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Original Research Article

Effect of Thoracocentesis on Spirometry, ABG Values and 6 Min Walk Test in Symptomatic Patients with Moderate and Massive Pleural Effusions

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Abstract:

Introduction: Pleural effusion is characterised by abnormal accumulation of fluid in pleural space secondary to local or systemic diseases. This clinical condition causes changes in respiratory mechanics with reduction in static and dynamic lung function. Impact of thoracocentesis on various physiological parameters of respiratory system including spirometric variables, arterial blood gases, mechanical properties and respiratory muscle function.

Aims and Objectives: To determine the effect of thoracocentesis on spirometry, exercise tolerance and ABG values in patients with moderate to massive pleural effusions and comparing pre and post thoracocentesis value.

Material and Methods: This is a prospective observational study accepted by the Institutional Ethics Committee of this tertiary medical college & hospital.

Inclusion Criteria: Symptomatic patients of > 18 years age admitted to chest and TB ward diagnosed with pleural effusions - moderate and massive by chest radiology.

Exclusion Criteria: Asymptomatic, not giving consent and having mild effusions, encysted effusions, effusions with hydropneumothorax other comorbidity that causes dyspnea and exercise intolerance. Spirometry, ABG and 6MWT done before and after thoracocentesis.

Results: Total of 71 patients included. Mean values of pre and post thoracocentesis FEV1 were 1.17±0.49 and 1.29±0.51 l respectively. Mean values of pre and post thoracocentesis FVC were 1.27±0.53 and 1.42±0.60 l respectively showing the improvement in both FEV1 and FVC to be statistically significant. PaO2 increased significantly 6 hrs after therapeutic aspiration. Mean values of PaO2 pre and post-thoracocentesis were 71.54±10.37 and 72.86±11.20 mmHg respectively with p value of 0.015. 6MWD also increase 6 hrs post thoracocentesis. Mean 6MWD pre and post thoracocentesis were 487±102.32m and 513±105.93m respectively. Post therapeutic aspiration 6MWD increased from 89% to 94% of predicted 6MWD of all patients with p value of 0.001 showing the improvement to be statistically significant.

Conclusion: Therapeutic thoracocentesis is highly effective in providing modest improvement in FeV1, FVC and PaO2 in patients with large volume effusion and there is significant improvement in 6MWD. The benefits of fluid removal are more evident in situations of exertion, where it allows patients to go back to their daily routine activities.

Keywords: Pleural effusion, Thoracocentesis, Spirometry, ABG,6MWD

Introduction

Pleural effusion is characterised by abnormal accumulation of fluid in pleural space secondary to local or systemic diseases. This clinical condition causes changes in respiratory mechanics with reduction in static and dynamic lung function. Large volume pleural effusion usually induces specific patho- physiological changes including increase in pleural pressure, decrease in lung volumes as well as

an impairment in respiratory muscle function and gas exchange. The impact of pleural effusion on lung functions has been extensively investigated in various experimental and clinical studies. Pleural effusion compresses lung parenchyma and displaces outwards the thoracic cage, both alterations being responsible for physiological changes in various publications. Several studies have evaluated the impact of thoracocentesis on various physiological parameters of respiratory system including spirometric variables, arterial blood gases, mechanical properties and respiratory muscle function.

Removal of pleural fluid by thoracocentesis causes relief of dyspnea and improvement in mechanical function of chest allowing patients to return to routine activities. Studies have reported a significant improvement in pulmonary function particularly in FVC, and FEV1 with removal of pleural fluid.

In previous studies this improvement was observed immediately after thoracocentesis when the adjustment of respiratory system to this new condition may not have occurred yet. Additionally it is important to consider during the first hours after procedure patient is still susceptible to acute effects resulting from intervention in pleural space, particularly coughing and pain that may underestimate improvement caused by fluid drainage. Changes resulting from removal of excessive volumes of pleural fluid should be analysed not only statically but also dynamically during exertion.

Aim and Objectives

- To determine the effect of thoracocentesis on spirometry, exercise tolerance and ABG values in patients with moderate to massive pleural effusions and thereby analyse the therapeutic effect of medical thoracocentesis.
- To assess the spirometric values pre and post thoracocentesis.
- To assess the ABG pre and post thoracocentesis.
- And to assess the 6MWD pre and post thoracocentesis.

Materials and Methods

Source of Data

The study shall be an institutional based prospective observational study. The study were conducted in the Department of Pulmonary Medicine, SCB Medical College, Cuttack.

