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Original Research Article

A study on clinical and arterial blood gas parameters before and after tube thoracostomy among cases of primary and secondary spontaneous pneumothorax

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ABSTRACT

Background and Objectives: Pneumothorax is a common respiratory emergency that requires active interventions in many cases specially Tube thoracostomy. Objective of the present study is to find out changes in clinical and arterial blood gas parameters in primary and secondary pneumothorax following tube thoracostomy at different time intervals.

Materials and Methods: Total 30 cases, Primary spontaneous pneumothorax (PSP) 11 and secondary spontaneous pneumothorax (SSP) 19. Clinical parameters: pulse rate, blood pressure, respiratory rates, oxygen saturation (SpO2).

ABG analysis: pH, partial pressure of carbon dioxide (pCO2), partial pressure of oxygen (pO2), AaDO2. Time interval: pre tube thoracostomy, 1hour and 24hours after thoracostomy and after tube removal.

Results: PSP was found more in young patients (mean 34.18), SSP in older patient (mean 52.68), (P=0.001). Among clinical parameters statistically significant changes were seen in pulse rate, (P<0.001) respiratory rate (P<0.001) in both groups, in both cases tachycardia and tachypnea decreased. Diastolic blood pressure in SSP group (P<0.01), SO_2 in SSP group (P<0.05). There is an increase in mean arterial pressure from pre thoracostomy compared to in 1hr, 24hr and at removal. Which statistically significant in SSP group.

In PSP group hypoxaemia was present in 54.54% patients before giving chest tube, after 1 hour of tube thoracostomy only 18.18% cases had mild hypoxaemia. In SSP group 68.42% cases presented with hypoxaemia initially, after tube removal 26.31% cases had mild hypoxaemia.No significant changes in other blood gas parameters were seen in either groups.

Conclusions: The impact of tube thoracostomy on primary and secondary pneumothorax are mainly reflected on clinical parameters rather than blood gas parameters.

1. Introduction

Pneumothorax is defined as the presence of air in the pleural space. If air is present in the pleural space,[1] one of three events must have occurred: 1) communication between alveolar spaces and pleura; 2) direct or indirect communication between the atmosphere and the pleural space; or 3) presence of gas-producing organisms in the pleural space. From a clinical standpoint, pneumothorax is classified as spontaneous (no obvious precipitating factor present) and traumatic. Primary spontaneous pneumothorax (PSP) is defined as the spontaneously occurring presence of air in the pleural space in patients without clinically apparent underlying lung disease. In secondary spontaneous pneumothorax (SSP) there is an underlying lung pathology that gives rise to the pneumothorax. Emphysema, Bbullous lung disease, cystic fibrosis, idiopathic pulmonary fibrosis,

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lymphangiomyomatosis are some important pathologies that are associated with SSP.[2,3]

Pneumothorax induces various clinical presentation in patient as well as changes in blood gas. A ball valve mechanism may give rise to tension pneumothorax which leads to circulatory and respiratory compromise. With prolonged collapse, the lung becomes vulnerable to infection, as does the pleura cavity when communication between it and the lung persists.[4]

Clinical manifestation of pneumothorax includes chest pain, shortness of breath, signs include tachycardia, tachypnoea, and hypoxia. Blood gas study can reveal decreased partial pressure of oxygen in arterial blood (PaO2), and changes in alveolar-arterial oxygen gradient (AaDO2).[5]

Pneumothorax is a respiratory emergency that requires active intervention, various treatment modalities are available for management of pneumothorax. Tube thoracostomy being one of the most commonly used intervention.

The changes that occur post tube thoracostomy in patients with primary and secondary spontaneous pneumothorax, over different time interval, are not well studied.

In our study we intend to study the effect on tube thoracostomy on clinical and arterial blood gas parameters in primary and secondary spontaneous pneumothorax.

2. Material and Methods

2.1. Study setting

Department of Respiratory Medicine, IPGME&R And SSKM Hospital.

2.2. Timeline

One and half year (February 2016- August 2017).

2.3. Definition of problem

Clinical and arterial blood gas changes among patients of primary and secondary pneumothorax before and after tube thoracostomy.

2.4. Definition of population

Patients with primary and secondary pneumothorax admitted in in-patient department (IPD) of Department of Pulmonary Medicine, IPGME&R, Kolkata.

2.5. Study variables

2.5.1. Inclusion criteria

Patients of primary and secondary pneumothorax in whom plan of management was tube thoracostomy and were of >14 years of age.

