



Original Research Article

Correlation between amount of pleural fluid aspirated and pulmonary function tests after thoracentesis

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ARTICLE INFO

Article history:

Received 20-07-2020

Accepted 27-08-2020

Available online 16-09-2020

Keywords:

Pleural effusion

Thoracentesis

Pulmonary function tests

ABSTRACT

Aims: Assessment of changes in the pulmonary function test before and within 24 hours of thoracentesis and correlation between the volume of pleural fluid aspirated and changes in FEV1 and FVC.

Materials and Methods: Prospective study done in 100 pleural effusion of patients presenting to the OPD/IP of the Department of Pulmonary Medicine, Sathagiri Institute of Medical Sciences and Research Centre for a period of 2 years included in the study. All the subjects were interviewed after taking the informed consent followed by physical examination and chest X-ray. It reported findings in proforma.

Results: Many of the patients belonged to the 40-50 year age group. The mean age was 44.9 years with male preponderance in distribution of cases with 81% being males and 19% females. In the present study there were 10 smokers all were males. Maximum number of patients (50%) had of mild pleural effusion, 21% patients had massive pleural effusion. After thoracentesis, there was a substantial, improvement in the pulmonary function test FVC, FEV1 and VC though FEV1/FVC showed no significant change. There was a clear link between the volume of aspirated fluid and the measures of pulmonary function. After removal of pleural fluid by thoracentesis. There was significant relief of dyspnoea these allowing patients to return their routine activities.

Conclusion: Thoracentesis in patients with pleural effusion is recommended for improving lung function and for symptomatic relief.

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1. Introduction

Pleura is the serous membrane that covers the lung parenchyma, the mediastinum, the diaphragm, and the rib cage; this structure is divided into the visceral and parietal pleura.¹ Visceral pleura covers the lung parenchyma, not only at its points of contact with the chest wall, diaphragm and mediastinum, but also in the intralobar fissures. The pleura in parietal form the interior of the thoracic cavities. The space between the two layers of pleura or potential space is designated as pleural space. A film of fluid (pleural fluid) between the parietal pleura and the visceral pleura is normally present.

Due to increased pleural fluid formation and decreased pleural fluid absorption, the excessive fluid accumulates

between parietal and visceral pleura.² Pleural effusion is a condition that is secondary to a local or systemic disease characterized by abnormal fluid accumulation in pleural space. This health condition induces changes in respiratory physiology with stagnant and fluid lung capacity decreased. During effusate loading, lung elastance increased gradually, possibly due to a combination of parenchymal displacement, which happens as the lung rotates along its long and transverse axes during effusate loading.³

In severe situations, elevated fluid accumulation will lead to respiratory collapse and death. The common signs reported by patients are dyspnoea, discomfort, and coughing, which typically escalate with effort, restricting the continuity of normal everyday activities in many cases. Impossible to determine the influence of pleural effusion on pulmonary function. The pulmonary parenchyma is also affected by many diseases that cause pleural effusions, such

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as congestive heart failure, malignancy, pneumonia and pulmonary embolism.

Therefore it is often difficult to determine which part of the pulmonary dysfunction is caused by pleural effusion and which part is caused by the underlying disorder. Removal of pleural fluid by thoracocentesis induces dyspnoea relief and improvement in chest mechanical function, enabling patients to return to daily activity. Studies have demonstrated substantial changes in pulmonary function, especially in FVC and FEV1 with pleural fluid removal. Improvement was observed immediately after thoracocentesis, when the respiratory system may not have adjusted to this new condition yet.

In addition, it is important to note that the patient is still prone to acute effects arising from the operation in the pleural space within the first hours after the treatment, especially coughing and discomfort, which underestimate the change caused by the drainage of the fluids. Therefore, improvements arising from the elimination of excessive quantities of pleural fluid should be evaluated not only predictably but also dynamically during exertion while the symptom improvement may be more evident.³

The spirometry test is carried out using a device called a spirometer, invented by a surgeon John Hutchinson. His basic spirometer measured VC. Modern parameters such as FEV1 were invented much later. Spirometer monitors ventilation in Litre from totally Filled Lungs over time. FVC and FEV1 are among the most important quantities. Most spirometers display the following graphs as Volume Time Curve called spiro grams—showing volume (litre) along the y axis and time (seconds) along the x axis. A loop of flow volume, graphically depicting the airflow scale on the y axis and the total volume inspired or expired on the x axis.