Sample Size: 71 patients

Period of Study: March 2021 To October 2022.

Sampling Procedure: All symptomatic patients with moderate to massive pleural effusions admitted fulfilling the inclusion criteria.

Method of Study

All symptomatic patients admitted to chest and TB ward will be diagnosed with pleural effusions by chest radiology(chest Xray +/- USG thorax).

Only those patients having massive or moderate effusions are taken for study. One litre of pleural fluid aspirated. Pre and post thoracocentesis Spirometry (24hrs post thoracocentesis),ABG (6hrs post thoracocentesis), 6MWD (6 hrs post thoracocentesis)values are compared.

Inclusion Criteria

Patients above 18 yrs of age and giving consent

Patients admitted to indoor of Pulmonary Medicine department with massive and moderate effusions of recent onset and are symptomatic.

Exclusion Criteria

Patients who are severely symptomatic, totally asymptomatic, not giving consent and having mild effusions, encysted effusions, effusions with hydropneumothorax other comorbidity that causes dyspnea and exercise intolerance. Clinical history, all routine blood investigations, chest Xray, USG thorax of all patients were done. Based on clinical history, chest radiography patients with other respiratory disorders that resulted in dyspnea apart from pleural effusion were excluded from study

Results

Table 1:

Age(In Years)	Number	Percentage
20-39	22	31.0
40-59	19	26.8
60-79	27	38.0
>80	3	4.2
Total	71	100

Table showing age distribution of our study group. Maximum percentage of patients are in the age group 60-79 yrs i.e. 38% followed by age group of 20-29 yrs i.e. 31% and the least number of patients in the age group>=80 yrs i.e.4.2%.

Table 2:

Gender	Number	Percentage
Male	55	77.5
Female	16	22.5
TOTAL	71	100

Table showing number of males and females included in my study. Total number of males is 55(77.5%) and number of females 16(22.5%). Males are more than females.

Table 3:

Spirometry	Pre Thoracocentesis Mean ± SD	Post Thoracocentesis Mean ± SD	P Value
FEV1	1.17±0.49	1.29±0.51	0.001
FVC	1.27±0.53	1.42±0.60	0.001
FEV1/FVC	0.92±0.11	1.91±0.10	0.342

Table showing mean values of pre and post thoracocentesis FVC, FEV1, FEV1/FVC. Mean values of pre and post thoracocentesis values of FEV1 are 1.17±0.49 and 1.29±0.51 respectively. Mean values of pre and post thoracocentesis values of FVC 1.27±0.53 and 1.42±0.60 respectively. Mean values of pre and post thoracocentesis FEV1/FVC are 0.92±0.11 and 0.91±0.10 respectively.

Table 4:

ABG	Pre Thoracocentesis Mean ± SD	Post Thoracocentesis Mean ± SD	P Value
Ph	7.93±0.05	6.39±0.	0.382
PaO2	71.54±10.37	72.86±11.20	0.015
PCO2	34.58±6.91	35.46±6.93	0.010

Table showing mean values of pre and post thoracocentesis Ph, PaO2, PCO2. Mean values of pre and post thoracocentesis Ph are 7.39±0.05 and 7.39±0.06 respectively. Mean values of pre and post thoracocentesis PaO2 are 71.54±10.37 and 72.86±11.20 mmHg respectively. Mean values of pre and post thoracocentesis PCO2 values are 34.58±6.91 and 35.46±6.93 mmHg respectively.

Table 5:

	Pre Thoracocentesis Mean ± SD	Post Thoracocentesis Mean ± SD	P Value
6MWD	487.14±102.32	513.65±105.93	0.001
% PRED 6MWD	89.25±3.43	94.13±3.86	0.001

Table showing 6MWD of patients pre and post thoracocentesis. Mean 6M distance walked pre thoracocentesis is 487±102.32m which is 89% of predicted 6MWD. Post thoracocentesis 6MWD is 513±105.93m which is 94% of predicted.

Table 6:

FEV1	PaO2	Total		Kappa Value	P Value
Improved					
	Improved	Not Improved		0.730	0.001
	46(90.2%)	5(9.8%)	51		
Not Improved	3(15%)	17(85%)	20		
Total	49	22	71		

Table showing correlation improvement in FEV1 vs improvement in PaO2 .46 patients showed improvement in both FEV1 and PaO2 with correlation coefficient 0.730.

