Predictors and Outcomes of Postoperative Pulmonary Complications following Abdominal Surgery in a South Indian Population

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Abstract

Background: Postoperative pulmonary complications (PPC) following abdominal surgery are associated with increased morbidity and poorer outcomes. We prospectively examined risk factors associated with the development of PPC in patients undergoing abdominal surgery.

Aims: The primary outcome was to determine the association of predefined risk factors in the prediction of PPC after abdominal surgery. Secondary outcomes were evaluation of outcomes of PPC.

Setting and Design: This was a prospective study conducted in the gastro-surgical and urological units of a tertiary care referral hospital in patients undergoing abdominal surgery over a period of 6 months (November 2015–April 2016).

Materials and Methods: Relevant preoperative and intraoperative variables were recorded by the anesthesiologist in a pro forma provided. Postoperatively, data from the Intensive Care Unit (ICU) were collected from data sheets. PPC were defined according to preset criteria and outcomes of the patients including ICU stay, hospital stay, and mortality were noted.

Statistical Analysis: Chi-square test was used to find the association of risk factors of PPC. Mann–Whitney test was used for continuous variables and McNemar’s test for postoperative respiratory variables. A final regression analysis was performed with factors with significant association ($P < 0.1$).

Results: One hundred and fifty patients were included, and 24 patients (16%) developed PPC as defined by our criteria. Emergency surgery (44.4% of PPC) and cardiac comorbidity (23.9% of PPC) were significant associations for pulmonary complications. The length of ICU and hospital stay (LOICU, LOHS) and mortality were higher in the group with pulmonary complications ($P < 0.001$).

Conclusions: Emergent surgery and cardiac comorbidities were independent predictors for the development of PPC. PPC are associated with increased LOHS, LOICU stay, and mortality.

Keywords: Abdominal surgery, postoperative pulmonary complications, predictors

INTRODUCTION

The outcomes after abdominal surgery are influenced by postoperative complications, and pulmonary complications are associated with increased morbidity and length of hospital stay. While cardiac complications are related directly to cardiac status, postoperative pulmonary complications (PPC) combine infectious causes such as pneumonia, respiratory failure as well as exacerbation of chronic obstructive pulmonary disease (COPD). To assist with resource allocation, efforts have been made to identify risk factors for PPC in an effort to direct efforts toward patients identified to be at high risk. The lack of specificity for respiratory symptoms makes it more difficult to individually evaluate PPC although unequivocal evidences are pneumonic changes on chest X-ray or positive sputum microbiology for pulmonary infections.

Patients with COPD are at greater risk for the development of PPC.

Preoperative risk factors are a major determinant of postoperative morbidity. Several risk factors both preoperatively and intraoperatively have been identified with respiratory impairment after abdominal surgery. Conventionally, factors associated with PPC are chronic airway disease, advanced age, upper abdominal surgery, intraperitoneal sepsis, and obesity. Other factors affecting this is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

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PPCs are patient’s preoperative mobility status, cardiac, respiratory conditions, and malignancies.

Patient-related risk factors that could influence PPC include age, chronic lung diseases, cigarette use, congestive heart failure, obesity, asthma, obstructive sleep apnea, site and type of surgical incision, duration of surgery, anesthetic technique, and emergency surgery. We included defined associations with PPCs in our group of patients for abdominal surgery namely age, emergency surgery, cardiac, respiratory comorbidities, smoking, body mass index (BMI), type of surgery, incision, analgesia, and intraoperative complications [Table 1].

The primary objective was to determine the association of predetermined risk factors in predicting pulmonary complication in patients undergoing abdominal surgery. The secondary objectives were to determine the impact and outcomes of pulmonary complications that occurred in this group with an aim at improving outcomes for patients.

Materials and Methods

The study was conducted in the gastrointestinal and urological surgical units of a tertiary care center between November 2015 and April 2016. The sample size was determined from a comparison of anesthesia duration between the groups with and without PPC in an earlier study. With a 95% confidence interval (CI), the sample size was calculated as 46 in each group. We included 150 patients undergoing abdominal surgery.