2.5.2. Exclusion criteria

Patients with traumatic pneumothorax, patients of spontaneous pneumothorax planned for management other than tube thoracostomy like needle aspiration, 100% supplemental oxygenation, surgery like decortications. Cases of hydropneumothorax, pyopneumothorax and pneumothorax patients developing bronchopleural fistula leading to failure of tube thoracostomy are also excluded. Patients <14 years of age were also excluded.

2.6. Sample size

30 patients. Informed consent has been taken from each patient with approval of institutional ethics committee.

2.7. Sample design

As such no sampling technique is being used. Patients admitted in IPD of Department of Respiratory Medicine were included in the study.

2.8. Control

Not required.

2.9. Method of data collection

1. Preformed structured questionnaire
2. Chest X-Ray:

Patients included in the study has undergone digital chest X-ray at our hospital. Standard plate size 25cm*19cm. Chest X-ray has been done before giving chest drain, when lungs appears to be clinically expanded and before removal of chest tube. Size of pneumothorax was measured using measuring scale.

2.10. Quantification of pneumothorax

Volume of pneumothorax was determined using the Collins formula from the chest X-ray. Collins et al.[6] have described an alternate method for estimating the percentage of collapse. With their method, the distance between the apex of the partially collapsed lung and the apex of the thoracic cavity (distance A), and the midpoints of the upper (distance B) and lower (distance C) halves of the collapsed lung and the lateral chest wall were measured in centimetres. They found that the percentage pneumothorax size could be calculated by the formula (Figure 1).

% of Pneumothorax= 4.2+4.7(A+B+C)Figure 1

2.10.1. Arterial blood gas analysis (ABG)

Arterial blood gas analysis was performed before giving chest drain, 1hour and 24 hours after chest drain, and after removal of chest tube after complete expansion of lungs.

Radial artery sampling was done for ABG analysis. The drawn samples are preferably bubble free, it's processed

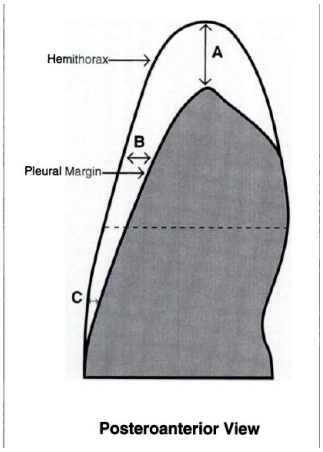

Fig. 1: Measuring the volume of pneumothorax.

immediately using EPOC blood gas analyzer available at Department. Supplemental oxygen was given only to those patients who were hypoxic at presentation and those with tension pneumothorax. During subsequent ABG patients were kept at least 20 minutes in room air before drawing blood samples.

2.10.2. Intercostal tube drainage (ICD)

Intercostal tube drainage was done in all patients included in the study as a definitive management of pneumothorax.

2.10.3. Removal of the chest drain

We have removed chest drain when the lung showed complete expansion both clinically and radiologically, bag collection <50 ml/day for 3 consecutive days, minimal or physiological swing.

Result analysis: The data were tabulated using Microsoft Excel software and analysed using following software.

1. Statistica version 6 [Tulsa, Oklahoma: StatSoft Inc., 2001]
2. GraphPad Prism version 5 [San Diego, California: GraphPad Software Inc., 2007]
3. Null hypothesis were:
   (a) There is no change in clinical parameters before and after tube thoracostomy among cases of PSP and SSP.
   (b) There is no change in ABG parameters before and after tube thoracostomy among cases of PSP and SSP.

3. Results

We had initially taken 37 cases of primary and secondary spontaneous pneumothorax who were planned for tube thoracostomy. Among them 30 cases were successfully treated with tube thoracostomy only, 7 patient required other modalities of managements apart from tube thoracostomy like decortication surgery. Finally 30 cases (n=30) cases of primary and secondary spontaneous pneumothorax were included in the study who had undergone tube thoracostomy as the only modality of treatment.

The results were: Out of 30 cases 11 cases were primary pneumothorax (36.67%) and 19 cases were of secondary pneumothorax (63.33%). Among 11 cases of primary spontaneous pneumothorax 10 cases were male, 1 case was female, among 19 cases of secondary spontaneous pneumothorax 18 cases were male, 2 cases were female. In our study most number of cases of primary spontaneous pneumothorax belongs to younger age group (15-45 years), whereas most number of cases in SSP group (73.68%) belongs to older age group (46-76 years) (P<0.001). In primary group 72.7% cases were smoker, in secondary group 84.21% cases were smoker. Both groups do not show any significant difference in smoking status. In Secondary pneumothorax group average pack year is 27.17, in primary group it is 9.22 (P=0.002, Chi Square test of Proportion).