Table 7:

FEV1	PaCO2			Kappa Value	P Value
	Improved	Not Improved	Total		0.069
Improved	29(56.9%)	22(43.1%)	51	-0.212	
Not Improved	26(80%)	4(20%)	20		
Total	45	26	71		

Table showing correlation between improvement in FEV1 and increase in PCO2. There is negative correlation between change in FEV1 and change in PCO2 (Kappa=-0.212)

Table 8:

FVC	PaO2		Kappa Value		P Value
	Improved	Not Improved	Total	0.829	0.001
Improved	48(92.3%)	4(7.7%)	52		
Not Improved	1(5.3%)	18(94.7%)	19		
Total	49	22	71		

Table showing correlation between FVC and PaO2 which shows a strong correlation(kappa=0.829) between improvement in FVC and increase in PaO2.

Table 9:

FVC	PaCO2			Kappa Value	P Value
	Improved	Not Improved	Total		
Improved	30(57.7%)	22(42.3%)	52	-0.190	0.1
Not Improved	15(78.9%)	4(21.1%)	19		
Total	49	22	71		

Table showing correlation between change in FVC and PaCO2 . There is negative correlation between improvement in FVC and chain PCO2 (kappa=-0.190)

Discussion

In this study the sample was taken from the patients who were admitted to the department of Pulmonary Medicine with respiratory complaints and were diagnosed with massive to moderate pleural effusions on basis of chest radiology. Our study sample comprised of 71 patients which is quite large as compared to the sample size of Sanjay Sahay et al study (1) where the sample size was 44 and Miguel Perpina et al study(3) where sample size taken was 33.

Patients in this study group averaged 51.72 yrs with SD of 16.361. Maximum number of patients were in the age group of 60-79 yrs(38%) followed by age group 20-39 yrs(31%). Least number of patients were from the age group >=80 yrs(4.2%). Sanjay Sahay et al(2014)(1) in their study had maximum number of patients in age group 36-50 yrs(45.47%) with next common age group 26-35 yrs.

Ana Maria Cartaxo et al(2) in their study had average age of 48+/-18□yrs which was similar to our study.

In this study the prevalence of male gender is 77.5% and of females is 22.5% which corroborates with the study by Sanjay Sahay et al (2014)(1) where the prevalence of male was 65.91% were males and 34.09% were females.

According to another study by Miguel Perpina et al (3) 63.63% were males and 36.37 % were females.

In Sanjay Sahay et al study (1) FVC before and after thoracocentesis was found out to be 1.38 l±0.351 l and 2.56±0.385 l respectively with net improvement of FVC being 1.18 litres approx.($p<0.001$). In this study FEV1 before and after thoracocentesis was found out to be 1.025±0.328 and 1.31±0.366 respectively with net improvement of 0.285 l approx($p<0.001$). However in this study the ratio of FEV1/FVC did not show significant change in p value which is similar to our study showing this ratio does not alter in pleural effusion.

In our study there is improvement in FEV1 and FVC which showed that there is improvement in lung volumes following aspiration ,which is in accordance with the above mentioned studies showing that pulmonary function tests in pleural effusion generally show restrictive abnormalities proportional to severity of effusion. There is primarily reduction in size of thoracic cage which allow inspiratory muscles to operate better bringing relief to dyspnea.

However work performed by Neil E. Brown et al (6)on pulmonary mechanics and gas exchange following thoracocentesis did not found any change in vital capacity. B. Zerahn et al(5) in their study also found that there is strong correlation between between amount of fluid aspirated and increase in lung volumes following aspiration.

Richard W. Light et al(10) in their study found that the mean vital capacity improved 410 ± 390 ml in their group of 26 patients who had 1,740 ± 900 ml fluid removed. The improvement in the VC most closely correlated with the pleural pressure after 800 ml fluid had been withdrawn ($r = 0.57$, $p < 0.005$). The ratio of the improvement in the VC to the amount of fluid removed most closely correlated with the pressure change after 800 ml fluidhad been removed ($r = -0.43$, $p < 0.05$). From this study they concluded that the improvement in the FVC after therapeutic thoracentesis is small relative to the amount of fluid withdrawn.

In our study the pre and post thoracocentesis pH of arterial blood was found out to be 7.39±0.05 and 7.39±0.06 respectively which did not show any significant improvement.

