Section: Pulmonary Medicine

Original Research Article

A STUDY ON PRE-OPERATIVE SPIROMETRY AND ITS EFFECTS ON POST-OPERATIVE PULMONARY COMPLICATIONS FOLLOWING THORACIC SURGERIES

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Abstract

Background: Postoperative pulmonary complications (POPCs) account for a substantial proportion of risk related to surgery and anesthesia and are a major cause of postoperative morbidity, mortality, and longer hospital stays. It incorporates a wide spectrum of processes such as pneumonia, atelectasis, respiratory failure, pulmonary embolism, pleural effusion, pneumothorax and pulmonary oedema. This is to study on pre-operative spirometry and its effects on post-operative pulmonary complications following thoracic surgeries. **Materials and Methods:** This Hospital based Prospective Observational Study was conducted at the Department of Pulmonary Medicine and Department of Cardio- Thoracic Surgery in Victoria Hospital, Bangalore Medical College and Research Institute (BMCRI). **Result:** The most common early complication was respiratory failure, seen in 8.9% of patients (n=7). Most common late complication was persistent air leak, which was seen in 8.9% of patients (n=7), which persisted for at least 2 weeks during their hospital stay. The following factors were statistically significant in patients who developed postoperative pulmonary complications, a. Low spirometric measures such as: I. Lower FEV1 (Mean = 1.12±0.42 L, p = <0.001), II. FEV1% < 80% (Mean = 56.63±19.34 %, p = <0.001), III. Lower FVC (Mean = 1.28±0.43 L, p= <0.001), IV. FVC% < 80% (Mean = 50.06±17, p = <0.001), b. Low % predicted 6-minute walk distance (Mean = 67.56±3.6 %, p = <0.001), c. Higher ARISCAT scores (Mean = 55.88±11.15, p = 0.011). **Conclusion:** In our study, Multiple factors, which mainly, Low spirometric measures such as: Lower FEV1, FEV1% < 80%, Lower FVC and FVC% < 80%, Low % predicted Six-minute walk distance and higher ARISCAT score are statistically significant in the development of POPCs.

INTRODUCTION

Pulmonary complications are a major cause of morbidity and mortality during the post-operative period following thoracic surgeries. Estimates of overall surgical mortality for pulmonary resection range in large series from 2% - 4%. The morbidity associated with pulmonary resections is also very high. Complications have been reported to occur in 36% - 75% of patients undergoing pneumonectomy and 41% - 50% after lobectomy.[1] A number of factors have been identified with the development of complications – including pre- operative factors such as chronic lung disease, smoking, general state of health, age, obesity, nutritional status, antecedent respiratory tract infections; intra-operative risk factors such as the type of procedure, type and duration of anaesthesia, location of the surgical site and type of surgical incision ; post-operative factors such as inadequate pain control and immobilization. Knowledge about the utility of preoperative assessment of the lung resection candidate was first developed in the 1950s.[2] Early methods of evaluating risk included the measurement of bellows function of the lungs such as maximum voluntary ventilation and Functional Residual Capacity.[3,4] Air flow parameters that are useful include FEV1 and forced expiratory flow rate in the middle 50% of the forced expiratory flow curve.[5] Further refinement of these measurements has included expressing them as a percentage of predicted based on patient age, sex,and height.[6] The calculation of postoperative