Among secondary pneumothorax cases 14 cases had COPD (73.68%), among these cases 4 patients also had past history of pulmonary tuberculosis (31.57)%, 1 patient had granulomatosis with polyangitis (GPA). 1 patient had active Pulmonary Tuberculosis. Multiple aetiological condition was present in same patient. Using Collins formula the mean volume of pneumothorax in primary group is 70.6% (standard deviation (SD) 22.55), and in secondary group it is 60.8 (SD 22.21).

The average duration of intercostal tube drainage in primary group is 9.72 (SD 4.14), in secondary pneumothorax group the average duration is 14.21 (SD 9.94).

3.1. Comparison of clinical data between two groups

3.1.1. Pulse rate

In PSP before tube, 1 hour post tube, 24 hours post tube and at removal pulse rates are 112.18 (SD 14.84), 104.72 (SD 12.01), 89.81(SD 5.96), 83.45 (SD 4.2). In SSP before chest tube, 1 hour after tube, 24 hours after tube and after tube removal pulse rates are 104.94 (SD 13.13), 102.52(SD 10.97), 89.26(SD 6.40), 86.21(SD 9.1). There is decrease in tachycardia in both PSP and SSP group. 1 hour, and 24 hours after tube thoracostomy and after removal.

3.1.2. Statistical comparison

Table 1: Comparison between pulse rate (Paired t-test)

Time intervals	P-values (PSP)	P-values (SSP)
Pre and 24 hour	<0.001	<0.001
Pre and at removal	<0.001	<0.001
1 hour and 24 hours	<0.01	<0.01
1 hour and at removal	<0.001	<0.001

3.1.3. Respiratory rate

Table 2: Absolute values:

Type	Before tube	1 hour after tube	24 hours after tube	After tube removal
Primary	27.54	24	18.81	15.9
Secondary	27.68	24.94	19	17

Table 3: Statistical Comparison between Respiratory rate (Paired t-test)

Time intervals	P-values (PSP)	P-values (SSP)
Pre and 1 hour	<0.001	<0.001
Pre and 24 hours	<0.001	<0.001
Pre and at removal	<0.001	<0.001
1 hour and at removal	<0.001	<0.001

There is decrease in tachypnoea in both PSP and SSP group 1hour and 24 hours after tube thoracostomy and after removal.

Table 4: Comparison betweensystolic blood pressure (mm of Hg):

Type	Before tube	1 hour after tube	24 hours after tube	After tube removal
Primary	115.63	116.54	115.81	112.18
Secondary	112	113.78	114.1	113.89

The changes in systolic blood pressure in both primary and secondary pneumothorax groups are statistically not significant.

Table 5: Comparison betweendiastolic blood pressure (mm of Hg):

Type	Before tube	1 hour after tube	24 hours after tube	After tube removal
Primary	71.09	74	73.45	74.18
Secondary	70.52	74.42	76.73	76.1

Table 6: Statistical Comparison between diastolic blood pressure (mm of Hg, paired t-test):

SSP (time intervals)	P-values
Pre and 1 hour	<0.01
Pre and 24 hours	<0.001
Pre and at removal	<0.001

The changes in diastolic blood pressure in primary pneumothorax group is statistically insignificant. Statistical analysis: Secondary spontaneous pneumothorax.

Changes in mean blood pressure in primary group is not significant but in secondary group changes between Pre and 1 hour, Pre and 24 hours, Pre and at removal mean blood pressure are significant. (P<0.05, P<0.001, P<0.001 respectively). (Paired T test) There is an increase in mean arterial pressure in 1hr, 24hr and at removal.

