e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2024; 16(1); 1142-1148

Original Research Article

Role of Preoperative Spirometry Test in Predicting Postoperative Pulmonary Complications in High-Risk Patients after Abdominal Surgery

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Received: 25-10-2023 / Revised: 23-11-2023 / Accepted: 26-12-2023
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Conflict of interest: Nil

Abstract:

Background: Postoperative pulmonary complications (PPC) are the most common type of postoperative complications among patients undergoing both cardiac and non-cardiac surgery including abdominal surgery. Whether preoperative spirometry in non-thoracic surgery can predict postoperative pulmonary complications (PPCs) is controversial.

Aim: The aim of the present study was to investigate whether preoperative spirometry results can predict the occurrence of PPCs in patients who had undergone abdominal surgery.

Material and Methods: This was a single centre, inpatient, hospital based prospective observation study involving 127 high risk patients undergoing major abdominal surgery. The incidence of the following postoperative pulmonary complications was measured: atelectasis, pneumonia, pulmonary embolism, bronchitis and acute respiratory failure. The association between PPC and the Pulmonary function test (PFT) were specifically studied by these parameters: FEV_1 (%) (Forced expiratory volume in 1 second), FVC (%) (Forced vital capacity) and FEV_1/FVC (%).

Results: A total of 18 patients (14.2%) developed PPC. The single most common PPC was pneumonia observed in 9 (7.1%) patients followed by acute respiratory failure in 5 (3.9%) patients. In the present study, all parameters of the PFT were significantly worse among the patients who developed PPC in comparison to those who did not develop PPC. Among the FVC, FEV_1, and FEV_1/FVC; the value of FEV_1/FVC differed most significantly between the patients who developed PPC and who did not develop PPC.

Conclusion: Poor preoperative spirometry findings are associated with the development of PPCs among high-risk patients undergoing abdominal surgery.

Keywords: Spirometry Test, Post Operative Pulmonary Complications, Abdominal Surgery.

Introduction

The term 'Postoperative Pulmonary Complications' (PPC) encompasses any type of complication affecting the respiratory system after surgery [1]. Pulmonary complications during the postoperative period result in delayed recovery and prolonged stay in the postoperative ward, thereby increasing the hospital expenditure.

It has been shown that patients experiencing postoperative pulmonary complications have on average 4-6 days longer stay in the postoperative ward [2,3]. From an epidemiological point of view, the pathologic conditions that increase the risk of PPC can be categorised into either patient-, anaesthesia-, and surgery-related factor [4,5]. Among these factors, the type of surgery and comorbidities of the patient are the predominant determinants of PPC. The most immediate risk factors for the development of PPC are related to the surgical procedure viz. duration, location, and type of surgical procedure [6,7].

The risk of having PPC is highest after General Anaesthesia (GA) among all anaesthetic techniques [8]. Collectively all these factors result in impairment of critical respiratory functions leading

to the development of one or other types of PPCs. The decrease in Functional Residual Capacity (FRC), along with abnormal regional distribution of ventilation and reduction in cardiac output, leads to Ventilation Perfusion (V/Q) mismatch in several areas of the lung (in some lobes V/Q ratio is high and in some lobes V/Q ratio is low). The high V/Q ratio results in an increase in alveolar dead-space leading to impairment of carbon dioxide elimination, whereas the low V/Q ratio results in impairment of oxygenation [9,10]. The factors that are most easily identified (screened) that lead to PPC are patient-related factors. Patient-related determinants of PPC include old age, impaired pulmonary function, substance abuse, immunocompromised status, and associated comorbidities [6,7,11]. High-risk patients like elderly patients (>60 years), chronic smokers and patients with pre-existing lung diseases presenting for upper abdominal laparotomy surgery are prone to develop postoperative pulmonary complications [6,7].

These life conditions are often associated with disturbed well-being, increased morbidity, worsened chances of survival, prolonged hospital stays. The anaesthetic management of such patients is challenging, it requires careful work up and care to prevent the postoperative pulmonary complications (PPCs) [10,12]. Thus, in this study, we propose to compare the pattern of the preoperative pulmonary function test results among the patients who developed pulmonary complications during the postoperative period vs. those who did not develop complications. The overarching aim of the present study was to identify the determinants of development of postoperative pulmonary complications.

Material and Methods

Study design and ethical statement: This was a single centre, prospective, observational study conducted at the Department of Anaesthesiology, LN Medical College, and affiliated hospitals, Bhopal for a duration of 18 months i.e. from March 2021 to August 2022. The study protocol was duly approved by Institutional Ethics Committee, LN Medical College, and affiliated hospitals, Bhopal (Letter no. LNMC&RC/Dean/ 2021/Ethics/ 285 dated Feb 2, 2021).

