

Do ARISCAT Scores Help to Predict the Incidence of Postoperative Pulmonary Complications in Elderly Patients After Upper Abdominal Surgery? An Observational Study at a Single University Hospital.

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Abstract

Background

The incidence of postoperative pulmonary complications (PPCs) is increasing in line with the rise in the number of surgical procedures performed on geriatric patients. In this study, we determined the incidence of PPCs in elderly Thai patients who underwent upper abdominal procedures, and we investigated whether the Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) score helps to predict PPCs in Thais.

Methods

A retrospective study was conducted on upper abdominal surgical patients aged over 65 years who had been admitted to the surgical ward of Siriraj Hospital, Mahidol University, Thailand, between January 2016 and December 2019. Data were collected on significant PPCs using the European Perioperative Clinical Outcome definitions. To identify risk factors, evaluations were made of the relationships between the PPCs and various preoperative, intraoperative, and postoperative factors, including ARISCAT scores.

Results

In all, 1,100 elderly postoperative patients were analyzed. Their mean age was 73.62 years, and 48.5% were male. The incidence of PPCs was 7.72%, with the most common being pleural effusion, atelectasis, and pneumonia. The average hospital and intensive care unit stays of the PPC patients were significantly longer than those without PPC (25.35 versus 7.30 days, with $p < 0.0001$; and 8.36 versus 2.84 days, with $p = 0.010$, respectively). Almost 90% of the PPC patients had intermediate-to-high ARISCAT scores, with an average of 43.15 ± 13.58 .

Conclusions

PPCs are common in elderly patients and are associated with increased levels of postoperative morbidities and extended ICU and hospital stays. Using the ARISCAT score as an assessment tool facilitates the classification of geriatric Thai patients into PPC risk groups. Its usage might help to raise healthcare awareness and improve the perioperative management of elderly Thai patients. Moreover, the ARISCAT scoring system might be able to be similarly applied in other Southeast Asian countries.

Introduction

In 2018, one-fifth of Thai citizens were over 60 years of age, and the number is steadily increasing. According to the World Population Prospects (2019 revision), the proportion of individuals aged 65 years or over in Thailand will increase by about 17.2% between 2019 and 2050.(1) Elderly people experience progressive degenerative changes in all of their physiological systems, and they have limited functional reserves(2); moreover, they frequently have many diseases, which sometimes need surgery. However,

surgery and anesthesia cause stress and change the normal physiology of these patients; unfortunately, this might not be tolerated well and can result in perioperative complications.

Postoperative pulmonary complications (PPCs) can happen in every age group, with an incidence ranging from less than 1% to 23%.⁽³⁾ PPCs affect the elderly easily because of the many changes that occur in an aging respiratory system, including the pulmonary structure, function, and neural controls. PPCs can also cause the lung compliance of elderly patients to increase and their chest wall compliance to decline. In addition, their cough reflexes might become depressed, and their ventilatory responses to hypoxia and hypercapnia impaired.⁽⁴⁾ In a 2006 study of PPCs, Smetana and colleagues found that old age is a risk factor; this finding was later supported by other studies.^(3, 5, 6)

PPCs are mostly temporary and tend to resolve spontaneously; however, their sequelae can affect patients for a prolonged period. PPCs in the elderly are not only associated with delayed recovery, extended durations of hospital stay, and hospital readmissions, but they also contribute negatively to overall healthcare costs, quality of life, and mortality rate.^(7, 8)

In Thailand, there is no incidence report of PPCs and their sequelae at a tertiary hospital. The primary aim of our study was to determine the prevalence of PPCs in elderly patients, using the European Perioperative Clinical Outcome definitions of 2015 (respiratory infection, respiratory failure, pleural effusion, atelectasis, pneumothorax, bronchospasm, aspiration pneumonitis, pneumonia, and bronchitis).⁽⁹⁾ Scholes et al. found that patients having upper gastrointestinal surgery were 50% more likely to develop PPCs than with other surgical procedures.⁽¹⁰⁾ As gastrectomy, pancreatic resection, and esophagectomy have been found to have higher mortality rates than colectomy in Australia and the United States, we decided to investigate PPCs in patients undergoing upper abdominal surgery.⁽¹¹⁾

Our secondary outcome was to ascertain the risk factors associated with PPCs and the effects of PPCs on hospital stay, ICU stay, postoperative ventilator support, and mortality.