Table 7: Comparison between themean blood pressure (mm of Hg)

Type	Before tube	1hr after tube	24hr after tube	After tube removal
Primary	85.93	88.18	87.57	86.84
Secondary	84.35	87.54	89.19	88.7

3.1.4. Comparison of arterial blood gas data

Table 8: Comparison between pH (paired t-test) pH:

Type	Before tube	1 hour after tube	24 hours after tube	After tube removal
Primary	7.39	7.4	7.4	7.4
Secondary	7.42	7.41	7.42	7.44

In primary pneumothorax group there is no significant change in pH values. In secondary group there is only statistically significant difference between 1 hour and pH at removal (P<0.5). (Paired t-test)

Table 9: Comparison betweenpartial pressure of oxygen (pO2) (mm of Hg)

Type	Before tube	1 hour after tube	24 hours after tube	After tube removal
Primary	72.32	90.78	91.68	86.85
Secondary	71.74	86.1	83.89	83.67

Table 10: Level ofhypoxemia

a): Primary spontaneous pneumothorax

Time interval	Mild (60-79 mm of Hg)	Moderate (40-59 mm of Hg)	Severe (<40 mm of Hg)
Pre Tube	3(27.27%)	2(18.18%)	1(9%)
1 hour post	2(18.18%)	0	0
24 hours post	1(9%)	0	0
At removal	1(9%)	1(9%)	0

b): Secondary spontaneous pneumothorax

Time interval	Mild (60-79 mm of Hg)	Moderate (40-59 mm of Hg)	Severe (<40 mm of Hg)
Pre Tube	8(42.11%)	4(21.05%)	1(5.2%)
1 hour post	9(47.36%)	1(5.2%)	0
24 hour post	5(26.31%)	1(5.2%)	0
At removal	5(26.31%)	1(5.2%)	0

Prethoracostomy hypoxemia was seen in 54.5% in PSP and 68.5% in SSP groups (P=0.209).Corresponding values

Table 11: Overall comparison

Group	Pre-pneumothorax	1 hour post ICD	24 hours post ICD
PSP	54.50%	18.18%	9.00%
SSP	68.50%	52.66%	31.51%

after 1 hour and 24 hours of tube thoracostomy in PSP group was 18.18% and 9% respectively and 52.66% and 31.51% respectively in SSP group. (P-value<0.001, Paired t-test)

Table 12: Comparison betweenpartial pressure of carbon dioxide (pCO2):

Type	Before tube pCO2	1 hour after tube pCO2	24 hours after tube pCO2	After tube removal pCO2
Primary	38.76	37.59	37.31	36.97
Secondary	39.91	39.2	38.45	37.04

In primary pneumothorax group there is no statistically significant changes in between different time intervals. There is no statistically significant change in pCO2 in secondary pneumothorax group either.

Oxygen saturation (SpO2) : In primary group there is significant change between pre and 24 hours SpO2 (P<0.05). In secondary pneumothorax group significant changes observed between pre and 1 hour (P<0.05), pre and 24 hours (P<0.01), pre and at removal SO2 (P<0.01). (Paired t-test)

Table 13: Comparison betweenAaDO2.

Type	Before tube	1 hour after tube	24 hours after tube	After tube removal
Primary	29.39	24.59	11.67	29.44
Secondary	31.74	25.39	21.41	20.02

There are no statistically significant changes in any of the groups for AaDO2. (Paired t-test)

4. Discussion

Our study was a descriptive observational study carried over a period of one year. Patients of Primary and secondary spontaneous pneumothorax requiring tube thoracostomy as management were included in the study. Main objective of our study was to find out the clinical and arterial blood gas parameter changes before and after tube thoracostomy at different time interval, among cases of primary and secondary spontaneous pneumothorax.

In our study population most cases are male (93.33%). Men are more prone to sustain a pneumothorax than women. Studies conducted in USA has shown a male female ratio of 3:1.[7] Higher incidence of spontaneous pneumothorax in men has been attributed to several factors such as higher rates of smoking,[8,9] taller body habitus,[4] and differences in mechanical properties of the lung.[10]

Primary spontaneous pneumothorax occurs mostly in young patients, (72.3% within 4^{th} decade of life) SSP in older age group. (73.8% beyond 4^{th} decade of life) (P=0.001). Literature review has shown most of the cases of PSP occurs in 2^{nd} and 3^{rd} decade of life. Roman et al. has found primary spontaneous pneumothorax to occur commonly in young adults.[11,12]

In a study from Scotland 90% of patients with pneumothorax under the age of 35 had no previous history of lung disease while 80% of patients over the age of 50 years had pre-existing lung disease.[13] Studies that have focused strictly on primary spontaneous pneumothorax, excluding all other forms of pneumothoraxes, have shown a monophasic age distribution with the peak falling in the 15–35 year age.[14,15]

Smoking is a common predisposing factor in both groups.[16,17] But in secondary group number of pack year smoked is more compared to primary group. In our study average pack year in PSP 9.22, in SSP 27.17. This difference is statistically significant (P=0.002). Jansveld et al. has shown smoking as an important risk factor for PSP.[18]

Change in respiratory rate was found to be earliest among both PSP and SSP group. Significant changes were observed within 1 hour of tube thoracostomy. In SSP group similar early changes were observed in pulse rate and diastolic blood pressure also.