In our study the mean values of pre and post thoracocentesis of partial pressure of oxygen of arterial blood (PaO2) were 71.54±10.37 and 72.86±11.20 mm Hg respectively. There was significant improvement in partial pressure of oxygen(PaO2) of arterial blood with a P value of 0.015

In our study the mean values of pre and post thoracocentesis values of partial pressure of carbon dioxide of arterial blood(PaCO2) were 34.58±6.91 and 35.46±6.93 mmHg respectively. There was significant increase in partial pressure of carbon dioxide(PaCO2) of arterial blood with a P value of 0.010.

In our study the mean values of P(A-a)O2 pre and post thoracocentesis were 35.2±14.9 mmHg and 32.8±14.9 mmHg respectively with a significant decrease of P(A-a)O2 (p value<0.05) post thoracocentesis. This shows the decrease in PaO2 in any pleural effusion is due to alveolar collapse because of fluid accumulation in pleural effusion resulting in shunting of blood thereby causing decrease in PaO2 . After thoracocentesis there is expansion of previously collapsed lung allowing for better oxygenation of arterial blood in pulmonary capillary bed after decrease of shunt.

Monika Zielinska-Krawczy et al (4) in their study found that mean values of pre and post(3 hr) thoracocentesis PaO2 were 71.3 mm Hg and 75.1 mm Hg respectively showing significant increase in PaO2 (P value=0.009). P(A-a)O2 decreased from 34.9 mmHg to 32.9 mmHg 3 hrs post thoracocentesis showing stastistically significant decrease.(P value=0.02).This study concluded that PaO2 significantly improved directly after thoracocentesis and returned to baseline values after 24 hrs. Miguel Perpina et al(3) in their study found that the PaO2, showed a significant increase at each time,(20 min,2hrs and 24 hrs post thoracocentesis) reaching a maximum at 24 hours (mean (SD) increase 1.1 (0.74) kPa; 8-17 (5.57) mm Hg). A concurrent significant decrease of P(A-a)O2 was observed (mean (SD) 1-72 (0.77) kPa; 12-92 (5.78) mm Hg). This was accompanied by a small but significant decrease of "anatomical" shunt (2.4% (1-5%)) and a greater decrease of the physiological shunt (6.5% (4-3%)), while VD/VT did not change. The results are probably due to improved ventilation perfusion relationships with, in particular, an increase in the ventilation of parts of the lung previously poorly ventilated but well perfused. Karetzky et al (11) studied 17 patients and concluded that the change in PaO2 one hour after thoracentesis was unpredictable. Brandstetter and Cohen(8) in a series of 15 cases found an initial systematic decrease of the PaO2 which had returned to preaspiration values by 24 hours. They attributed these changes to altered capillary permeability, due to a sudden increase of blood flow in the previously collapsed lung or ventilation perfusion abnormalities, or both.

Brown et al(6) observed an increase of PaO2 in five of six patients studied three hours after thoracentesis and no change in the remaining patient. The overall increase was significant. There were no concomitant changes in P(A-a)O2 or shunt breathing 100% oxygen. On this basis they concluded that no modifications in gas exchange occur during the first hours after thoracentesis. In a study by Alvar G.N. Agusti et al (4) it was found that thoracentesis drained 693+/-424 ml of fluid and caused a significant fall in mean pleural pressure (by -10.7 +/- 7.1 mm Hg; $p < 0.01$), PaO2, AaPO2, and shunt remained unchanged; only the amount of blood flow perfusing low VA/Q ratios increased slightly (2.4+/- 2.6%; $p < 0.05$). This study showed that: (1) intrapulmonary shunt is the main mechanism underlying arterial hypoxemia in patients with PE and (2) effective thoracentesis has minor short-term effects upon pulmonary gas exchange. These findings are in accord with delayed (> 30 min) pulmonary volume re-expansion after thoracentesis with or without the coexistence of mild ex vacuo pulmonary edema.

Pulmonary function tests as well as PaO2 are decreased due to accumulation of pleural fluid. Pleural effusion produce a restrictive pattern in Spirometry which show statistically significant improvement(p value<0.05) after withdrawal of pleural fluid. FVC increase by 0.14±0.27 l and FEV1 increase by 0.12±0.22 litres 24 hrs post thoracocentesis of 1 litre.Similarly PaO2 increase by 1.32 ± 4.45 mmHg significantly(p<0.05) 6hr after drainage of fluid resulting in better exercise tolerance in patients after thoracocentesis. 6MWD improve significantly by 26.50±15.71 metres (p value=0.001)and from 89% to 94% of predicted value with a 6% net gain 6 hrs post thoracocentesis.