Finally, we set out to establish whether the Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) score can be applied to predict PPCs in the Thai population. ARISCAT scores are derived from a number of variables: age, oxygen saturation, respiratory tract infection in the preceding month, anemia, abdominal or thoracic surgery, operative time, and emergency surgery.⁽⁶⁾ The scoring system was developed to predict the risk of PPCs, and it demonstrated good performance in a Western European subsample.⁽¹²⁾

Methods

Objectives

The primary outcome was the incidence of PPCs in elderly patients who underwent upper abdominal surgery. The secondary outcomes were the risk factors associated with the PPCs, and the effects those PPCs had on hospital stay, ICU stay, postoperative ventilator support, and mortality.

Study design and participants

Prior approval for this retrospective study was obtained from the Siriraj Institutional Review Board (Si 006/2019). Using ICD-10-CM procedure codes, the authors searched electronic medical records to identify the open and laparoscopic upper-abdominal surgeries performed at Siriraj Hospital, Mahidol University, Bangkok, Thailand. The inclusion criteria were patients aged over 65 years who had undergone open or laparoscopic upper-abdominal surgery (for example, Whipple procedure, liver resection, liver transplantation, cholecystectomy, bile duct resection, pancreatectomy, adrenalectomy, splenectomy, gastrectomy, and hyperthermic intraperitoneal chemotherapy; **Figure 1**). The exclusion criteria were incomplete medical records; patients who had a tracheal tube or required a ventilator before the surgery; thoracic surgery; and a blunt chest injury. The study period was from January 2016 to December 2019.

The sample size was calculated using the average incidence of PPCs (7.49%) obtained from a literature review; the allowable error was 1.87% at a 95% level of confidence. After adding 15% to the calculated population, the study size was determined to be 900 patients. We then performed a calculation using the multiple logistic regression “rule of thumb” with 7 independent variables: smoking, oxygen saturation, recent upper respiratory infection, abnormal chest X-ray, hemoglobin, surgical duration, and urgency of surgery. With that method, the minimum number of patients required was 1,100; that figure became the final sample size target.

Assessment of postoperative pulmonary risks

Details of the cohorts’ demographic data and the factors that might be related to PPCs were retrieved from the medical records. The PPCs complied with the European Perioperative Clinical Outcome definitions of 2015.

Statistical analysis

Comparisons were made of the characteristics of the 2 study groups (namely, the non-PPC and PPC groups) using an analysis-of-variance model, the independent t-test, or the Mann–Whitney U test for continuous variables, and the chi-squared or Fisher’s exact test for categorical variables. Missing data were treated as missing and not imputed. Significant variables in the preliminary univariable analyses, at the predetermined alpha level of 0.2, were included in a multivariable logistic regression model. Due to the exploratory nature of our study, model-building was done by analyzing the factors related to the occurrence of PPCs after surgery using stepwise backward logistic regression. Results of the multivariable logistic regression analysis were reported as adjusted odds ratio (OR) and 95% confidence interval (CI). We deemed probability (*P*) values < 0.05 to be statistically significant, and *P* values were two-sided for all statistical tests, when applicable. The data analyses were performed using IBM SPSS Statistics for Windows (version 21.0; IBM Corp., Armonk, N.Y., USA).

Results

In all, 1,100 elderly postoperative patients were recruited and analyzed. Their mean age was 73.62 years, and 48.5% were male. The detailed patient demographic data are listed in **Table 1**. As to the patients with and without PPCs, there were no preoperative statistical differences in their ages, genders, body mass indexes, respiratory comorbidities, chest X-ray findings, or creatinine levels.

The most frequent surgical operation was cholecystectomy (630 cases; 57%), with 80% done laparoscopically. This was followed by liver resection (183 cases; 17%) and gastrectomy (65 cases; 6%).

The PPC incidence was 7.7% (85/1,100 patients). Of those cases, pleural effusion had the highest incidence (31/85; 36%), while atelectasis and pneumonia were found in 24/85 (28%) and 21/85 (24%) patients, respectively. The median lengths of hospital and ICU stay were significantly longer for the patients with PPCs than those without (26 vs 8 days, and 9 vs 3 days, respectively).

The mean ARISCAT scores of the non-PPC and PPC groups were 32 ± 13 and 43 ± 14 , respectively (P value < 0.001), both of which signified an intermediate risk under the scoring system. Relative to the patients with a low ARISCAT score, those with an intermediate score had a threefold higher risk (95% CI, 1.528–6.034) of developing PPCs. By contrast, those with a high ARISCAT score had a 7.8-fold greater chance (95% CI, 3.89–15.69).