predicted values for both spirometric raw numbers and percentage of predicted values has further increased the accuracy of spirometry as a preoperative tool for evaluating pulmonary risk preoperatively.[7,8] This calculation is usually performed by estimating the number of functional lung segments that will remain postoperatively. Quantitative ventilation perfusion scans used to assess regional lung function have aided considerably in the calculation of predicted postoperative spirometric function in patients who are considered borderline candidates for operation based on standard techniques.[9,10] In addition to these standard methods, other measures of gas exchange and oxygen consumption have also proved useful in the preoperative assessment of risk. These include clinical assessments such as the 6-minute walk distance and stair climbing effort and laboratory measures of exercise capacity such as maximum oxygen consumption during exercise (V˙o2max).[11,12] All have shown some promise in the prediction of postoperative pulmonary complications and, in some settings, postoperative mortality. Measurement of gas exchange capacity using diffusing capacity of the lung for carbon monoxide (DLCO) has proved to be an independent and useful means of estimating operative risk for patients undergoing major lung resection. Preoperative raw values or values expressed as a percent of predicted (DLCO%)as well as calculated postoperative values expressed as a percent of predicted function have all been shown to be useful, although the best value to use is the calculated postoperative DLCO expressed as a percent of predicted (ppoDLCO%).[13,14,15] Also, there have been multiple predictive models such as ARISCAT, Arozullah Score, EVADS score, ESSS.01, ESOS.01 VANSIQP score , Thoracoscore, CPRI and many other scoring systems which have been used to identify the patients with increased risk of major morbidity or morality following surgeries. A high index of suspicion, early recognition and prompt treatment are needed to minimize such complications. As there are limited number of studies regarding the post-operative pulmonary complications especially following thoracic surgeries in India, this study is intended to study on pre-operative spirometry and its effects on post-operative pulmonary complications following thoracic surgeries.

MATERIALS AND METHODS

This Hospital based Prospective Observational Study was conducted at the Department of Pulmonary Medicine and Department of Cardio- Thoracic Surgery in Victoria Hospital, Bangalore Medical College and Research Institute (BMCRI). 78 patients who underwent elective Thoracic surgeries in the Department of Cardio-Thoracic Surgery in Victoria Hospital, Bangalore Medical College and Research Institute (BMCRI), Bangalore, were enrolled for the study. Duration of study was 18 months.

Inclusion Criteria

1. Age more than 18 years.
2. Patients willing to give written informed consent in their own understandable language.
3. Patients undergoing elective Thoracic Surgeries after pre-operative evaluation.
4. Patients undergoing elective Thoracic Surgeries under General, Neuraxial, Regional Anaesthesia.

Exclusion Criteria

1. Patients undergoing emergency thoracic surgeries.
2. Patients who required pre-operative endotracheal intubation.
3. Outpatient procedures, defined as those requiring less than 1-day stay for a patient alive at discharge.
4. Procedures where only Local, Peripheral nerve anaesthesia are used.
5. Patients requiring repeat or undergoing second thoracic surgery.
5. Patients not willing to give written informed consent.

Patients who underwent elective thoracic surgeries, meeting the inclusion criteria were enrolled after taking a written informed consent and then they were assessed a day before surgery and monitored for seven days after surgery.

Pre-operatively patients were assessed by:

- Demographic data
- Brief Clinical history
- Smoking History
- ARISCAT Score (Assess Respiratory Risk in Surgical patients in CATalonia Score)
- Spirometeric tests were performed by Spirotech (Vitalograph) device in sitting position. Spirometry was performed as per ATS guidelines for spirometry. Forced vital capacity (FVC), FVC%, Forced expiratory volume during the first second of FVC (FEV1), FEV1%, FEV1/FVC were recorded.

Intra-operative factors that were considered were –

- Type of Procedure
- Type of Anaesthesia
- Duration of Surgery
- Need for Blood transfusion
- Need for Post-Operative Non-invasive ventilation or Invasive mechanical ventilation.

Post-operatively patients were monitored for a period of 7 days following surgery by Clinical examination, Chest radiography and Blood tests as needed. Complications were defined as per the EPCO and other guidelines for Postoperative pulmonary complications as mentioned below.

Complications were classified as:

- Immediate (0-6hours),
- Early (6-72 hours),
- Late (>72 hours) complications.

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Statistical Analysis: All the data were collected and systematically entered in MS Excel spread sheet and data analysis was done using SPSS software version 22. The data collected was statistically analyzed using descriptive statistics namely, mean, standard deviations and percentage, wherever applicable. Chi Square test and Student's t test were applied to determine significant difference between two groups. The values obtained were considered significant if, p value <0. 05.