In our study pre and post thoracocentesis values of 6MWD were 487±102.32m and 513±105.93 m respectively. Post thoracocentesis 6MWD increased from 89% of predicted 6MWD to 94% of predicted 6MWD.

In Ana Mario Cartaxo et al (2) in their study found 6-min walk distance increased ($P < 0.001$), whereas dyspnea decreased ($P <0.001$). The distance walked after pleural fluid removal increased significantly ($P <0.001$), with a mean gain of 63 m (14.6%), varying from 432±78 m (73.3% predicted) in the presence of pleural effusion to 495±76 m (83.9% predicted) after thoracentesis. Correlation was found out between individual tests. It was found that there was a significant and strong correlation between change in FVC and increase in PaO2(correlation coefficient =0.829 and p value=0.001). Similarly significant and strong correlation was found between increase in FEV1 and increase in PaO2

(correlation coefficient =0.730 and p value=0.001). This shows thoracocentesis improves lung volumes thereby allowing previously collapsed alveoli to expand allowing for better oxygenation of blood in pulmonary vascular bed.

However there was negative correlation between improvement in FEV1 and increase in PCO2 with correlation coefficient of -0.212.

Similarly there was negative correlation between improvement in FVC and increase in PCO2 with correlation coefficient of -0.19. This shows improvement in lung volumes has no impact on changes in PCO2.

Light and co-workers (10) suggested that improvements in lung volumes after effusion drainage may be related to the absolute magnitude of pleural pressure or to changes in pleural pressure in response to intervention..

In a study conducted by Keyvan Razazi et al(9)on mechanically ventilated patients drainage of large pleural effusion(>500 ml) improved oxygenation and end expiratory lung volume. They concluded that oxygenation improvement correlated with an increase in lung volume and a decrease in transpulmonary pressure, but was less so in ARDS patients.

There was a significant but very weak correlation between improvement in 6MWD and increase in FVC (Correlation coefficient=0.133 and p value<0.05) and increase in FEV1(correlation coefficient=0.108 and p value<0.05). There was a significant and very weak correlation between increase in 6MWD and increase in PaO2 (correlation coefficient=0.152 and p value<0.05).

Ana Mari Cartaxo et al(2) in their study found significant and strong correlations between 6MWD and the values of change in FVC(r=0.725) and FEV1(r=0.661) following thoracocentesis.(p value<0.001) .

This significant correlation between increase in lung volumes, PaO2 and increase in 6MWD suggests that improvement of lung volumes improves oxygenation of arterial blood thereby improving dyspnea during exertion.

In our study we have only focused on change in spirometry, ABG and 6MWD post thoracocentesis but did not find the amount of improvement of decrement per amount of fluid aspirated. No correlation was found out between the amount of change in tests (Pulmonary function tests, 6MWD, ABG) with the amount of fluid aspirated as in all patients the amount of fluid aspirated was constant i.e 1 litre.

Repeated spirometry, ABG and 6MWD analysis after successive thoracocentesis not done to determine the amount of improvement in spirometry values after every successive episode of thoracocentesis.

Secondly in 6MWD the Borg Dyspnea index could not be calculated due to lack of cooperation of patients after performing multiple tests. So only subjective improvement of dyspnea post thoracocentesis was taken into consideration.

Besides repeated ABG monitoring post a single episode of thoracocentesis was not done in our study for which we failed to decide whether there was a transient increase or permanent increase in PaO2 as found out in other studies.

Conclusion

Pulmonary function tests as well as PaO2 are decreased due to accumulation of pleural fluid. Pleural effusion produce a restrictive pattern in Spirometry which show statistically significant improvement(p value<0.05) after withdrawal of pleural fluid. FVC increase by 0.14±0.27 l and FEV1 increase by 0.12±0.22 litres 24 hrs post thoracocentesis of 1 litre. Similarly PaO2 increase by 1.32 ± 4.45 mmHg significantly(p<0.05) 6hr after drainage of fluid resulting in better exercise tolerance in patients after thoracocentesis. 6MWD improve significantly by 26.50±15.71 metres (p value=0.001) and from 89% to 94% of predicted value with a 6% net gain 6 hrs post thoracocentesis.

Therapeutic thoracocentesis is highly effective in providing modest improvement in pulmonary function and PaO2 in patients with large volume effusion. In addition to the improvement in lung function after thoracocentesis, the benefits of fluid removal are more evident in situations of exertion, where it allows patients to go back to their daily routine activities.

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