In PSP group (table 10 a) Pre thoracostomy 54.54% cases presented with hypoxemia, among which 27.27% had mild hypoxemia (pO2 60-80 mm of Hg), 18.18% had moderate hypoxemia (pO2 40-59 mm of Hg), 1 case (9.1%) presented with severe hypoxemia (pO2< 40 mm of Hg). After 1 hour of tube thoracostomy only 18.18% cases had mild hypoxemia, no cases had moderate or severe hypoxemia, After 24 hours 9% cases had mild hypoxemia, at removal 1 among 11 cases(9%) developed moderate hypoxemia, that case had developed respiratory failure post pleurodesis.

In SSP group (table 10 b) before tube thoracostomy 68.42% cases presented with hypoxemia, among which 42.11% had mild hypoxemia, 21.05% cases had moderate hypoxemia, 1 case (5.2%) presented with severe hypoxemia. After 1hr of tube thoracostomy 52.56% cases had hypoxemia, 47.36% had mild hypoxemia and 5.2% (1 case) had moderate hypoxemia, after 24 hr 31.51% had hypoxemia, among which 26.31% had mild hypoxemia and 5.2% had moderate hypoxemia. Similar changes were observed at the time of tube removal.

In a study by Norris et al.[19] among 12 patients, the PaO_2 was below 80 mm Hg in 9 patients (75%) and was below 55 mm Hg in 2 patients. Our study also showed similar finding.

In both groups after tube thoracostomy there is improvement in hypoxemia, In PSP group only mild hypoxia persisted after 1 hour of tube thoracostomy. In

SSP group only 1 case (5.2%) showed persistent moderate hypoxemia, probably due to underlying lung disease.

Change was observed in SpO2 in PSP group before tube thoracostomy and 24 hours after thoracostomy (P<0.05). In SSP group the changes of SpO2 was significant during all measurements. (P<0.05, P<0.01). In PSP group 3 patients presented with hypoxia, in SSP group 4 patients presented with hypoxia, that was corrected within 24 hours.

The present study did not reveal statistically significant changes regarding alteration of pH, pCO2, and AaDO2 among cases of PSP and SSP pre and post thoracostomy. Causes may be owing to the compensatory mechanisms that operate in case of lung collapse due to pneumothorax. However studies with larger sample size are desirable.

So, considering our initial null hypothesis, we have observed significant changes in clinical parameters (respiratory rate, pulse rate, diastolic blood pressure) before and after tube thoracostomy in both primary and secondary spontaneous pneumothorax cases.

Regarding arterial blood gas values peripheral arterial oxygen saturation showed significant changes before and after tube thoracostomy in both primary and secondary pneumothorax cases.

Tube thoracostomy is considered the treatment of choice in pneumothorax[20,21], monitoring the patients undergoing tube thoracostomy is an integral part of the management. With availability of multiple parameters and modalities choosing the correct one is important.

So the study shows that cases of primary and secondary pneumothorax requiring tube thoracostomy can be best assessed and monitored by clinical parameters like examination of pulse, respiratory rate, blood pressure and non-invasive parameter like pulse oximetry.

4.1. The study ad few limitations which are as follows

1. To maintain a homogenous sample size cases with primary and secondary spontaneous pneumothorax those requiring tube thoracostomy were included in the study. The study was carried out for only one year. So the sample size in our study in small, which is the chief limitation of our study.
2. HRCT thorax was not done in all cases, Primary and secondary pneumothorax was classified, in those cases, based on the history and clinical findings.
3. Supplemental oxygen has to be given in some patient due to hypoxia before ABG can be arranged.

5. Conclusions

The present study shows that there is serial improvement of vital signs like pulse rate, respiratory rate, diastolic blood pressure and oxygen saturation following tube thoracostomy among cases of both primary and secondary spontaneous pneumothorax. There is decrease in tachypnea, tachycardia post tube thoracostomy and improvement of hypoxia. The study also shows that functional improvement following tube thoracostomy among cases of spontaneous pneumothorax can be better assessed by simple clinical parameters like pulse rate, respiration, blood pressure and pulse oximetry compared to arterial blood gas analysis.

6. Conflicts of Interests

None declared.

7. Source of Funding

None.

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