

## Original Research Article

# Comparative efficacy of different modules on pulmonary functions after lung resection

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## ABSTRACT

**Background:** Lung resection in patients with lung cancer and inflammatory lung pathology, not only improves the symptoms but also long-term survival. The aim of this study was to compare the effect of conventional chest physiotherapy, continuous positive airway pressure (CPAP) and incentive spirometry (IS) after lung resection on pulmonary function tests and postoperative pulmonary complications.

**Methods:** A prospective, randomized, case control study was conducted in a tertiary care teaching hospital. Thirty patients were included, who underwent lung resection. Detailed clinical history, examination and appropriate investigations were done. Patients were randomized into three groups, and accordingly postoperative incentive spirometry with physiotherapy, CPAP with physiotherapy and physiotherapy alone was given. All the groups were compared pre-and postoperatively for pulmonary functions and complications.

**Results:** Majority males (90%) patients of 40-60 years. Significant difference was present in FEV1/FVC on post-OP day one and day twenty-eight only ( $p < 0.05$ ). FVC in all three groups declined most significantly on first postoperative day and then consistently increased till 28<sup>th</sup> day. Group II and III patients showed a significant difference in increase in FVC between 8<sup>th</sup> and 28<sup>th</sup> postoperative day. In group, I maximum increase in FEV1 occurred till day 8<sup>th</sup>, whereas in group II and III significant difference was still present on day 28<sup>th</sup>. There was no significant difference between the three groups with regard to FVC, FEV1 and FEV1/FVC. No significant difference in pH value while pO<sub>2</sub> showed a marked decrease on first post-op day in all groups. Incidence of atelectasis was found to be highest in group I (5 out of 11).

**Conclusions:** As incentive spirometry offered no advantage over chest physiotherapy but does involve the added expense of spirometer, a vigorous chest physiotherapy requires no special equipment and can be delivered by less trained personnel, chest physiotherapy is more economic.

**Keywords:** Conventional chest physiotherapy, CPAP, Incentive spirometry, Lung resection, Pulmonary function

## INTRODUCTION

Lung resection in patients with lung cancer and inflammatory lung pathology, not only improves the symptoms but also long-term survival. However, these patients have frequent co-existent chronic airflow limitation which increases the risk of surgery because

removal of lung tissue may grossly impair postoperative ventilatory function. Following lung resection, pulmonary changes may lead to hypoxemia, atelectasis, and pneumonia and occasionally to respiratory failure. In such patients physiotherapy is used with or without mechanical aids to increase lung volume for better oxygenation and reduced postoperative complications.

Incentive spirometry is a popular maneuver and used extensively as it encourages deep breathing and needs minimal supervision, an important nursing consideration. Similarly, continuous positive pressure ventilation is also used to reduce the incidence of postoperative pulmonary complication, although the technique involved is more complex and labour intensive. Though a number of publications suggest that the use of incentive spirometry and CPAP is beneficial their true value over conventional post-operative physiotherapy has not been adequately studied, especially in the context of thoracic surgical patients.<sup>1-3</sup>

It is important to answer this question because the addition of incentive spirometry and CPAP in the postoperative period needs access to additional equipment and may be expensive and make extra demands on nursing time.

This study aims to compare the effect of conventional chest physiotherapy, continuous positive airway pressure (CPAP) and incentive spirometry after lung resection on pulmonary function tests and postoperative pulmonary complications so as to elucidate the true value of these maneuvers on outcome after pulmonary resection.

## METHODS

A prospective, randomized, case control study was conducted in an apex tertiary care teaching hospital. The study included 30 patients, who underwent lung resection for various lung pathologies. A written informed consent was taken from all the patients. Ethical clearance was obtained from the Institutional Ethics Committee for the conduction of study.

**Randomization:** Randomization was done by computer generated table of random numbers.

**Blinding:** Radiologist and anesthetist participating in the study were blinded to treatment group and preoperative pulmonary functions respectively.

### Inclusion criteria

All patients admitted under Surgery unit for lung resection, irrespective of age, sex and pathology were included in the study.

### Exclusion criteria

The only exclusion criterion was inability to obtain written informed consent.