The perioperative risk factors are tabulated in **Tables 2–4**. Our multivariable analysis identified that 5 risk factors were strongly associated with PPCs. They were a preoperative hemoglobin level of < 10 gm/dl (OR, 2.94; 95% CI, 1.96–4.66); a surgery duration exceeding 3 hours (OR, 3.892; 95% CI, 2.32–6.53); open surgery (OR, 3.01; 95% CI, 1.86–4.88); emergency surgery (OR, 3.65; 95% CI, 1.93–6.91); and an intraoperative intravenous crystalloid infusion exceeding 1 liter (OR, 4.06; 95% CI, 2.44–6.76).

In contrast, a high incidence of PPC was not associated with gender, body mass index, or a history of asthma, chronic obstructive pulmonary disease, or obstructive sleep apnea. On the other hand, a low PPC incidence was not related with preoperative spirometer usage or deep-breathing exercises.

Discussion

The definitions of PPCs are wide and tend to depend on the objectives of individual studies and institutions. In Thailand, there is no incidence report of PPCs and their sequelae in a tertiary hospital. Identifying their incidence and the associated, modifiable, risk factors in high-risk patients might increase the quality of perioperative care and decrease the overall morbidity. To this end, we collected the data relating to 1,100 patients aged over 65 years who had either open or laparoscopic upper-abdominal surgery between January 2016 and December 2019.

In our study, the overall incidence of PPCs was 7.7%. That level was comparable with the incidence of PPCs after abdominal surgery (5.8%) found in an analysis of the National Surgical Quality Improvement Program by Yang et al.(13) Moreover, the incidence for those patients in the current investigation who

underwent non-cardiac surgery (7.9%) was similar to the finding of an observational study entitled "Prospective Evaluation of a Risk Score for Postoperative Pulmonary Complications in Europe".(12)

Our investigation revealed that the PPC with the highest incidence (36%) was pleural effusion, which was diagnosed from postoperative chest X-ray reports. Rossi and Bromberg also reported finding a high rate of pleural effusion through ultrasound examinations during the postoperative period following elective abdominal surgery (70.3%). Most of their cases were asymptomatic and self-limiting.(14) Pleural effusions might result from sodium and water retention, and they may be aggravated by the relative cardiac decompensation typically found in the elderly.(15) Subsequent to the performance of hepatectomies for the treatment of primary liver cancer, postoperative pleural effusions were found in a quarter of such cases. Subphrenic collection and operative injuries to the liver were found to be statistically related to those pleural effusions.(16)

Preoperative parameters

Like other studies, older age was determined to be an independent risk factor for PPCs. Qaseem et al. reported that, compared with younger patients, the odds ratios of developing PPCs were 2.09 (95% CI, 1.70–2.58) for patients aged 60–69 years and 3.04 (95% CI, 2.11–4.39) for those aged 70–79 years. Although age cannot be modified, careful perioperative management might decrease the incidence or severity of complications in these patients.(17)

We also found that the incidence of PPCs rose in patients having an American Society of Anesthesiologists physical status > II, but it declined in those with a preoperative peripheral capillary oxygen saturation value of over 94% in room air. Our study showed that a high PPC incidence was not associated with gender; body mass index; or a history of asthma, chronic obstructive pulmonary disease, or obstructive sleep apnea. At the other end of the scale, a low PPC incidence was not associated with preoperative spirometer usage or deep-breathing exercises.

Unlike the findings of other studies, no correlations were found in the present work between PPCs and respiratory comorbidities (asthma, chronic obstructive pulmonary disease, and history of smoking).(18) This may be attributed to the fact that there were only 50 cases of respiratory-related patients, and they were all well controlled medically. Moreover, some of those 50 cases had been screened and treated by specialist staff at our Siriraj Pre-Anesthetic Clinic—with several achieving optimized medical conditions—at least 2 weeks prior to their surgeries. A retrospective review conducted at Pusan National University Yangsan Hospital, South Korea, found that the incidence of PPCs after non-cardiothoracic surgery with adult asthma patients was as high as 29.1%, with the most common PPCs being pneumonia (32.4%) and bronchospasm (24.3%). The significant risk factors identified by the South Korean study were age, the presence of preoperative respiratory symptoms, and a low forced expiratory volume in 1 second.(19)

