC, Irwin MG. The ASA Physical Status Classification: inter-observer consistency. *Anaesth Intensive Care.* 2002;30:633–640. https://doi.org/10.1177/0310057X0203000516
22. Aronson WL, McAuliffe MS, Miller K. Variability in the American Society of Anesthesiologists Physical Status classification scale. *AANA J.* 2003;71:265–274.
23. Erbesler Z. Comparison of Markers for Prediction of Postoperative Pulmonary Complications; ASA and ARİSCAT. *Ahi Evran Med J.* 2021; 5(1): 50-54. https://doi.org/10.46332/aemj.787569
24. Mitchell CK, Smoger SH, Pfeifer MP, Vogel RL, Pandit MK, Donnelly PJ, et al. Multivariate analysis of factors associated with postoperative pulmonary complications following general elective surgery. *Arch Surg.* 1998;133(2):194–198. https://doi.org/10.1001/archsurg.133.2.194
25. Hall JC, Tarala RA, Hall JL, Mander JA. Multivariate analysis of the risk of pulmonary complications after laparotomy. *Chest*. 1991;99923-927. https://doi.org/10.1378/chest.99.4.923
26. Fernandez-Bustamante A, Frendl G, Sprung J, Kor DJ, Subramaniam B, Martinez Ruiz R, et al. Postoperative pulmonary complications, early mortality, and hospital stay following noncardiothoracic surgery: A multicenter study by the perioperative research network investigators. *JAMA Surg.* 2017;152:157-166. https://doi.org/10.1001/jamasurg.2016.4065
27. Canet J, Gallart L. Predicting postoperative pulmonary complications in the general population. *Curr Opin Anaesthes*iol. 2013(4);26(2):107-115. https://doi.org/10.1097/ACO.0b013e32835e8acd
28. Musallam KM, Tamim HM, Richards T, Spahn DR, Rosendaal FR, Habbal A, et al. Preoperative anaemia and postoperative outcomes in non-cardiac surgery: a retrospective cohort study. *Lancet*. 2011(10) 15;378(9800):1396-407. https://doi.org/10.1016/S0140-6736(11)61381-0
29. McAlister FA, Khan NA, Straus SE, Papaioakim M, Fisher BW, Majumdar SR, et al. Accuracy of the preoperative assessment in predicting pulmonary risk after nonthoracic surgery. *Am J Respir Crit Care Med.* 2003;167(5):741-744. https://doi.org/10.1164/rccm.200209-985BC
30. Qaseem A, Snow V, Fitterman N, Hornbake ER, Lawrence VA, Smetana GW, et al. Clinical Efficacy Assessment Subcommittee of the American College of Physicians. Risk assessment for and strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery: a guideline from the American College of Physicians. *Ann Intern Med.* 2006 (4);144(8):575-580. https://doi.org/10.7326/0003-4819-144-8-200604180-00008
31. Sento Y, Suzuki T, Suzuki Y, Scott DA, Sobue K. The past, present and future of the postanesthesia care unit (PACU) in Japan. *J Anesth.* 2017(31); 601–607. https://doi.org/10.6002/ect.mesot2016.P89