**Preoperative assessment:** A detailed clinical history was taken and examination was done including general examination, examination of CNS, CVS, per-abdominal examination and detailed examination of respiratory system. Appropriate investigations were done including Chest X-ray, CECT chest, Fiberoptic bronchoscopy and

CT or ultrasound guided FNAC for confirmation of diagnosis.

**Preoperative preparation:** All patients underwent pulmonary function assessment by pulmonary function test (by spirometry) and arterial blood gas analysis and whenever required, technetium 99 m MAA Perfusion scan for borderline pulmonary functions. Patients were prepared well by deep breathing exercises and nebulization to improve the preoperative respiratory status of the patients.

**Randomization and grouping:** Patients were randomized into three groups and were educated about the incentive spirometry, CPAP, physiotherapy, deep breathing, coughing, and huffing according to their respective group.

**Treatment group 1:** Randomized to incentive spirometry and conventional physiotherapy. They were instructed regarding use of incentive spirometer preoperatively and treatment was given every hour postoperatively for 30 deep breaths for consecutive three days during awake hours.

**Treatment group 2:** Randomized to CPAP and conventional physiotherapy. They were educated regarding CPAP and received periodic continuous positive airway pressure by face mask for one hour in immediate postoperative period and then for 6 cycles of 30 minutes (total 3 hours per day) for the first three postoperative days.

**Control group 3:** This group received physiotherapy alone

- Deep breathing Exercises: 30 deep breaths once every hour during awake hours
- Chest physiotherapy: everyone to two hours
- Coughing and Huffing

Patients in all groups received conventional physiotherapy and oxygen by base mask for first three days after surgery and if required later also.

### Postoperative assessment

- Pulmonary function tests were done on days 1,3,5,8 and 4 weeks postoperatively
- Daily postoperative arterial blood gases and oxygen saturation measurement was done
- Daily postoperative chest X-rays were done. Any evidence of atelectasis and consolidation was noted and its incidence in all the three groups was compared
- If suspected to have developed pneumonia, sputum for culture sensitivity was sent for documentation and appropriate antibiotics were used when indicated.

### Criteria for defining postoperative pulmonary complications

- Radiologic evidence of atelectasis, alveolar infiltrates
- Basal rales, tubular breathing by auscultation
- Evidence of elevation of body temperature above 38.5°C and increased WBC count greater than 15000/cmm associated with minimal symptoms in the absence of any other cause
- Need for admission to ICU for management of pulmonary complications
- Duration of hospitalization.

### Data collection and analysis

Data was collected in a proforma for every patient with regard to pulmonary pathology, type of pulmonary resection, preoperative pulmonary function tests, ABG analysis and post-operative values of PFT, chest X-rays. Data were analyzed using software package (SPSS 101).

### Evaluation of treatment

- Comparison of PFTs between three groups
- Comparison of incidence of atelectasis as evidenced by daily chest X-rays between three groups
- Comparison of arterial blood gases.

## RESULTS

The study included 30 patients with various pulmonary pathologies, who were planned for lung resection surgery. Age of the included patients ranged from 14 to 74 years. Majority of patients were in age group of 40-60 years. Majority of patients (90%) were males.

**Table 1: Types of surgeries.**

Operation	Total	Group I	Group II	Group III
Right upper lobectomy	7	2	3	2
Right lower lobectomy	7	1	2	4
Left upper lobectomy	6	2	2	2
Left lower Lobectomy	4	2	1	1
Right middle Lobectomy	1	0	1	1
Right lower + middle Lobectomy	3	2	1	0
Right Metastasectomy + left lower Lobectomy	2	1	0	1
Total	30	10	10	10

### Surgery

All patients included in the study underwent Lobectomy, Bilobectomy or combination of Metastasectomy and lobectomy by standard posterolateral Thoractomy incision (Table 1). Majority of patients had lung cancer, either primary (more common) or metastatic (Table 2).

### Inter-group comparison of preoperative and postoperative characteristics

Individual characteristics of all three groups were compared and ANOVA was applied after calculating mean and standard deviation of each variable in all the three groups.