In our study, patients who had a serum hemoglobin level of < 10 gm/dl had a threefold greater chance of experiencing at least 1 PPC than patients without anemia. Similar to the findings of earlier thoracic and lung resection studies, anemia in the present investigation demonstrated a two- to threefold increase in

respiratory and infectious complications.(20, 21) Even at a mild degree (hemoglobin < 13 gm/dl in males and < 12 gm/dl in females), preoperative anemia has been reported to be independently related to a heightened risk of 30-day mortality and morbidities (cardiac, respiratory, CNS, urinary tract, wound, sepsis, and venous thromboembolism outcomes) in patients undergoing major non-cardiac surgery.(22) Therefore, anemia should be screened and corrected preoperatively, especially for reversible causes such as iron deficiency or nutritional deficiency anemia. Correcting anemia decreases the need for blood transfusions during abdominal surgery while concurrently shortening the length of hospital stay.(23, 24) Enhancing red blood cell production through the administration of erythropoietin should be considered for patients who have adequate iron levels or no evidence of other macronutrient deficiencies. However, transfusions are not recommended if the hemoglobin level is above 7 g/dL as they might cause immune modulation, volume overload, or transfusion reactions.(25) Preoperative blood transfusion is recommended only for patients with symptomatic anemia or hemoglobinopathy.(26, 27)

Although there was a statistical difference in the mean serum albumin levels of the non-PPC and PPC groups, neither mean was < 3.0 gm/dl, which Smetana and colleagues identified as a PPC predictor.(5, 28) Preoperative albumin has been reported to correlate inversely with complications such as reintubation, pneumonia, and failure to wean from a mechanical ventilator, especially after upper abdominal surgery.(29) Compared with colonic surgery, patients undergoing esophageal or pancreatic procedures have also been found to have significantly higher complication rates at any level of serum albumin < 3.25 gm/dl.(30) The relationship between serum albumin levels and mortality has also been demonstrated to be continuous when the levels were < 3.5 gm/dl.(31) Preoperative protein depletion might alter pulmonary dynamics and the respiratory muscle function, leading to a higher rate of pneumonia.(32) To reduce perioperative pulmonary complications, the American College of Physicians has recommended the strategy of measuring serum albumin in all patients clinically suspected of having hypoalbuminemia. The College has also suggested that the approach be considered for patients with one or more risk factors for perioperative pulmonary complications.(17)

Preoperative spirometry usage and deep breathing exercises showed no benefits in reducing the incidence of PPCs. This might be because the hospital's high surgery volume and chronic shortage of healthcare staff had resulted in no individual having clear organizational responsibility for the consistent preoperative implementation and assessment of spirometry usage and deep breathing exercises. The preoperative physiotherapist consultations also varied, depending on the judgements of the attending surgeons, the operation type, and patient comorbidities.

Intraoperative and postoperative parameters

In the present work, strong relationships were demonstrated between PPCs and surgical duration (especially if longer than 3 hours) and open surgery, with at least a threefold increase in the incidence of complications. Patel et al. reported that the risk of PPCs increased with every additional minute of operating time.(33) Despite finding that laparoscopic and open cholecystectomies had similar PPC risk profiles in terms of their operative durations, Owen and colleagues demonstrated that open surgery had at least double the risk of PPCs than that of laparoscopic surgery.(34) A separate study comparing open

and minimally invasive esophagectomies reported that there was a significant reduction in postoperative pneumonia when the minimal approach was employed.(35) Therefore, in identified high-risk patients, we should aim to limit the duration of surgery and a minimally invasive surgical technique should be considered. According to a study of the factors predicting mortality in emergency abdominal surgery of the elderly, the incidence of postoperative pneumonia was 12.8%, with over half of those occurrences being caused by aspiration. Furthermore, another 4.3% of the study cohort died from pneumonia.[36] By comparison, our study revealed the incidence of patients having PPCs after emergency abdominal surgery was 16% (OR, 3.65; 95% CI, 1.93–6.91); however, there was no mortality.

During induction of general anesthesia, lung capacity decreases, resulting in a heightened possibility of atelectasis.(36) In patients undergoing abdominal surgery, epidural analgesia reduces the risk of postoperative pneumonia while improving the pulmonary function and arterial oxygenation.(37) However, in our study, the PPC incidence was not affected by the choice of anesthesia (general, versus a combination of general and regional anesthesia). There were also no statistical differences in the postoperative pain-rating scores or 72-hour opioid consumption levels of the non-PPC and PPC groups.