RESULTS

There were no statistically significant differences in the occurrence of Post-operative pulmonary complications on the basis of gender or demographic basis. Majority of the patients were of the age group between 21-50 years. 6.4% (n=5) of patients were less than 20 years of age, 23% (n=18) of patients were between 21-30 years, 23% (n=18) of patients were aged 31-40 years, 23% (n=18) of patients were of the 41-50-year age group and 10.2% (n= 8) of patients were above 60 years of age. However, there were no statistically significant differences in the occurrence of Post-Operative Pulmonary com various age groups (Chi-Square Test; p=0.034). Mean Pre-operative SpO2 at the time of evaluation were significantly lower in patients of 'Complications' group than 'No complications' group (Mean SpO2 = 94.94±3.34 %). Patients who developed POPCs had a higher Mean Pulse rate than those patients in 'No complications' group (Mean PR = 107.06±20.5 bpm). Also, in our study we noted a statistically lower pre- operative systolic blood pressures (SBP Mean: 109.63±11.3 mmHg) in patients who developed complications post-operatively. These variables were statistically significant and associated with higher risk of development of POPCs.

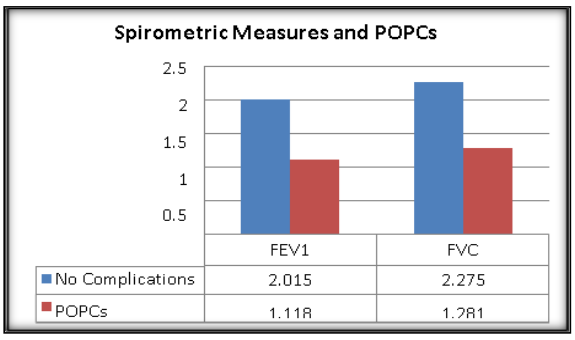

Figure 1: Pulmonary Function Tests and POPCs

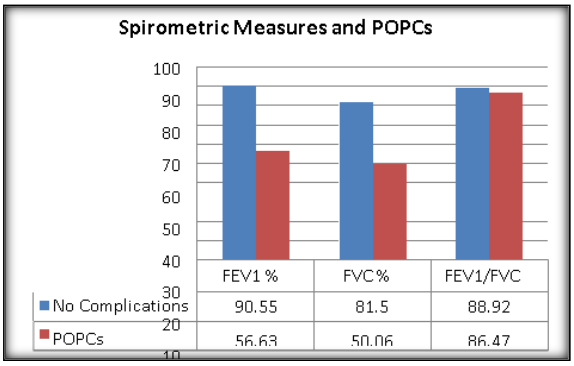

Figure 2: Pulmonary Function Tests and POPCs

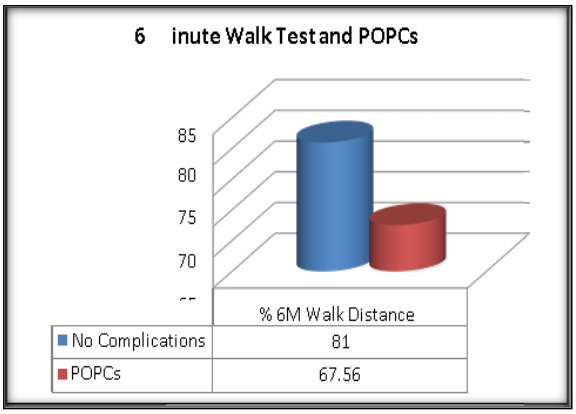

Figure 3: 6 Minute walk test and POPCs

All patients were able to complete 6 Minute walk test. Among them 1 patient had Significant desaturation (>4%) who developed POPC. % Predicted 6-minute walk distance was significantly lower in those with POPCs than in 'No complications' group. ABG parameters like pH, pCO2, pO2 and HCO3- were not significantly different among two groups.