Following Hospital Ethical Committee approval, one hundred and fifty patients scheduled to undergo surgery were screened for inclusion. All patients undergoing abdominal surgery aged between 18 and 80 years and managed in a postsurgical Intensive Care Unit (ICU) for longer than 8 h postoperatively were included in the study. The preoperative and intraoperative variables were collected by the designated anesthetist through a structured pro forma [Table 2]. Postoperatively, all patients were shifted to postsurgical ICU, and the further progress of the patient including respiratory complications was obtained from the data sheet of the patient in the ICU.

Assessment of the patient was performed by the American Society of Anesthesiologists physical status assessment and by Duke’s activity scoring based on metabolic equivalent test. A chest X-ray was obtained in all patients while more advanced investigations including pulmonary function tests and arterial blood testing were performed at the discretion of the assessing physician or anesthesiologist.

Cardiac comorbidity included hypertension, ischemic heart disease with or without intervention, and previous cardiac surgery. Respiratory comorbidity was defined as history and signs suggestive of COPD, reactive airways or bronchial asthma, and chest infections. Smoking history was elicited and patients classified as ex-smokers, current, and nonsmokers. BMI, type of surgery, incision, and duration were recorded.

The intraoperative variables included the type and duration of anesthesia. Any intraoperative complications relating to surgery and anesthesia defined as unanticipated blood loss needing transfusion, hypothermia, aspiration during intubation, failure to extubate on table, or elective postoperative ventilation were noted.

Postoperatively, patients were shifted to the surgical ICU and occurrence of PPC as recorded. We defined PPC as the occurrence of 2 or more of the symptoms and signs [Table 3]. These included respiratory rate, oxygenation, auscultatory findings, radiological diagnosis, and microbiological evidence suggestive of chest infections. The profile of the patient in the ICU, quality of analgesia, and length of ICU and hospital stay were noted. The protocol for pain management was as per standard ICU practice; open surgical patients received an infusion of local anesthetic epidurally. Patients who underwent laparoscopic surgery on dual antiplatelets or had spinal instrumentation earlier were excluded from epidural administration. Patients who underwent laparoscopic surgery

| Factor                        | Category       | Pulmonary complication | P      |
|-------------------------------|----------------|------------------------|--------|
|                               | Yes, n (%)     | No, n (%)              |        |
| Timing surgery                | Elective       | 16 (12.1)              | 116 (87.9) | <0.001 |
|                               | Emergent       | 8 (44.4)               | 10 (55.6)   |        |
| Sex                           | Male           | 17 (18.9)              | 73 (81.1) | 0.237  |
|                               | Female         | 7 (11.7)               | 53 (88.3)  |        |
| BMI                           | ≥30            | 2 (9.5)                | 19 (90.5)  | 0.383  |
|                               | <30            | 22 (17.1)              | 107 (82.9) |        |
| Cardiac comorbidity           | Yes            | 16 (23.9)              | 51 (76.1) | 0.018  |
|                               | No             | 8 (9.6)                | 75 (90.4)  |        |
| Respiratory comorbidity       | Yes            | 5 (25.0)               | 15 (75.0)  | 0.238  |
|                               | No             | 19 (14.6)              | 111 (85.4)|        |
| Cardiac and respiratory comorbidity | Yes   | 4 (57.1)               | 3 (42.9)  | 0.013  |
|                               | No             | 20 (14)                | 123 (86)   |        |
| Malignancy                    | Yes            | 13 (21.3)              | 48 (78.7)  | 0.142  |
|                               | No             | 11 (12.4)              | 78 (87.6)  |        |
| Preoperative ventilation       | Yes            | 5 (31.3)               | 11 (68.8)  | 0.078  |
|                               | No             | 19 (14.2)              | 115 (85.8) |        |
| Smoking                       | Yes            | 1 (33.3)               | 108 (66.7)| 0.757  |
|                               | No             | 20 (15.6)              | 2 (84.4)   |        |
|                               | Ex             | 3 (16)                 | 126 (84)   |        |
| Intraoperative complication    | Yes            | 8 (22.9)               | 27 (77.1)  | 0.206  |
|                               | No             | 16 (13.9)              | 99 (86.1)  |        |
| Preoperative pulmonary        | Yes            | 1 (9.1)                | 10 (90.9)  | 0.516  |
| complication                  | No             | 23 (16.5)              | 116 (83.5)|        |
| Laparoscopy                   | Yes            | 4 (7.8)                | 47 (92.2)  | 0.061  |
|                               | No             | 20 (20.2)              | 79 (79.8)  |        |
| Type of anesthesia            | GA             | 9 (12.5)               | 63 (87.5)  | 0.422  |
|                               | GA + epidural  | 14 (18.7)              | 61 (81.3)  |        |
|                               | Epidural/spinal| 1 (33.3)               | 2 (66.7)   |        |
| Malignancy                    | Yes            | 14 (18.7)              | 61 (81.3)  | 0.373  |
|                               | No             | 10 (13.3)              | 65 (86.7)  |        |