Pulmonary function testing has come to assume a central place in the practice of pulmonary medicine with great advances in pulmonary physiology and medical instrumentation that have taken place during the last 40 years. Pulmonary function tests allow for an accurate reproducible evaluation of the functional state of the respiratory system and allow for the quantification of disease severity, thus allowing early detection.

2. Materials and Methods

It is a prospective study of 100 patients who are diagnosed as pleural effusion on basis of chest radiograph. This study was conducted in Department of Pulmonology, Sathagiri institute of medical sciences and research center from January 2018 – January 2020. All 100 patients included in the study was evaluated both by chest X-ray and PFT before and after thoracocentesis. The chest radiographs (pre-thoracocentesis) was classified as mild, moderate and massive effusion.

2.1. Inclusion criteria

All cases of pleural effusion

2.2. Exclusion criteria

1. Patients in whom fluid cannot be withdrawn.
2. Patients who do not give consent for the procedure.
3. Patient who are unable to perform spirometry.
4. Patient on domiciliary oxygen therapy and non-invasive ventilation.
5. Disease (eg- unstable angina, CHF any other disease limiting patients movement).

2.3. Radiography

Chest X ray of before and within 24 hours of all 100 patients included in the study were evaluated..

The patients were graded as mild moderate, and huge forms based on the chest. Patients with fluid levels up to the lower fifth rib border were classified as mild, up to the lower third rib border as moderate, and above the third rib as massive effusion.F

2.4. Thoracocentesis Procedure⁴

Thoracocentesis is performed using standard technique. The procedure is explained to the patient carefully and a signed consent is obtained. Once the site is identified for thoracocentesis then marked by exerting pressure using the end of a ballpoint pen with the tip retracted. Then the skin surrounding the site is thoroughly cleansed from the proposed thoracocentesis site with antiseptic solution over an area extending at least 4 inches in all directions. Then the sterile drape with middle hole is taped to the back of the patient and another sterile drape is placed on the bed.

Local anesthesia with 2 percent lignocaine should be given to anaesthetize the skin, rib periosteum, and parietal pleura. Then pleural fluid is aspirated by 50cc syringe via 3 way cannula through a 22-gage needle, and aspirated fluid is quantified.

If the patient experienced discomfort with symptom exacerbation (coughing, dyspnoea, or chest pain) or vagal manifestations (dizziness or nausea) the procedure was suspended.

2.5. Pulmonary function tests

The patients are evaluated for lung functions by spirometry. To measure FVC and FEV1, a spirometer (Spiro Air, Medisoft) is used, and manoeuvres were performed according to the guidelines of the American Thoracic Society.

3. Results

The present study was designed to test whether there was a significant improvement in pulmonary function within 24 hours of the therapeutic thoracocentesis.

Among the 100 subjects observed in the study, patients were graded into mild, moderate and severe pleural effusion based on the radiological findings. Patients were having the complaints of chest pain, breathlessness, dry cough and difficulty in performing daily routine activities before thoracocentesis. Patient pulmonary function test was performed before and within 24 hrs. of thoracocentesis and there was significant change in pulmonary function, recorded as shown in tables below.

Table 1: Shows age distribution of the gender among study group

Age intervals in years	Male	Female	Total
10->20	5	0	5
20->30	14	3	17
30->40	10	5	15
40->50	14	6	20
50->60	16	2	18
60->70	16	2	18
70->80	6	0	6
80->90	0	1	1
Total	81	19	100

Among 100 subjects there were 81 (81%) men and 19 (19%) women. Maximum number of subjects are in the age group of 40->50 years. minimum number of subjects are in the age group of 80->90 years. Mean age of the patients is 44.97 years with range of 14-84 years on which the study was conducted.

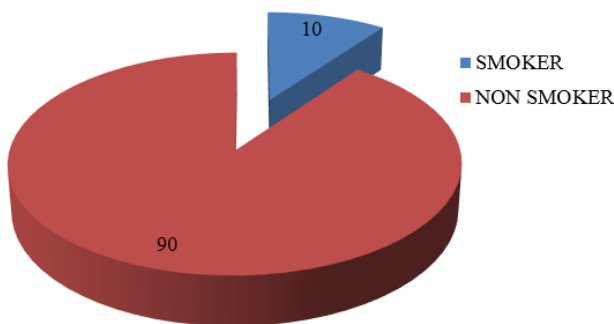


Fig. 1: Shows age distribution of smokers in the present study

Fig. represents number of smoker and non-smokers in the present study. There are total 10 smokers and all are males in the present study maximum number of smokers are in age the group of 50->60 years