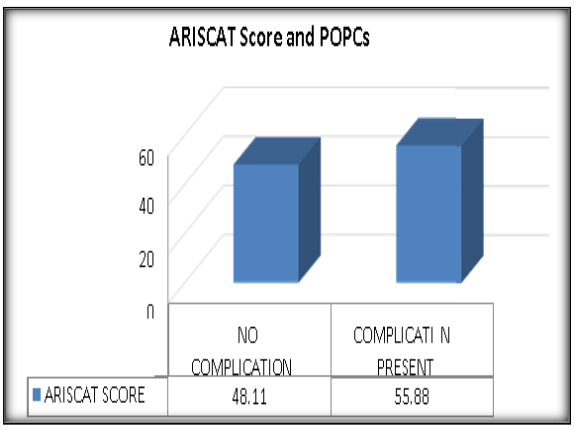

Figure 4: ARISCAT score and POPCs

ARISCAT score was significantly higher in patients with POPCs (Mean: 55.88±11.15) than in those with 'No complications' (Mean: 48.11±10.54). 2 patients with ARISCAT Moderate risk had POPC and 14 patients with ARISCAT high risk developed POPCs.

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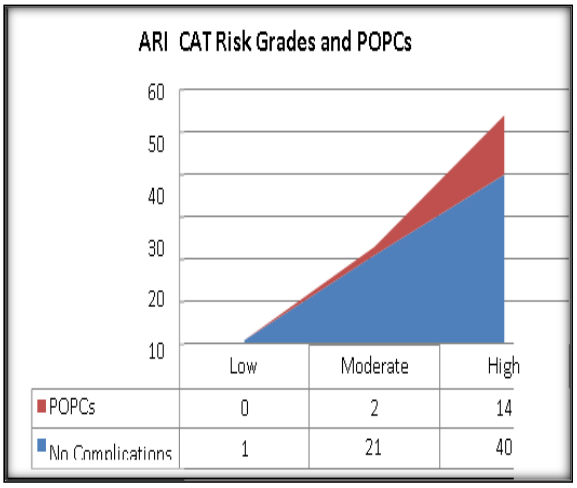

Figure 5: ARISCAT Risk Grades and POPCs

Table 1: Pulmonary Function Tests and POPCs.

Pulmonary Function Tests and POPCs	No Complication(n=62)	Complication Present(n=16)	t	p value
Independent 't' Test	**Mean ± SD**	**Mean ± SD**		
Spirometry				
FEV1	2.02±0.51	1.12±0.42	6.474	<0.001
FEV1%	90.55±19.46	56.63±19.34	6.224	<0.001
FVC	2.28±0.6	1.28±0.43	6.176	<0.001
FVC%	81.5±17.16	50.06±17	6.547	<0.001
FEV1/FVC	88.92±8.48	86.47±11.24	0.813	0.426
6 Minute Walk Test				
6MWT % predicted	81±7.98	67.56±3.6	9.918	<0.001
Arterial Blood Gas Analysis				
pH	7.36±0.38	7.4±0.05	-0.482	0.631
pCO2	42.02±4.07	42.18±6	-0.124	0.902
pO2	99.96±27.11	110.15±34.71	-1.263	0.21
HCO3-	23.06±1.74	22.84±1.83	0.448	0.656
ARISCAT SCORE				
ARISCAT Score	48.11±10.54	55.88±11.15	-2.596	0.011

34 patients had a FEV1% of less than 80% of which 15 patients had POPCs (p=<0.001), 43 Patients had a FVC% of less than 80% of which 15 patients had POPCs (p=<0.001). The Mean value of FEV1 in patients who developed POPCs was 1.12±0.42 L, which was lower than the 'No complications' group. Mean FEV1 % was 56.63±19.34 %, Mean FVC was 1.28±0.43 L, Mean FVC% was 50.06±17 % and FEV1/FVC ratio was 86.47±11.24, all of which were lower in patients who developed complications post-operatively compared to 'No complication group'. Spirometric values such as FEV1, FEV1%, FVC, FVC% were observed to be significantly lower in patients who developed complications postoperatively. However, no statistically significant difference in FEV1/FVC was observed in patients who developed POPCs and 'No complications' group.

DISCUSSION

The incidence of POPCs following surgeries vary greatly and depends on the type of surgery, type of anesthesia and many other pre-operative; intra-operative and post-operative factors. POPCs have been noted to be the highest following thoracic and upper abdominal surgeries. The definition and criteria for POPCs vary widely between studies. Also, many of the identified risk factors for POPCs are interrelated which has made it difficult to define individually.