There was no significant difference among three groups in any of the preoperative characteristics shown above except for the pCO<sub>2</sub> which was on higher side in group II and group III. So, preoperatively all the three groups were comparable (Table 3).

**Table 2: Histopathological diagnosis.**

Histopathology	Total	Group I	Group II	Group III
<b>Benign:</b>	10	4	3	5
Aspergilloma	1	0	1	0
Bronchiectasis	3	0	1	2
Tuberculosis	3	2	1	2
Hydatid cyst	3	2	0	1
<b>Malignant</b>	20	8	7	5
Carcinoid	2	1	1	0
Metastasis	3	1	0	2
Carcinoma	15	6	6	3

Significant difference was present in ratio of FEV1 to FVC on post-OP day one and day twenty-eight only. To know further difference for above three significantly different variables, Bonferroni test was applied, and it was found that pre-op pCO<sub>2</sub> was significantly different, was lower in group I as compared to group II and III (Table 3).

### Intra-group and intergroup comparison of preoperative and postoperative PFTs

The preoperative and postoperative PFTs were compared within a group as well as in between groups to know whether the changes within a group are similar to each other or different to changes in other groups. FVC in all three groups declined most significantly on first postoperative day and then consistently increased till 28<sup>th</sup> day. Postoperative day 3 onwards, group I patients showed no further significant increase whereas significant increase still occurred in group II and III.

**Table 3: Inter-group comparison of preoperative and postoperative characteristics.**

Characteristic	Group I Mean±SD	Group II Mean±SD	Group III Mean±SD	P Value (<.05, Significant)
Age	48.3±18	47±17	42±18	>0.05
Sex M/F	9/1	8/2	10/0	>0.05
<b>Preoperative PFT</b>				
FEV1	3.21±0.57	3.35±1.13	3.77±0.93	>0.05
FEV1	2.40±0.86	2.59±0.99	3.09±1.00	>0.05
FEV1/FVC	72.98±15.13	77.25±13.72	81.25±9.39	>0.05
<b>Preoperative ABG</b>				
pH	7.395±0.047	7.370±0.037	7.376±0.050	>0.05
pO <sub>2</sub>	97.00±10.58	90.62±11.93	88.14±9.67	>0.05
pCO <sub>2</sub>	31.53±8.537	38.77±1.83	39.97±5.15	<0.05*
O <sub>2</sub> Sat.	97.65±1.57	96.03±1.68	96.36±1.87	>0.05
<b>Postoperative PFT</b>				
Day1	FVC	1.61±0.388	1.61±0.49	>0.05
	FEV1	1.04±0.32	1.18±0.42	>0.05
	FEV1/FVC	64.22±11.30	70.37±8.79	<0.05*
<b>Postoperative PFT</b>				
Day3	FVC	2.08±0.50	2.16±0.65	>0.05
	FEV1	1.34±0.37	1.50±0.54	>0.05
	FEV1/FVC	67.62±13.13	67.80±11.01	>0.05
<b>Postoperative PFT</b>				
Day5	FVC	2.15±0.38	2.32±0.75	>0.05
	FEV1	1.47±0.42	1.69±0.67	>0.05
	FEV1/FVC	67.69±11.74	70.04±11.24	>0.05
<b>Postoperative PFT</b>				
Day8	FVC	2.41±0.43	2.50±0.82	>0.05
	FEV1	1.69±0.57	1.81±0.67	>0.05
	FEV1/FVC	68.69±11.74	72.40±10.14	>0.05
<b>Postoperative PFT</b>				
Day28	FVC	2.52±0.60	2.76±0.89	>0.05
	FEV1	1.92±0.43	2.13±0.76	>0.05
	FEV1/FVC	68.58±8.70	76.66±8.27	<0.05*
<b>Postoperative ABG</b>				
Day 1	pH	7.382±0.33	7.370±0.33	>0.05
	PO <sub>2</sub>	78.77±9.71	75.53±4.89	>0.05
	PCO <sub>2</sub>	37.47±4.77	39.55±1.79	>0.05
	O <sub>2</sub> Sat.	94.66±1.58	94.46±7.36	>0.05
<b>Postoperative ABG</b>				
Day 2	pH	7.364±0.039	7.367±0.034	>0.05
	PO <sub>2</sub>	79.15±6.8	77.62±4.98	>0.05
	PCO <sub>2</sub>	37.89±5.33	38.91±2.17	>0.05
	O <sub>2</sub> Sat.	93.9±1.31	94.28±1.68	>0.05
<b>Postoperative ABG</b>				
Day 3	pH	7.377±0.029	7.350±0.37	>0.05
	PO <sub>2</sub>	80.27±8.16	76.22±4.57	>0.05
	PCO <sub>2</sub>	37.58±3.59	38.74±3.67	>0.05
	O <sub>2</sub> Sat.	93.9±0.76	93.53±1.56	>0.05
<b>Postoperative ABG</b>				
Day 4	pH	7.367±0.031	7.356±0.021	>0.05
	PO <sub>2</sub>	82.31±8.64	82.62±7.33	>0.05
	PCO <sub>2</sub>	37.37±3.79	37.13±3.25	>0.05
	O <sub>2</sub> Sat.	94.30±1.60	94.70±1.30	>0.05