Inclusion and exclusion criteria: The participants were recruited into the study as per the following inclusion criteria: patients giving valid consent, patients aged >60 yrs., patients with chronic lung disease (COPD, asthma), patients with interstitial lung disease and patients who were chronic smokers. The patients who underwent emergency surgery, major abdominal surgery in last three months and who did not gave consent to participate in the study were excluded from the study.

Sample size and data collection: For patient recruitment, following statistical formula was used: $n= (z)^2 P (1-P) / d^2$, where n= sample size, z=1.96, P=prevalence of upper abdominal laparotomy surgeries in J.K. Hospital, Bhopal during a period of 1 year, d = maximum random sampling error / desired precision. Using this formula, the minimum sample size was calculated as 113. During the study period, 127 patients were recruited as per inclusion and exclusion criteria. The data was collected in a pre- approved proforma, which was divided into 4 parts as follows: 1: Pre-anaesthetic check-up details, 2: Pre-operative Pulmonary Function Tests, 3: Intra-operative details, 4: Post-operative details including PFTs and complications.

Study outcomes: Following postoperative pulmonary complications were measured: atelectasis, pneumonia, pulmonary embolism, bronchitis and acute respiratory failure. Diagnosis of PPCs was based on the clinical features and radiological examinations during the postoperative period. Pulmonary function tests were measured by following parameters: Forced vital capacity (FVC), Forced expiratory volume @ 1 second (FEV_1) and FEV_1/FVC using a spirometer during pre-operative check-up and 48 hours after the completion of surgery.

Study plan and procedure

Clinical examination and pre-operative check-up: A day before the surgery, detailed clinical examination of every patient was completed, this was followed by appropriate laboratory and radiological investigations. A team of anaesthesiologists completed the pre-anaesthetic check-up.

Preoperative PFT measurement: The spirometry was conducted under the supervision of a pulmonologist. If the results of the spirometry tests were abnormal requiring medical attention, then such patients were referred to the department of pulmonary medicine for further management.

Intra-operative period: Upon arrival in the operating room, the identity of the participant and the consent were verified again; the preoperative assessment was reviewed and updated.

Various monitors were attached to measure the multiple vital parameters viz. pulse rate, non-invasive blood pressure, pulse oximetry, cardiac rhythm and body temperature during the intra-operative period. Any instance of complication including injury, bleeding, etc., was recorded. Total time for the surgery (skin incision to skin suturing) was noted.

Post-operative period: Predetermined clinical parameters were monitored during the postoperative period until discharge from the hospital. The patient's respiratory conditions were assessed daily including a clinical examination of

pulmonary symptoms like cough, dyspnoea, excessive sputum production, chest pain, wheezing, crackles, and fever > 38.5 C. A chest X-ray was examined by a radiologist.

Post-operative PFT measurement: Similar to the pre-operative period, the PFT was conducted after 48 hrs of surgery under the supervision of the pulmonologist.

Statistical Analysis: All the data were collected in a proforma and thereafter the data was entered into Microsoft excel 2010. Comparison of continuous variables was analysed using a student's t-test. Categorical variables were analysed using chi-square test (χ^2). A P-value < 0.05 was considered statistically significant.

Results

A total of 127 high risk patient participants with COPD were included in the study. Post operatively 86% had no pulmonary complications, 9 (7.1%) had pneumonia and 5 (3.9%) had acute respiratory failure, 2 patients had atelectasis (1.6%) and one patient each (0.9%) had embolism & bronchitis.

Most of the participants in the study were in the age group of 71-80 years. The mean age of the participants with pulmonary complications was 77.3 years and without complications was 71.6 years. Majority of the participants with post-operative pulmonary complications were males (77.8%). Overall majority of the participants were obese (37.8%). Among the participants with complications, most were overweight (44.4%) and while among participants without complications most were obese (39.5%). Overall, only 23.6% patients were in ASA Grade I while among the participants with complications none of them were in ASA Grade I and majority were in ASA Grade III & IV groups (77.2%) (p=0.0494).

Overall, most of the participants had dyspnoea at rest (40%), among the participants with complications most had dyspnoea at exertion (55.6%) (Table 1). Overall, only 33% of the participants were independent and the rest were either partially (37.8%) or completely (29.1%) dependent. Among the participants with post-operative pulmonary complications 16.7% were independent and 83.4% dependent (p=0.0241).

All the participants with post-operative pulmonary complications had history of steroid therapy before surgery and among the participants with no pulmonary complications 69.7% had steroid therapy before surgery (p=0.006). Overall, most of the participants had history of smoking >100 packs/year (27.6%) and also among the participants without complications (30.3%); while among participants with post-operative pulmonary complications most had a history of smoking 51-75 packs/year (38.9%) (Table 2). Distribution of study participants based on PFT revealed that most of the participants had FEV_1: FVC ratio >0.60 (56.7%) pre-operatively while among participants with complications most had the ratio between 0.4-0.5 (p=0.001). The difference between the FEV_1 between the participants who did and did not develop PPC was statistically significant (p=0.0003) (Table 3).