In our study, postoperative pulmonary complications were seen in 16 patients (20.5%). The most common early complication was Respiratory failure, seen in 8.9% (n=7) patients. Most common late complication was Persistent Air leak, which was seen in 8.9% of patients (n=7).

Studies by Deslauriers et al and Abolhoda et al have reported an incidence of Acute postoperative respiratory failure between 2.4% and 17% with a mean incidence rate estimate of 9.0%; The possible explanation for the development of Respiratory failure may be due to the notable depression of central respiratory drive, and diminution of compensatory responses to hypoxia and hypercarbia. Respiratory muscle tone is also altered, precipitating anatomic airway obstruction. Functional residual capacity is diminished, the diaphragm is displaced, and many patients develop postoperative atelectasis which contributes to the development of Respiratory failure. Functional residual capacity reaches its nadir at 1 to 2 days postoperatively and can remain diminished for upto 5 to 7 days afterwards.[16,17] Studies by Nieuwenhuijs et al have suggested that

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normalization of respiratory physiology could take up to 6 weeks.[18] Gupta H et al, suggested that the type of surgery, emergency case , dependent functional status , sepsis and higher ASA class were associated with increased risk of Postoperative respiratory failure.[19] According to Kelkar K V et al, interventions such as such as oxygen therapy, minimally invasive surgery, regional anesthesia, adequate analgesia , protective ventilator strategies, usage of Nasogastric feeding techniques, early ambulation are protective measures to prevent serious postoperative acute lung injury.[20] In our study postoperative respiratory failure was seen in 8.97% (n=7) of patients and there were no mortality in the postoperative period due to respiratory failure.

According to Mueller et al, Persistent air leaks are the most prevalent postoperative complication with a reported occurrence of 18-26%.[21] PAL is the most important determinant of length of postoperative hospital stay. The consequences of development of PAL are manifold and include:

- Prolonged chest tube drainage causes prolonged pain
- Restricted ventilation leads to increased risk of pneumonia
- Decreased ambulation due to presence of chest tubes and related pain
- Decreased mobility results in increased risk of thromboembolism
- Necessity of pleurodesis, mechanical ventilation, and reoperation
- Higher readmission rate to intensive care units
- Prolonged hospital stay

In 2010, Brunelli et al published a paper with a scoring system for prediction of Air leaks based on the analysis of 658 patients undergoing lobectomies between 2000 and 2008 without the use of sealants, pleural tent, or buttressing material. Potential predictors were identified by univariate analysis and subjected to stepwise logistic regression analysis to generate a scoring system.[22]

The set of potential predictive variables and their scores were:

- Age greater than 65 years, 1.0 point;
- Presence of pleural adhesions, 1.0 point;
- FEV1 less than 80%, 1.5 points;
- Body mass index less than 25.5 kg/m2, 2.0 points.

In their study, these four risk classes according to their aggregate scores were significantly associated with incremental risk of PAL.

In our study, the most common late complication was Persistent air leak and 8.97% (n=7) of patients had persistent air leak following thoracic surgeries. It was observed in patients for more than 2 weeks post-operatively during their hospital stay.

Other complications were: Hematoma (n=1), Hemorrhage (n=1), Pneumonia (n=1), ARDS (n=1), Empyema (n=2), Pulmonary edema (n=1) and post-operative wound infection (n=1). However, there were no mortality among the 78 patients who underwent thoracic surgeries in our study.

Patients who developed POPCs had the following characteristics:

1. Smokers who quit smoking within 8 weeks of surgery (p = 0.003)
2. Lower Pre-operative SpO2 (Mean = 94.94±3.34 %, p= 0.023)
3. Lower Spirometric measures such as:

a. Lower FEV1 (Mean = 1.12±0.42 L, p = <0.001)
b. FEV1% < 80% (Mean = 56.63±19.34 %, p = <0.001)
c. Lower FVC (Mean = 1.28±0.43 L, p= <0.001)
d. FVC% < 80% (Mean = 50.06±17, p = <0.001)

4. Low % predicted 6-minute walk distance (Mean = 67.56±3.6 %, p = <0.001)
5. Higher ARISCAT scores (Mean = 55.88±11.15, p = 0.011)

Spirometry is a universal, simple, and non-invasive pulmonary function test. Spirometry, along with calculation of the forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC), is helpful for diagnosing obstructive or restrictive ventilatory defects.