Shows maximum number of subjects i.e 44 subjects height ranges from 160-<170cm and only 2 subjects height is <150 cm in the present study. Mean height of the subjects as shown in Table 4 was 165 cm with minimum height

Table 2: Represents height and weight distribution of the gender among study group

Height(cm)	Male	Female	Total
<150	0	2	2
150 - <160	10	11	21
160 - <170	39	05	44
170 - <180	20	0	21
> 180	11	01	12
Weight (kg)			
<40	1	1	2
40 - <50	6	3	9
50 - <60	25	8	33
60 - <70	25	6	31
70 - <80	12	1	13
> 80	12	0	12

of 145cm and maximum height of 185 cm and standard deviation of 9.58 cm.

33 subjects weighs 50< 60 kg and only 2 subjects weighs <40 kg in the present study.

According to Table 5 the minimum weight is 34kg, maximum weight is 96kg with mean weight of 61.77 Kg.

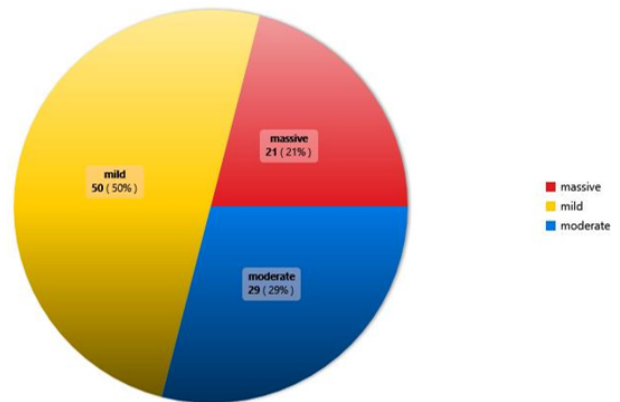


Fig. 2: Radiological grading of pleural effusion

Among 100 subjects those who underwent thoracocentesis, there were 50 patients of mild pleural effusion, 29 patients of moderate pleural effusion and 21 were having massive pleural effusion.

Table 3: Shows fluid distribution in the present study

RT/LT	Frequency	Percent
Bilateral	2	2.00 %
Left	49	49.00 %
Right	49	49.00 %
Total	100	100.00 %

There were 49 patients of right sided pleural effusion, 49 were having left sided pleural effusion and 2 were of bilateral pleural effusion.

Table 4: Pulmonary function results before and after thoracentesis in case of mild pleural effusion.

Parameters	Before Thoracentesis (% predicted)	After Thoracentesis (% predicted)	Difference	Correlation (r) value	P value
Mild					
FVC	50.86	57.82	6.96(13.68%)	0.948	<0.01
FEV1	48.34	54.96	6.62(13.69%)	0.931	<0.01
FEV1/FVC	0.9504	0.9503	-0.0001	NS*	NS*
VC	51.50	59.34	7.84(15.22%)	0.907	<0.01
Moderate					
FVC	44.24	55.97	11.73(26.51%)	0.912	<0.01
FEV1	41.69	52.72	11.03(26.45%)	0.845	<0.01
FEV1/FVC	0.942	0.941	-0.001	NS*	NS*
VC	48.03	70.52	22.49(46.82%)	0.681	<0.01
Massive					
FVC	42.38	56.00	13.62(32.13%)	0.885	<0.01
FEV1	43.67	56.62	12.95(29.65%)	0.814	<0.01
FEV1/FVC	1.030	1.011	0.019	NS	NS
VC	44.14	57.38	13.24(29.99%)	0.813	<0.01

*Non-significant

As shown the predicted values in mild pleural effusion change in FVC, FEV1 and VC shows a strong correlation of $r=0.948$ ($p<0.01$), $r=0.931$ ($p<0.01$) and $r=0.907$ ($p<0.01$) following thoracentesis which is highly significant. The mean change in FVC, FEV1 and VC was 13.68%, 13.69%, 15.22% respectively. The FEV1/FVC ratio was found to be non-significant.

Similarly, in patients of moderate pleural effusion, change in FVC, FEV1 and VC shows a strong correlation of $r=0.912$ ($p<0.01$), $r=0.845$ ($p<0.01$) and $r=0.681$ ($p<0.01$) following thoracentesis which is highly significant. The mean change in FVC, FEV1 and VC was 26.51%, 26.45%, 46.82% respectively. The FEV1/FVC ratio was found to be non-significant.