Comparison of pulmonary function tests before and after surgery revealed that mean of FVC, FEV_1 and FEV_1: FVC was reduced post-operatively in comparison to pre-operative values (p=0.002, 0.012, & <0.001 respectively) (Table 4).

Table 1: Descriptive Characteristics of participants (n = 127)

Age (Years)	Pulmonary Complications		p-value
	No, n (%)	**Yes, n (%)**	
Age			
Mean (±SD)	**71.6 (6.75)**	**77.3 (5.59)**	0.008
Range	61 -82	66-84	
Gender			
Female	7 (6.4%)	4 (22.2%)	0.0272
Male	102 (93.6%)	14 (77.8%)	
BMI			
Mean (±SD)	28.1 (3.9)	27.5 (4.9)	0.5302
Range	23.4 – 34.6	21.1 – 31.4	
Obese	43 (39.5%)	5 (27.8%)	
ASA Grade- II			
I	30 (27.5%)	0 (0.0%)	0.0494
II	22 (20.2%)	4 (22.2%)	
III	21 (19.7%)	7 (38.9%)	
IV	36 (33.1%)	7 (38.9%)	
Dyspnoea			
No	33 (30.3%)	0	0.0632
At Exertion	33 (30.3%)	10 (55.6%)	
At Rest	43 (39.5%)	8 (44.4%)	

Table 2: COPD associated factors among participants (n=127)

Factors	PPC		
	No N (%)	**Yes N (%)**	***p*-value**
Functional dependency			
Independent	39 (35.8%)	3 (16.7%)	0.0241
Partially	36 (33.0%)	12 (66.7%)	
Completely	34 (31.2%)	3 (16.7%)	
Steroid therapy			
No	33 (30.9%)	0 (0.0)	0.006
Yes	76 (69.7%)	18 (100.0%)	
Smoking (Pack per year)			
<25	27 (34.8%)	0 (0.0%)	0.0412
25-50	17 (15.6%)	5 (27.8%)	
51-75	21 (19.3%)	7 (38.9%)	
76-100	11 (10.1%)	4 (22.2%)	
>100	33 (30.3%)	2 (11.1%)	

Table 3: Distribution of study participants based on PFT (n=127)

PFT	PPC		p-value
	No	**Yes**	
FVC			
Mean (SD)	3.3 (0.697)	**2.8 (0.61)**	0.0286
Range	2.4 -3.8	2.1 – 3.4	
FEV1			
Mean (SD)	**2.2 (0.59)**	**1.7 (0.51)**	0.0003
Range	1.2 – 2.9	0.98- 2.3	
FEV1: FVC			
Mean (±SD)	0.64 (0.119)	0.50 (0.068)	<0.0001
Range	0.48 – 0.78	0.41 -0.64	

Table 4: Comparison of Pulmonary Function tests before and after surgery

PFT	Pre-operative	Postoperative	*p*-value
FVC			
Mean	3.1	2.8	0.002
Range	2.90 - 3.90	1.7 -3.7	
FEV_1			
Mean	2.1	1.9	0.012
Range	1.1- 2.9	0.9 -2.6	
FEV_1: FVC			
Mean	0.62	0.53	<0.001
Range	0.41 - 0.78	0.33 - 0.71	

Discussion

In both cardiac and non-cardiac surgery, postoperative pulmonary complications (PPCs) constitute the main cause of mortality and raise hospital care costs. PPCs have been associated with more frequent ICU hospitalisations, hospital readmissions, longer postoperative stays and greater expenses. Patients with PPCs have an estimated risk of hospitalisations that varies greatly, ranging from 9.5 to 91% higher, and PPCs can extend ICU stays by up to 72 times [1].

The Postoperative Length of Stay (PLOS) is a common metric for determining the level of morbidity and the financial impact on the healthcare system. PPCs enhance PLOS in noncardiac patients, according to several studies [13]. Improving our understanding of illness severity, prediction and risk stratification can help us better manage these potentially fatal consequences by allowing us to plan appropriate preventive interventions and deliver optimal follow-up treatment. A key objective in this drive is to improve informed consent prior to surgery, direct clinical decision-making during the perioperative period, and gauge the effectiveness and safety of hospital treatment to reliably forecast modifiable PPC risk. In view of this, we carried out this study to observe the incidence of postoperative pulmonary complications among 127 high risk

COPD patients who underwent abdominal surgery at our centre.