Therefore, preoperative spirometry results are used for predicting the occurrence of POPCs, especially in thoracic surgery patients. Stein et al published a prospective study and found that the incidence of pulmonary complications was higher in patients with abnormal preoperative spirometry (70%) than in patients with normal spirometry (3%).[23]

Latimer et al and Collins et al found abnormal spirometry (FEV1 and FVC) to be a good predictor of POPC after surgery. [24] Grover et al reported an operative mortality of 11.7% for patients with an FEV1 of less than 1.25 1ts compared with 3.8% for those with an FEV1 of greater than 1.25 lts in cardiac surgery practice.[25] Kroenke et al,[26] and Fuso et al,[27] supports the concept that abnormal lung function may be associated with higher incidence of POPC. Similar results were seen in our study where, patients who developed POPC had a lower Spirometric values than 'No complications' group. FEV1 (Mean = 1.12±0.42 L, p = <0.001), FEV1% < 80% (Mean = 56.63±19.34 %, p = <0.001), FVC (Mean = 1.28±0.43 L, p= <0.001), FVC% < 80% (Mean = 50.06±17, p = <0.001) were found to be significantly lower in patients who developed POPCs. However, there were no statistically significant differences in FEV1/FVC ratio among POPC group and 'No complications' group.

The six-minute walk test (6MWT) is a simple and valid test for assessing cardiopulmonary fitness. In a study by Ramos et al., Preoperative 6MWT distance had a modest association with moderate or severe complications after inpatient non-cardiac surgery. In our study, it was found that pre-operative % predicted 6 minute walk distance was significantly lower in patients who developed POPCs (Mean %6MWD = 67.56±3.6 %, p = <0.001).[28]

The Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) is a commonly used model for

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predicting POPCs and was validated by 'Prospective Evaluation of a Risk Score for Postoperative Pulmonary Complications in Europe' - Periscope trial. In our study, higher ARISCAT score were noted in patients who developed POPCs than in the 'No complications' group, confirming the utility of ARISCAT score as a useful predictive score for the development of POPCs (Mean = 55.88±11.15, p = 0.011).[29]

Results from this study agree with this thought. Findings from our study shows that patients who developed pulmonary complications postoperatively had abnormal preoperative spirometry, quit smoking within 8 weeks of surgery, Low preoperative SpO2, Preoperative Tachycardia, Low Preoperative SBP, ASA class > II, Low % predicted six-minute walk distance and higher ARISCAT score.

CONCLUSION

The most common early complication was postoperative respiratory failure seen in 8.9% (n=7), and the most common late complication was persistent air leak seen in 8.9% (n=7). Other complications were: Hematoma (n=1), Hemorrhage (n=1), Pneumonia (n=1), ARDS (n=1), Empyema (n=2), Pulmonary edema (n=1) and post-operative wound infection (n=1).

The following factors were statistically significant among patients who developed complications postoperatively following thoracic surgeries:

a. Low spirometric measures such as:
I. Lower FEV1 (Mean = 1.12±0.42 L, p = <0.001)
II. FEV1% < 80% (Mean = 56.63±19.34 %, p = <0.001)
III. Lower FVC (Mean = 1.28±0.43 L, p= <0.001)
IV. FVC% < 80% (Mean = 50.06±17, p = <0.001)
b. Low % predicted 6-minute walk distance (Mean = 67.56±3.6 %, p = <0.001)
c. Higher ARISCAT scores (Mean = 55.88±11.15, p = 0.011)

We conclude in our study that Multiple factors, which include Low spirometric measures, Low % predicted Six-minute walk distance and higher ARISCAT score are statistically significant in the development of POPCs.

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