BMI=Body mass index, GA=General anesthesia
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Statistical analysis
To test the statistical significant changes in the mean age, length of hospital stay and ICU stay and duration of anesthesia with respiratory complication, Mann–Whitney U-test was used. To test the statistical significant changes of postoperative respiratory variables, McNemar’s test was used. Chi-square test was used to assess the association of risk factors for PPC.

Statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 20.0. IBM Corp., (Armonk, NY, USA).

Results
Of the 150 patients studied, 24 patients (16%) developed pulmonary complications as defined by our criteria. Emergency surgery was associated with a significantly higher risk for pulmonary complications [Table 1 and Figure 1]. The mean

Table 2: Predictors and outcome of postoperative pulmonary complications in major abdominal surgery - pro forma

| Name                        | MRD | Age | Sex | Height (cm) | Weight (kg) | BMI |
|-----------------------------|-----|-----|-----|-------------|-------------|-----|

 receive multimodal analgesia on a three-tiered protocol and were assessed to keep the numerical rating for pain on a scale <3.

Stepwise binary logistic regression analysis was used to predict the risk factors and estimate the odds ratio with 95% CI.
age of patients with pulmonary complications was significantly higher than those without [Table 4]; however, on regression analysis, age was not a predictor for PPC [Table 5]. Gender distribution between both groups was comparable. Patients were classified as obese or nonobese based on the BMI ≥30. There was no association with increasing BMI and pulmonary complications [Table 1].

Sixty-seven patients undergoing surgery were identified to have cardiac comorbidity, and 16 (23.9%) among them developed PPC [Table 1 and Figure 2]. Four patients (57.1%) with combined cardiac comorbidity and respiratory comorbidity had significantly increased the risk for the development of PPC [Table 1] although this was insignificant on regression analysis.

Among 16 patients who were ventilated preoperatively, 5 patients (31.3%) developed PPC [Table 1] which was insignificant on multivariate analysis. The presence of respiratory comorbidity, smoking, or PPC did not increase PPC in the groups of patients included in our study [Table 1]. Twenty patients had preoperative respiratory disease, and only 5 (25%) developed PPC. Eleven patients had preoperative pulmonary issues as recent chest infection, and only 1 of them developed PPC.

A total of 75 patients among the group studied underwent surgery for malignancy. Only 14 patients (18.7%) developed PPC [Table 1]. Fifty-one patients underwent laparoscopic surgical procedures, and 4 (7.8%) developed PPC as defined by our criteria [Table 2]. All open surgical patients received epidural anesthesia according to the proposed procedure unless contraindicated. Surgical categories were grouped as hepatobilary, colorectal, upper gastrointestinal tract including the stomach and esophagus and duodenum, urological and other groups that included vascular surgery and retroperitoneal tumors. Although 11 out of 40 patients who underwent colorectal surgery developed PPCs, this was not significant.

The type of anesthesia was classified as general anesthesia, general anesthesia with epidural, and sole regional anesthesia, and they were not related to postoperative pulmonary outcomes. Seventy-five patients received epidural analgesia with general anesthesia, and 11 (18.7%) patients among them had respiratory complications.

The quality of pain relief did not correlate with the development of PPC. Among 150 patients studied, 11 patients had excellent analgesia, 121 good quality analgesia, while 16 were dissatisfied and 2 had poor pain relief.