Compared to conventional ventilation, a protective ventilation strategy reduces inflammation and improves oxygenation in patients undergoing esophagectomies. In a protective ventilation group, the incidence of pneumonia was demonstrated by 1 study to be lower than that for a conventional-ventilation group, although the difference was not significant.[40] In our investigation, most of the ventilation parameters followed the lung-protective strategy; the mean tidal volume in both the PPC and non-PPC groups was almost 9 mL/kg, and all parameters of the groups were not statistically different. As to the anesthetic-risk factors, no relationship was apparent between the PPCs and airway equipment, inhalation agent, or anesthetic technique. We found an association between rocuronium and postoperative complications; the PPC-inducing action of rocuronium still remained even when used in conjunction with neostigmine or sugammadex. The observational study entitled “Post-Anesthesia Pulmonary Complications After Use of Muscle Relaxants” showed that the administration of neuromuscular blocking drugs during general anesthesia was associated with an elevated risk of PPCs (OR, 1.86; 95% CI, 1.53–2.26). Furthermore, the usage of neuromuscular monitoring and reversal agents (sugammadex or neostigmine) were not associated with a decreased PPC risk.(38) However, in a multicenter, matched-cohort analysis (STRONGER), sugammadex administration was associated with a reduction in PPC risk (adjusted OR, 0.70 (95% CI, 0.63–0.77) as well as a 55% reduced risk of respiratory failure, compared with the administration of neostigmine.(39) In addition, a randomized controlled trial by Togioka and colleagues explored the effects of reversal agents on the PPC incidence of older adults undergoing prolonged surgery. Their work confirmed that sugammadex is superior to neostigmine in reducing the incidence of residual neuromuscular paralysis. Moreover, there was a threefold increase in the 30-day hospital readmission rate of the neostigmine group (15%) relative to that of the sugammadex group (5%).(40)

In recent years, our institution has been revising its perioperative management protocol for enhanced recovery (the Siriraj ERAS Protocol). Our observation has been that perioperative outcomes appear to be

improved when a goal-directed therapy is employed as opposed to a liberal fluid therapy. An increased volume of fluid administration has been associated with an elevated risk of pulmonary complications, whereas goal-directed fluid administration has been reported to offer a 30% reduction in pulmonary complications following upper abdominal and major vascular surgery (OR, 0.7; 95% CI, 0.6–0.9).(41, 42) In the current work, although we were able to retrospectively collect and analyze the intraoperative fluid administration for each case, we were unable to identify which fluid strategy was used. Our results showed that the mean intraoperative crystalloid infusions of the PPC and non-PPC groups were $2,166 \pm 1,689$ ml and $1,198 \pm 1,118$ ml, respectively. No cut-off point has been established for the quantity of intraoperative fluid that might cause PPCs as many factors are involved in the administration of the fluid, for example, the presence of patient comorbidities, preoperative volume status, and perioperative fluid loss. The fluid administration, in terms of its volume and rate, should be performed cautiously, and anesthetists should always regard intravenous fluid as a kind of medication. Moreover, our statistical analysis revealed that an intraoperative crystalloid administration exceeding 1,000 ml was associated with a high PPC risk (OR, 4.06; 95% CI, 2.44–6.76).

A systematic review and meta-analysis focusing on the prevention of PPCs published in 2020 identified 7 perioperative interventions that probably reduce PPCs.

They were the use of enhanced recovery after surgery pathways; prophylactic mucolytics; postoperative, continuous positive airway pressure plus non-invasive ventilation; lung-protective intraoperative ventilation; prophylactic respiratory physiotherapy; epidural analgesia; and goal-directed hemodynamic therapy. However, some other factors might not be beneficial, namely, restrictive fluid administration strategies; postoperative, bi-level, non-invasive ventilation; postoperative, high-flow, nasal cannula oxygenation; smoking cessation therapy; inhaled β agonists; incentive spirometry; and variation of the intraoperative, fractional inspired oxygen concentration.(43)

The estimated blood loss in our study was 653 ± 735 ml for the PPC group, which was significantly higher than that for the non-PPC group (267 ± 655 ml). This result is consistent with the findings of a multivariate analysis conducted by Sah and colleagues of the gastric cancer treatments provided by a specialized center: if the blood loss volume exceeded 500 ml, it was associated with early postoperative complications (OR, 2.86; 95% CI, 1.67–4.92).(44)

Although the presence of a nasogastric (NG) tube has been reported by some studies to be a PPC risk factor(45), there were no significant differences between its use and non-use in terms of the PPC incidences in our study. One explanation is that nasogastric decompression was not a routine procedure at our hospital during the study period.

A systematic review of prophylactic nasogastric decompression after abdominal operations by Nelson et al. reported that patients with selective NG-tube usage after laparotomies developed pneumonia and atelectasis less often than patients using NG tubes until gastrointestinal motility returned.(46) With the presence of an NG tube, patients might not cough effectively, resulting in secretion retention and

atelectasis. Furthermore, the tube can trigger silent aspiration and pneumonia as the lower esophageal sphincter cannot work as it should.(47)

The lengths of hospital and ICU stays are longer for PPC patients (Table 3), which inevitably leads to higher costs for the patients, their families, and the healthcare system. A multicenter study concluded that even mild PPC cases—such as atelectasis and the need for prolonged oxygen therapy—were related to increases in early postoperative mortality and extended ICU and hospital stays. The researchers opined that all such cases deserve attention and intervention.(48) There were no deaths during the perioperative period that were directly attributable to the PPCs in our study.