In patients of massive pleural effusion, change in FVC, FEV1 and VC shows a strong correlation of $r=0.885$ ($p<0.01$), $r=0.814$ ($p<0.01$) and $r=0.813$ ($p<0.01$) following thoracentesis which is highly significant. The mean change in FVC, FEV1 and VC was 32.13%, 29.65%, 29.33% respectively. The FEV1/FVC ratio was found to be non-significant.

Similar findings were observed in present study as well, in which there was significant improvement in FVC, FEV1 and VC ($p<0.01$) after thoracentesis showing strong correlation.

4. Discussion

It was observed in the study that patients presenting with pleural effusion graded as mild, moderate or severe based on radiological finding showed a marked improvement in their pulmonary function i.e. FEV1, FVC and VC after the thoracentesis was performed. This change was statistically highly significant in all the patients

of mild, moderate or severe grade. While performing the thoracentesis, the procedure was stopped when no fluid came out spontaneously. Following the procedure of thoracentesis, no patient had clinical or radiological evidence of pneumothorax or signs of re-expansion pulmonary edema.

Study done by Gilmatin et al⁴ also showed significant improvement in FEV1, VC and TLC which is comparable to the present study done showing similar improvement in FVC, FEV1 and VC following the thoracentesis.

Another study done by Wang et al⁵ showed small but significant improvement in FEV1 and FVC ($p<0.01$) after removal of 600 to 2,700 ml of fluid by thoracentesis which also is consistent with finding of present study.

Study done by Cartox et al in 2011 performed a study on 25 patients of pleural effusion. After removal of mean fluid of 1564 ml, there was in FVC and FEV1. However, no correlation was observed between the spirometric results and volume of fluid drained.

Similar findings were observed in present study as well, in which there was significant improvement in FVC, FEV1 and VC ($p<0.01$) after thoracentesis showing strong correlation. There was also weak but highly significant correlation ($p<0.01$) between amount of fluid removed and improvement in FVC & FEV1 in the present study as compared to the above discussed study. Patients with symptoms of breathlessness, chest pain and decreased ability to perform routine activities showed improvement in all these factors following the procedure of thoracentesis.

Improvement in pulmonary function was not similar to the predicted value of spirometer (Spiro Air, Medisoft). This could be due to the fact that patients presenting with pleural effusion have other underlying conditions that leads to decreased pulmonary function.

Table 5: Pulmonary function results before and after thoracocentesis

Parameters	Before Thoracocentesis (% predicted)	After Thoracocentesis (% predicted)	Difference	Correlation (r) value	P value
FVC	53.8+/-12.8	64.5+/-14.4	10.7	NS	<0.001
FEV1	52.7+/-12.3	60.9+/-12.5	8.3	NS	<0.001
FEV1/FVC	0.8+/-0.1	0.7+/-0.1	-0.1	NS	<0.051

Data are presented as mean +/-SD

Removal of pleural fluid by thoracocentesis causes relief of dyspnea and improvement in the mechanical function of the chest, allowing patients to return to routine activities.

Studies have reported a significant improvement in pulmonary function, with pleural fluid removal especially in FVC and FEV1. It should be noted that this change was detected instantly or within 24 hours of thoracocentesis, although there could not have been an adjustment of the respiratory system to this new diagnosis yet. Furthermore, it is important to note that the patient is already vulnerable to acute effects resulting from the pleural space intervention within the first hours after the operation, especially coughing and pain which may underestimate the change induced by the fluid drainage.

Consequently, changes resulting from the removal of expressive volumes of pleural fluid should be analyzed not only statically but also dynamically during exertion when the symptom improvement may be more evident.⁶

5. Conclusion

From the findings of this study, which was concluded on 100 subjects that there is a significant association between the quantity of fluid aspirated with thoracocentesis and improvement in FVC, FEV1, VC and significant improvement in FVC, FEV1, VC after thoracocentesis and the association has been shown to be significant scientifically using statistical analysis. In 24 hours of thoracocentesis, the patients observed under analysis also reported improvement of chest pain and breathlessness. Thus, it is advisable to conduct thoracocentesis in pleural effusion patients for improving lung function and for symptomatic relief from all the findings observed in the study.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Cite this article: Kiran N , Venkatesh B C . Correlation between amount of pleural fluid aspirated and pulmonary function tests after thoracocentesis. *IP Indian J Immunol Respir Med* 2020;5(3):141-145.