Intraoperative complications were defined as unanticipated blood loss needing transfusion, aspiration during induction, severe hypothermia, cardiovascular and respiratory events, failure to extubate on table, and postoperative ventilation. Thirty-five patients had intraoperative complications of which 7 (22.9%) developed PPC. Among the patients who developed PPC, 12 (50%) patients needed reintubation. The length of ICU stays and hospital stay and overall mortality were significantly higher in the group with PPC [P < 0.001, Table 4 and Figure 3]. Among the risk factors, age, timing of surgery, presence of cardiac comorbidity, combined cardiac and respiratory comorbidity, preoperative ventilation, and laparoscopic surgery were individually associated with the development of PPC (P < 0.1). These risk factors were considered for a final prediction model with multiple regression analysis. Emergent surgery and cardiac comorbidity were found to be significantly associated with the development of PPC [Table 5].
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Figure 2: Cardiac comorbidity and postoperative pulmonary complications

Figure 3: Mortality and postoperative pulmonary complications

**Discussion**

We aimed to evaluate correlations of predetermined factors on respiratory complications in a selected group of patients undergoing abdominal surgery at our center. Pulmonary complications have been contributory to postoperative morbidity and mortality in abdominal surgery.\(^6\) In this study,\(^6\) authors had taken into account cognitive dysfunction as a variable as impaired cognitive functions could predispose to pulmonary complications by increasing susceptibility to aspiration.\(^7\) We documented a 16% incidence in complications although the reported incidence is variable between 9% and 40%.\(^1\) The variations result on account of the differences in the quantification of respiratory problems and patient profiles and nature of surgeries.

We did not include cognitive dysfunction in our patients, but we observed that 33.3% of patients with pulmonary complications had undergone an emergent surgery. Emergency abdominal surgery carries higher risks for aspiration by impaired bowel motility, obstructive bowel lesions predisposing to aspiration during anesthesia.\(^8\) Patients undergoing emergency surgery could also be obtunded and have impaired cognition predisposing to pulmonary complications by suppressing the cough reflex and making them susceptible to aspiration. Serejo et al.\(^9\) reported a 28.2% incidence of pulmonary complications in patients undergoing emergency abdominal surgery. This is higher than the complications for nonemergent surgery, and they identified increasing age, BMI, and upper abdominal surgeries as additional contributory factors.

We presumed that patients with preoperative respiratory problems would have increased postoperative respiratory problems based on earlier studies.\(^10\) Patients with COPD have a higher incidence of PPC after abdominal surgery.\(^11\) We had identified 20 patients among 150 studied to have respiratory comorbidity, and they included patients with history, signs and symptoms of chronic obstructive airway disease, reactive airway diseases, and pneumonia. All elective patients were prepared by standard pre- and intra-operative protocols that included nutritious protein-rich diet, preoperative exercises, and incentive spirometry. Patients with reactive airway diseases were instituted in a level of treatment higher than the existing treatment for the surgery. We did not find increased PPC in patients with preexisting respiratory problems. It is possible that our patient profile did not include patients with severe impairment in respiratory function. Our findings matched those by Kim et al.\(^12\) who studied 387 patients undergoing abdominal surgery and concluded that in mild to moderate COPD, multiple logistic regressions did not show any increased risk for PPC in comparison with controls.

Obesity could be a contributor for PPC,\(^13,14\) and incidence has been variably predicted between 5% and 35% for colorectal surgery.\(^15\) The cephalad diaphragmatic shift due to intra-abdominal fat decreases functional residual capacity and increases ventilation-perfusion mismatch. A large prospective cohort study or >2200 patients evaluated effects of BMI on patient outcomes in patients undergoing abdominal surgery.\(^16\) They concluded that after adjustments for risk factors, BMI >30 was not a risk factor for mortality. In contrast, a similar large study found an increase in pulmonary complications in the overweight, obese, and morbid obese particularly if this was associated with the metabolic syndrome.\(^17\) We had profiled our patients as < or >30 BMI as this was the standard definition for obesity. We did not find an association for pulmonary complications in the obese group (9.5% vs. 17.1%). It is possible that these numbers were too small and the variety of surgeries too diverse to account for differences.