Our main concern with the upper abdominal operations was postoperative pain; this was because patients might avoid moving or breathing deeply when they felt uncomfortable, thereby possibly triggering a PPC. However, the average postoperative pain-rating scores for the PPC and non-PPC groups did not differ significantly. An analysis of the maximum postoperative pain ratings during the first 72 hours following surgery determined that the pain score was 5.92 for the PPC patients versus 5.25 for those without PPCs. Furthermore, the total opioid usage (morphine, pethidine, and fentanyl) of the 2 groups were not statistically different. However, our findings contrast with those of Roberta et al., who investigated PPCs experienced by the elderly after abdominal surgery. Those researchers concluded that pain is a contributing factor to the development of PPCs. This difference might result from the different assessment durations that were utilized. Specifically, the current investigation assessed the pain levels of both groups within 3 days postoperatively. By comparison, Roberta and colleagues assessed pain daily between postoperative Days 1 and 6, inclusive, and they found that their PPC patients experienced significant levels of pain at rest on postoperative Day 4.(49)

There are many predictive tools for PPCs, for example, the ARISCAT scoring system, the LAS VEGAS risk score, the Melbourne Risk Prediction Tool, and the Surgical Lung Injury Prediction model. However, only the ARISCAT system has a sufficient predictive power that has been confirmed by external validation.[48] In Thailand, only 1 risk scoring system for the prediction of respiratory complications after thoracic surgery has been validated for the Thai population.(50) For our elderly patients undergoing upper abdominal surgery, we used the ARISCAT scoring system as a tool to predict PPCs. The mean ARISCAT scores for the non-PPC and PPC groups were 32 ± 13 and 43 ± 14 , respectively (P value < 0.001). Although the means of both groups were categorized as an intermediate risk for PPCs, it can be seen that the higher the score, the greater the chance of developing PPCs. In addition, patients whose scores ranked in the intermediate-risk level had an odds ratio for pulmonary complications of 3.04 (95% CI, 1.53–6.03), while for those with scores in the high-risk level, the odds ratio was as high as 7.82 (95% CI, 3.90–15.70).

As only 85 cases out of the 1,100 patients in our study cohort developed PPCs, we could not establish a predictive score that would demonstrate an effective power as well as the ARISCAT scores presently do. However, the ARISCAT scores did help to predict PPCs in our high-risk patients and in our high-risk operations. Those scores could therefore be applied well to the general Thai population and might be used in other Southeast Asian countries.

Limitation

As this study involved a retrospective data collection, some factors that might have affected the results could not be controlled.

Conclusions

PPCs were common in the elderly patients, being found in 7.7% of the study cohort. The complications elevated the incidence of postoperative morbidity of the patients and extended their lengths of ICU and hospital stay. It is appropriate to use the ARISCAT scoring system as an assessment tool to classify geriatric Thai patients into PPC risk groups. Identifying and correcting modifiable risk factors perioperatively may improve the perioperative outcomes.

Further Research

Functional dependence status, frailty, and sarcopenia are interesting factors and might be modifiable. Although we are unable to recruit such data from our standard medical records retrospectively, they might be usefully included in a further prospective study to improve PPC management.

Abbreviations

ARISCAT = Assess Respiratory Risk in Surgical Patients in Catalonia

EPCO = European Perioperative Clinical Outcome

ICU = Intensive care unit

OR = Odds ratio

PPC = Postoperative pulmonary complication

Declarations

Ethics approval and consent to participate

The ethics approval for this retrospective study was obtained from the Siriraj Institutional Review Board (Si 006/2019), and the need for patient consent was waived.

Consent for publication

Not applicable

Availability of data and materials

The data that supported the findings of this study are available from the Faculty of Medicine Siriraj Hospital, Mahidol University, but restrictions apply to their availability: they were used under license for the current study and are not publicly available. Data are, however, available from the authors upon reasonable request and with the permission of the Faculty of Medicine Siriraj Hospital, Mahidol University.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AS was an initiator and supervised this project at every step. RJ, SJ, and NH collected and analyzed the patient data. JN and NT interpreted the data and were major contributors to the writing of the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1: Patient demographic data