**Table 4: Comparison of Pre-and Postoperative PFTs.**

Group	Preop PFT	Postop PFT Day 1	Postop PFT Day 3	Postop PFT Day 5	Postop PFT Day 8	Postop PFT Day 28
<b>Group I</b>						
FVC	3.21±0.57	1.61±0.38	2.08±0.50	2.15±0.38	2.41±0.43	2.52±0.60
FEV1	2.40±0.86	1.04±0.32	1.34±0.37	1.47±0.42	1.69±0.57	1.92±0.43
FEV1/FVC	72.98±15.13	64.22±11.30	67.62±13.13	67.69±11.74	68.69±11.74	68.58±8.70
<b>Group II</b>						
FVC	3.35±1.13	1.66±0.49	2.16±0.65	2.32±0.75	2.50±0.82	2.76±0.89
FEV1	2.59±0.99	1.18±0.42	1.50±0.54	1.69±0.67	1.81±0.67	2.13±0.76
FEV1/FVC	77.25±13.72	70.37±8.79	67.80±11.01	72.04±11.24	72.40±10.14	76.66±8.27
<b>Group III</b>						
FVC	3.77±0.93	1.74±0.49	2.17±0.49	2.37±0.69	2.56±0.70	2.94±0.89
FEV1	3.09±1.00	1.39±0.47	1.61±0.46	1.87±0.60	2.01±0.63	2.32±0.66
FEV1/FVC	81.25±9.39	77.39±11.10	73.65±9.96	78.33±600.40	79.53±11.71	79.91±9.12

But in all the groups maximum increase occurred on day 3 and in group III, the increase between day 3 and day 5 was not significant. Group II and group III patients showed a significant difference in increase between 8th and 28<sup>th</sup> postoperative day also (Table 4). Forced expiratory volume in one second (FEV1) also decreased significantly and maximally on postoperative day one and then showed a consistent increase similar to FVC. But again, in group I there was no significant difference between preoperative value and value on day 28<sup>th</sup>, and between day 8<sup>th</sup> and 28<sup>th</sup>, meaning thereby that in group I maximum increase occurred till day 8<sup>th</sup>, whereas in group II and group III significant difference was still present on day 28<sup>th</sup> but in group II there was no significant increase between day 3 and day 5 (Table 4).

Ratio of FEV1 to FVC did not show any significant difference in group 1 as compared to preoperative value

but in group II there was a decrease in ratio on day 28<sup>th</sup> which was significant. Group III patients showed a decrease in ratio on day 3<sup>rd</sup> as compared to all other days (Table 4).