Cardiovascular outcomes increase with increasing age, and some of the manifestations of cardiac failure including breathlessness and desaturation could confound the diagnosis in the background of respiratory diseases. Patients with COPD belonging to Global Initiative for Obstructive Lung Disease class 3 and 4 have a higher incidence of diabetes, hypertension, and cardiovascular diseases.\(^18\) Although our study showed cardiovascular comorbidity and combined cardiovascular and respiratory comorbidity as predictors for PPC on regression analysis, only cardiac comorbidity was identified as a predictor.

Nearly, 58.3% of patients underwent open surgery with epidural analgesia, and van Lier et al. have reported improved surgical outcomes in surgical patients who receive epidural analgesia.\(^19\) We, however, did not find an association with the use of epidural.

Waheed et al.\(^20\) have shown that impaired pulmonary function and cardiovascular functions are prevalent in the
elderly and are an important cause of cardiovascular and all-cause mortality. They have recommended that isolated prevalence of either pulmonary or cardiovascular comorbidity can contribute to overall cardiovascular outcomes and have also recommended a comprehensive cardiac and pulmonary evaluation in the prediction of cardiovascular outcomes. We found that increasing age was associated with increasing PPCs even though respiratory associations were not seen. We propose that age-associated cardiovascular risk coexists with subclinical pulmonary impairment as had been described by Waheed et al. and could explain our findings of PPC in patients with cardiac comorbidity.

Transverse incisions are associated with lesser pain, wound dehiscence, and lesser pulmonary complications. We did not find any correlates with the type of incision or portholes and the development of PPC. Fifty-one patients underwent laparoscopic surgery and had analgesia management as per protocol that included intraoperative opioid and postoperative three-tier management of pain. Patients who underwent open surgery had an upper midline incision (hepatobiliary surgery), lower midline (colorectal), lateral incision (renal), and lower transverse for retroperitoneal tumor. Epidural analgesia was instituted intraoperatively with 0.25% bupivacaine and postoperatively with 0.125% bupivacaine with 2 μg/ml fentanyl administered as an infusion. Patients with poor quality of pain relief were managed with administration of higher volumes of local anesthetic. If this did not provide satisfactory relief then multimodal analgesia that included a nonsteroidal anti-inflammatory drug, weak opioid, and a strong opioid was administered as per protocol. The assigned nurse monitored all patients for pain scores using the numerical rating scale at 6th hourly intervals.

The overall scorings for pain were satisfactory, and only 13 patients were not completely satisfied with the quality of pain relief. Besides 6th h assessment, patients were provided analgesia when they complained of discomfort; however, we did not look at the pain scores on ambulation or during spirometry. Our records showed that analgesia was adequate in most patients and we did not find correlates between the intensity of pain relief and pulmonary complications.

We had deduced a simple classification for the diagnosis of pulmonary complications that was based on clinical signs and symptoms. This was not as stringent as per the classification for PPC after thoracic surgery. We had felt that our classification would include all pulmonary complications however minor following surgery. The incidence of PPC even with this classification was only 16%, which appeared acceptable for the profile of surgeries performed.

Smoking has been associated with an increased incidence of PPC. Barrera et al. had shown a significant increase in pulmonary complications after thoracic surgery in smokers compared to nonsmokers although there was no difference between the time of cessation of smoking before surgery. Other studies evaluating PPC have suggested that smoking history >40 pack-years increases risk of PPC by 5.7%. In our groups of patients studied, smoking did not have a positive association. Only one patient who was smoking at the time of surgery, 3 ex-smokers, and 20 nonsmokers developed PPC as per criteria. The number of smokers in our study was very low. We believe this could have been due to reluctance in admitting a smoking habit amongst our patients. This may have been a reason for the smaller numbers and lack of association seen with pulmonary complications in our patients.

Our study had some limitations. Although we chose patients undergoing abdominal surgery only, the types of surgeries and patient profiles were very diverse. Fifty-one patients underwent laparoscopic surgery as was the practice of the surgeon. We included all patients including emergent surgeries in whom some of the patients had been intubated before the procedure. We proposed this study to evaluate incidence of pulmonary complications at our center with a view to improve correctable causes and quality of care. We did not identify correctable causes but were able to identify some predispositions.

**Conclusions**

Emergent abdominal surgery, increasing age, and cardiac comorbidity increase the risks of PPC. PPCs were associated with increased length of ICU and hospital stay and mortality.

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**Conflicts of interest**

There are no conflicts of interest.

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