Demographic data	PPCs (n = 85)	No PPCs (n = 1,015)	Pvalue
Age	74.95 ± 7.662	73.50 ± 6.500	0.052
Male sex	46/54.11%	488/8.07%	0.285
ASA classification > 2	50/58.82%	452/44.53%	0.011
BMI (kg/m ²)	23.65	24.06	0.389
Previous pulmonary disease	4/4.70%	31/3.05%	0.34
Respiratory infection in preceding month	0/0	7/0.68%	1
History of smoking	27/31.76%	229/22.56%	0.054
Current smoker	7/8.23%	38/3.74%	0.077
Chronic obstructive pulmonary disease	3/3.52%	22/2.16%	0.434
Asthma	2/2.35%	23/2.26%	1
Obstructive sleep apnea	2/2.35%	14/1.37%	0.354
Congestive heart failure	1/1.17%	2/0.19%	0.215
Preoperative SpO ₂ (%)	97.8 ± 1.5	98.3 ± 1.7	0.012
Preoperative albumin (g/dl)	3.44 ± 0.98	3.80 ± 1.17	0.002
Preoperative Hb (g/dl)	11.04 ± 2.32	11.93 ± 1.96	< 0.001
Preoperative HCO ₃	25.02 ± 3.49	25.79 ± 2.82)	0.053
Preoperative creatinine	1.28 ± 1.48	1.08 ± 0.79	0.224
Abnormal CXR	24/28.23%	252/24.82%	0.486
Spirometer usage	5/5.88%	51/5.02%	0.598
Deep breathing exercises	2/2.35%	23/2.26%	0.707

Table 2: Intraoperative parameters

Intraoperative parameters	PPCs (n = 85)	No PPCs (n = 1,015)	Pvalue
Open surgery	60/70.58%	450/44.33%	< 0.001
Emergency surgery	14/16.47%	52/5.12%	< 0.001
Duration of surgery	3.82 ± 2.65	2.43 ± 1.84	< 0.001
Anesthesia technique			0.012
General anesthesia	51/60%	739/72.8%	
Combined GA & epidural	34/40%	276/27.19%	
Crystallloid IV (ml)	2,165.71 ± 1688.68	1,198.29 ± 1118.16	< 0.001
Blood loss (ml)	652.76 ± 734.68	266.58 ± 654.95	< 0.001
Inhalation			0.147
Isoflurane	4/4.70%	70/6.89%	
Sevoflurane	21/24.70%	335/33%	
Desflurane	60/70.58%	603/59.40%	
Midazolam used	20/23.52%	162/15.96	0.071
Neuromuscular blocking			0.005
Cisatracurium	49/57.64%	605/59.60%	0.724
Atracurium	22/25.88%	348/34.28%	0.115
Rocuronium	14/16.47%	59/5.81%	< 0.001
Ventilator setting			0.608
VCV mode	63/74.11%	643/63.34%	
PCV mode	18/21.17%	159/15.66%	
TV (cc/kg)	8.88 ± 1.18	8.99 ± 1.35	0.459
PAP (cmH2O)	20.65 ± 5.28	21.21 ± 4.53	0.346
RR (/min)	12.16 ± 2.19	12.42 ± 2.65	0.4
PEEP (cmH2O)	4.82 ± 0.825	4.82 ± 0.94	0.994
ARISCAT score	31.93 ± 12.87	43.15 ± 13.58	< 0.001

Table 3
Postoperative parameters

Postoperative parameters	PPCs (n = 85)	No PPCs (n = 1,015)	Pvalue
Postop. ventilator (minutes)	179.49 ± 238	54.13 ± 72.5	0.003
Numerical pain rating score	5.92 ± 3.18	5.25 ± 3.21	0.074
Morphine dose (mg)	6.357 ± 5.55	5.41 ± 3.23	0.647
Pethidine dose (mg)	45.00 ± 7.07	42.58 ± 12.16	0.823
Fentanyl dose (mcg)	103.25 ± 52.49	91.77 ± 41.09	0.145
Length of hospital stay (days)	25.35 ± 21.17	7.30 ± 8.66	< 0.001
Length of ICU stay (days)	8.36 ± 10.34	2.84 ± 3.00	0.001

Table 4
Significant factors associated with postoperative pulmonary complications

Protective/risk factors	Pvalue	Odds ratio	95% interval
Preoperative SpO ₂ < 95%	0.005	3.312	1.685–6.510
Preop. Hb < 10 mg/dL	< 0.001	2.943	1.859–4.659
Preop. albumin < 3.5 g/dl	0.015	1.52	0.918–2.51
Duration of surgery (reference < 2 hours)			
2–3 hours	< 0.001	1.799	0.936–3.456
> 3 hours	< 0.001	3.892	2.321–6.525
Open surgery	< 0.001	3.013	1.859–4.883
Emergency surgery	< 0.001	3.651	1.93–6.907
Crystalloid IV > 1,000 ml	< 0.001	4.063	2.444–6.755