#### *Intra-group and intergroup comparison of ABGs*

There was no significant difference in pH value in all the groups. But pO<sub>2</sub> showed a marked decrease on first post-op day in all groups. It increased progressively in all groups till 28<sup>th</sup> post-op day. In group I, pCO<sub>2</sub> showed an increase which was maximum on day 3. Group III showed an increase on day I which then decreased and was minimum on day 4. In group II there was no significant difference noted. Oxygen saturation also decreased on first post-operative day in all three groups but then showed a rising trend. (Table 5)

**Table 5: Comparison of preoperative and postoperative ABGs.**

Group	Preop ABG	Postop ABG Day1	Postop ABG Day2	Postop ABG Day3	Postop ABG Day4
<b>Group I</b>					
pH	7.395±0.047	7.382±0.033	7.364±0.039	7.377±0.029	7.367±0.031
pO <sub>2</sub>	97.00±10.58	78.77±9.7	79.15±6.	80.27±8.1	82.31±8.64
pCO <sub>2</sub>	31.53±8.537	7.47±4.77	37.89±5.33	37.58±3.59	37.37±3.79
O <sub>2</sub> Sat.	97.65±1.57	94.66±1.58	93.9±1.31	93.99±0.76	94.30±1.60
<b>Group II</b>					
pH	7.370±0.037	7.370±0.033	7.367±0.034	7.350±0.037	7.356±0.021
pO <sub>2</sub>	90.62±11.93	75.53±4.89	77.62±4.98	76.22±4.57	82.62±7.33
pCO <sub>2</sub>	38.77±1.83	39.55±1.79	38.91±2.17	38.74±3.67	37.13±3.25
O <sub>2</sub> Sat.	96.03±1.68	94.46±1.65	94.28±1.68	93.53±1.56	94.70±1.30
<b>Group III</b>					
pH	7.376±0.50	7.377±0.043	7.380±0.035	7.362±0.036	7.364±0.028
pO <sub>2</sub>	88.14±9.67	78.00±10.63	77.33±8.47	77.01±7.90	83.48±7.17
pCO <sub>2</sub>	39.97±5.15	41.5±3.91	40.97±3.81	39.56±4.03	37.72±2.95
O <sub>2</sub> Sat.	96.36±1.87	94.33±2.08	93.72±1.59	93.28±1.23	95.00±1.03



### **Intergroup comparison of CXR findings**

Incidence of atelectasis was found to be highest in group I and was comparable in remaining two groups. Eleven patients (36%) had evidence of atelectasis on chest radiographs and their distribution between the three groups was; 5 in group I and 3 each in group II and group III respectively.

### **Mortality**

A single death was recorded during the study period and the cause was pneumonia leading to ARDS. This patient belonged to CPAP group, but on comparison there was no statistical significant difference between all three groups as far as mortality was concerned.

## **DISCUSSION**

Surgical resection when possible offers the best treatment for lung cancer and for some patients with localized benign lung pathologies. Unfortunately, these operations are frequently accompanied by postoperative pulmonary complications and they are the major cause of morbidity and mortality.

Various respiratory maneuvers have been described in literature to prevent the occurrence of postoperative pulmonary complications.<sup>4</sup> In addition to physiotherapy, accessory devices such as positive expiratory pressure mask breathing and incentive spirometry are provided to patients to reduce pulmonary complications. Evidence for the effectiveness of physiotherapy in preventing postoperative pulmonary complications after abdominal surgery is provided in randomized controlled trials.<sup>5</sup> There are, however, no sufficient data on the efficacy of physiotherapy after thoracic surgery. Although incentive spirometry is used widely in clinical practice, it has not been shown to be of additional value after major abdominal or cardiac surgery.<sup>6</sup>

To prevent pulmonary complications incentive spirometry, physiotherapy and continuous positive airways pressure are routinely used and there are not enough studies in literature regarding their use in thoracic surgery patients. Thus, there was a need to perform the present study to investigate the potential benefits of additional incentive spirometry and continuous positive airway pressure on postoperative outcomes.

### **Pulmonary functions**

Pulmonary functions were significantly reduced in present study subjects after surgery. Forced vital capacity (FVC) and forced expiratory volume in first second (FEV1) were reduced to 50% on day one and reduction was found in all the three groups whereas FEV1/FVC was almost constant indicating a restrictive pattern of lung function. There was a consistent improvement in lung function till even the 28<sup>th</sup> day, but most marked

improvement occurred between day 1 and day 3. Bastin R et al. also found the similar decrease in lung volumes in 19 patients undergoing lobectomy for lung cancer.<sup>7</sup>

There was no significant difference between the three groups with regard to FVC, FEV1 and FEV1/FVC in the present study. Gosseling et al compared the additional effect of incentive spirometry to chest physiotherapy to prevent postoperative pulmonary complications after thoracic surgery for lung and esophageal resections. They also found similar pattern of decrease in lung functions and there was no significant difference between the two groups.<sup>8</sup> So decrease in lung functions is irrespective of the treatment modality used.