In the present study, 127 patients undergoing upper abdominal laparotomy under general anaesthesia were enrolled, out of which 18 patients (14.2%) developed PPC. The most common PPC observed was pneumonia in 9 (7.1%) patients followed by acute respiratory failure, atelectasis, bronchitis and embolism. None of the participants died secondary to PPC or any other complications. In a Brazilian study with 408 patients who underwent upper abdominal surgery, 58 (14%) developed PPCs. Pulmonary infection (pneumonia or tracheobronchitis) accounted for 40 % of the patients with PPCs. Sixty-five percent of these patients developed acute respiratory failure with prolonged intensive care treatment and hospitalization [14]. Several other investigators have reported PPCs in 4-14% patients following different surgeries [15-22].

The main determinants of PPC include age, gender, body mass index, preoperative PFT etc. The mean age of the participants who did not develop PPC was significantly lower in comparison to those who developed PPC (71.6(±6.75) years vs. 77.3(±5.59) years (p=0.008). Similar to our findings, others have also reported that patients who developed PPC were significantly older in comparison to those who did not develop PPC after major surgery [15-18, 23]. Most authors have attributed increased incidence of PPC among elderly to the presence of multiple morbidities. In our study, more than three-fourth of all episodes of PPC were noticed among the male participants (p=0.0272). Similar to our findings, several other studies have also reported that PPCs are more common among male patients [16,17,24,25]. Many authors have attributed this to increased prevalence and severity of smoking among male participants.

The mean BMI of the participants who did and did not develop PPC was not significantly different (p>0.05). This may be due to the fact that the patients in both groups were overweight. Majority of the existing literature suggests that contrary to popular belief, obesity does not appear to increase the risk of pulmonary problems [5,26-30]. For instance, in a case series of patients who underwent gastric bypass surgery- the incidence of pneumonia and atelectasis were similar in the obese and non-obese patients [27]. More recently, no difference was observed in the incidence of pulmonary complications following laparoscopic cholecystectomy between obese and non-obese individuals [31]. In contrast to our findings, Yang et al found that among 165,196 patients who had underwent major abdominal surgery, 9595 patients (5.8%) experienced PPCs. This was probably because there was a statistically significant difference in the BMI of the patients between both the groups [19]. Also, the difference in our findings and that of Yang et al could be attributed to the larger sample size with considerable variation in the BMI of the patients.

All parameters of the PFT were significantly worse among the patients who developed PPC in comparison to those who did not develop PPC. Among the FVC, FEV_1, and FEV_1: FVC ratio; the value of the last parameter i.e., FEV_1: FVC ratio differed most significantly between the patients who developed PPC and who did not develop PPC (p<0.0001). Collectively, the existing literature is divided or does not have clear cut evidence on the utility of the spirometry to predict the occurrence of PPC after surgery. Several other investigators have also looked for importance of preoperative spirometry testing for non-thoracic procedures. In this context, preoperative spirometry test results were useful for predicting the development of postoperative pneumonia in patients who underwent colorectal surgery [32], as well as predicting PPC occurrence in obese individuals following bariatric surgery [33]. Further, it was observed that preoperative lower FVC was associated with increased occurrence of PPCs after laparoscopic abdominal surgery, while FEV_1 and FEV_1/FVC were not [15]. On the contrary, some investigators showed that preoperative spirometry measurements could not be utilised to stratify the risk of PPC in elderly patients having laparoscopic gastrectomy [34].

Preoperative spirometry provides the benefit of detecting previously undiscovered lung illness, but routine preoperative examinations are not advised for patients undergoing non-thoracic surgery, with the exception of those who have preoperative asthma or COPD. Following this recommendation, only patients who were old (>60 years), current smokers, and those with a history of chronic pulmonary disease—all of whom were comparatively more susceptible to PPCs—were subjected to preoperative spirometry testing [35-37].

These conflicting findings may be explained by the fact that PPC is affected by a variety of factors, such as the type of surgery (laparotomy vs. laparoscopy), the surgical site (upper or lower abdomen), the intraoperative ventilator care strategy, the postoperative lung care strategy, and other patient characteristics. Therefore, a more categorical criterion than that provided by the existing guidelines must be used to assess if preoperative spirometry is necessary. The results of our study largely demonstrated that patients undergoing laparoscopic abdominal surgery who were already at high preoperative risk for these complications had lower FVC% was related with a greater likelihood of PPC development. More in-

depth population-based studies should be conducted in order to determine this demand.

Conclusions

Adverse events involving respiratory system were the most common type of complications observed during the postoperative period. In the present study, most episodes of postoperative pulmonary complications were seen among the patients having severe or advanced disease of the lung. Most of the high-risk patients with increased likelihood of developing pulmonary complications during postoperative period could be identified/ screened preoperatively using spirometry. Lastly, major abdominal surgery causes significant decline in the pulmonary function indices.

Acknowledgement: The authors are thankful to the Dean, JK Hospital & LN Medical College, Bhopal, Madhya Pradesh, India for providing facilities and permission to perform this study at this Institute.

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