Figures

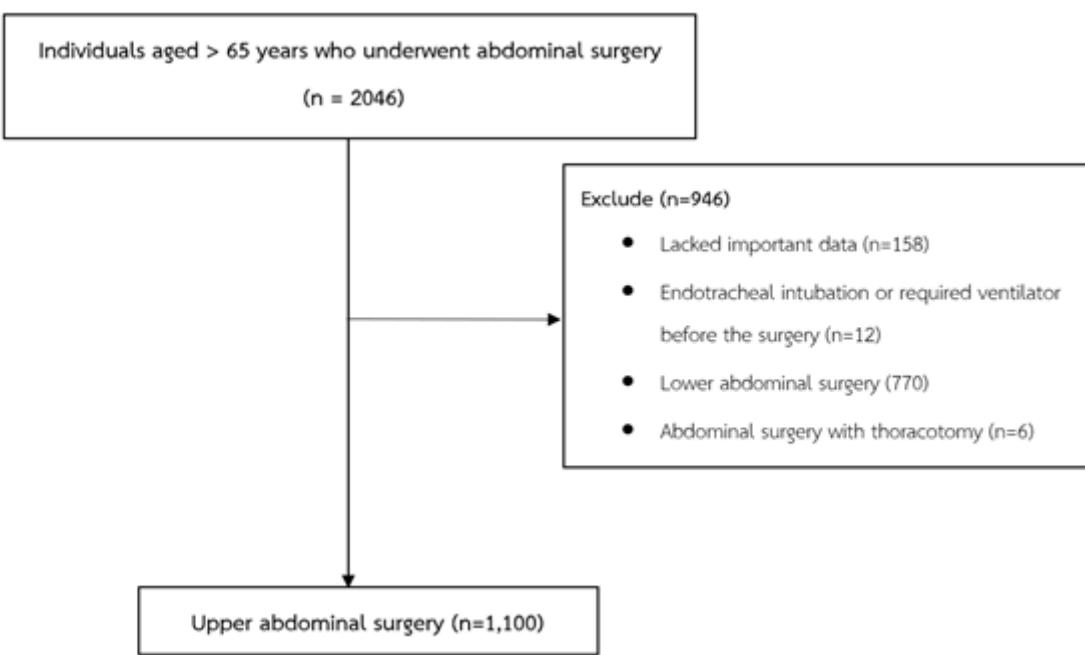


Figure 1

Participant recruitment

<input type="checkbox"/> Respiratory infection	Antibiotics for suspected infection with one or more of the following: new or changed sputum, new or changed lung opacities, fever, white blood cell count $> 12 \times 10^9 \text{ litre}^{-1}$.
<input type="checkbox"/> Respiratory failure	Postoperative $\text{PaO}_2\text{PaO}_2 < 8 \text{ kPa}$ (60 mm Hg) on room air, a $\text{PaO}_2:\text{FiO}_2$ ratio $< 40 \text{ kPa}$ (300 mm Hg), or arterial oxyhaemoglobin saturation measured with pulse oximetry $< 90\%$ and requiring oxygen therapy
<input type="checkbox"/> Pleural effusion	CXR with blunting of costophrenic angle, loss of sharp silhouette of the ipsilateral hemidiaphragm in upright position, displacement of adjacent anatomical structures, or (in supine position) hazy opacity in one hemithorax with preserved vascular shadows
<input type="checkbox"/> Atelectasis	Lung opacification with mediastinal shift, hilum or hemidiaphragm shift towards the affected area, with compensatory hyperinflation in adjacent non-atelectatic lung
<input type="checkbox"/> Pneumothorax	Air in the pleural space with no vascular bed surrounding the visceral pleura
<input type="checkbox"/> Bronchospasm	Newly detected expiratory wheeze treated with bronchodilators
<input type="checkbox"/> Aspiration pneumonitis	Acute lung injury after inhalation of regurgitated gastric contents
<input type="checkbox"/> Tracheobronchitis	CXR with at least one of the following: infiltrate, consolidation, cavitation; plus at least one of the following: fever $> 38^\circ\text{C}$ with no other cause, white cell count < 4 or $> 12 \times 10^9 \text{ litre}^{-1}$, > 70 yr of age with altered mental status with no other cause plus at least two of the following: new purulent/changed sputum, increased secretions/suctioning, new/worse cough/dyspnoea/tachypnoea, rales/bronchial breath sounds, worsening gas exchange
<input type="checkbox"/> Pneumonia	
<input type="checkbox"/> ARDS	

Figure 2

Postoperative pulmonary complications (PPCs), as defined by the European Perioperative Clinical Outcome (2015)