### **Pulmonary complications and atelectasis**

In present study, pulmonary complications rate i.e pneumonia after thoracic surgery was low as compared to other studies. (R) Mortality rate (3%) is comparable to previous studies after lobectomies. The overall perioperative mortality rate was 2.1% to 3.7% for pulmonary resection in most large series.<sup>9,10</sup> But the radiological evidence of atelectasis in present study was significantly high (36%) and the incentive spirometry groups had highest rate of atelectasis 5 out of 10 (50%) and remaining 6 equally distributed between CPAP and conventional physiotherapy. Ricksten SE et al in their study in patients undergoing abdominal surgery showed 33 percent atelectasis in incentive spirometry group and 15% in CPAP group.<sup>11</sup> Matte et al also showed similar incidence of atelectasis, 30% in incentive spirometry group and 15% in CPAP group.<sup>12</sup>

High incidence of atelectasis in our study might be because the use of incentive spirometer was not monitored and quantified for patient compliance with the treatment. It was not supervised by any physiotherapist and there is no data to identify patients who were very strict in their exercise and patients who were less motivated for performing incentive spirometry. CPAP application is effortless, no initiative is required from patient side and it is painless and requires no monitoring and supervision once applied. The lack of effectiveness of incentive spirometry in various studies could be related to inadequacy of the equipment. Most studies used the flow signal as feedback. This might enhance inspiratory flow rate rather than inspiratory volume. Volumetric incentive spirometry might offer superior feedback.

### **Arterial blood gas analysis**

The present study showed that pH remains almost stable, but PO<sub>2</sub> decreased significantly on first postoperative day in all the three groups, drop was present on 2<sup>nd</sup> day also and showed consistent increase thereafter. Decrease in pH matched with the decrease in lung volumes, and is because of impaired gas exchange and restrictive pattern of lung functions. PCO<sub>2</sub> showed a decrease in incentive spirometry group as compared to other two groups. It

might be due to more increase in respiratory rate as compared to other two groups, as CPAP application is painless and is known to decrease the respiratory rate and increase the functional residual capacity. Matte P et al also showed a similar trend in arterial blood gas analysis.<sup>12</sup>

Carvalho et al have conducted a systematic review which evaluated the use of IS for prevention of post-operative complications and for recovery of pulmonary functions. This review concluded that IS is not beneficial in reducing post-operative pulmonary complications as compared to other physical therapy interventions among patients undergoing abdominal surgery. Studies which included patients with cardiac surgery showed improvement with CPAP as compared to IS. Only two studies were included where thoracic surgeries were done and results were inconclusive for IS.<sup>6</sup>

In present study, patients who received conventional physiotherapy alone recovered from the postoperative restrictive defect as effectively as those who received CPAP and Incentive spirometry. Incentive spirometry offered no advantage over CPAP and conventional physiotherapy. In addition, it appears that frequent and vigorous respiratory therapy with or without CPAP is associated with decreased incidence of postoperative atelectasis.

## CONCLUSION

As incentive spirometry offered no advantage over chest physiotherapy but does involve the added expense of spirometer, a vigorous chest physiotherapy regimen requires no special equipment and can be delivered by less highly trained personnel, chest physiotherapy is more economic. The CPAP mask requires nurse, respiratory therapists in both familiar with its use, but may require less intensive supervision than incentive spirometry or conventional physiotherapy alone once the mask is applied. In addition, CPAP, unlike chest physiotherapy or incentive spirometry does not require the patient to perform a painful task and success of the therapy does not depend upon the patient's effort. So, considering all these chest physiotherapies alone is good enough to prevent the postoperative complications and under some circumstances. CPAP use can be considered.

There are few studies in literature involving patients with thoracic surgery, thus more studies with large number of patients with adequate methodological designs are required to justify the use of this technique.

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