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Original Research Article

FACTORS AFFECTING LUNG EXPANSION AND DURATION OF TUBE THORACOSTOMY IN SPONTANEOUS PNEUMOTHORAX

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Abstract

Background: Intercostal tube drainage (ICD) is the main treatment of pneumothorax. Studies on spontaneous pneumothorax and ICD duration are limited. **Objectives**: To estimate overall tube thoracostomy duration in patients with spontaneous pneumothorax and study factors delaying lung expansion. **Materials and Methods:** In this prospective study, details of 58 patients were collected in a structured proforma. Duration of thoracostomy tube, hospital stay and association with the etiological factors were assessed, using SPSS version 25. Results were expressed in percentage, mean and wherever relevant, p value was also calculated. **Results:** The mean ICD duration was 13.2±7.6 days, mean air leak duration was 8.67±7.72 days and mean hospital stay was 14.03±7.9 days. The mean duration was higher with history of current COVID-19 infection (19.5±17.7 days), past TB (15.25±9.2 days), recurrent pneumothorax (14.1±8.2 days), COPD (13.79±8 days), past COVID-19 (11.2±7.3 days), active pulmonary TB (10.75±6.8 days) and type 2 diabetes mellitus (10.23±5 days). Secondary infection (n=17,29.3%, p value=0.006), and a need for intercostal drainage bag change or reinsertion (n=16, 27.6%, p value=0.001), had association with delay. Lung did not expand in one patient and three patients died due to other illnesses. Nearly all patients had a favorable outcome with expansion of the lungs. **Conclusion:** The maximum duration of ICD was for COVID-19 cases, followed by previous TB patients, recurrent pneumothorax and COPD. Delayed lung expansion was associated with tube-related factors. In most cases with persistent air leak, lung expanded slowly without surgical management, indicating early surgical referral may not be necessary in resource limited setting.

INTRODUCTION

Spontaneous pneumothorax may be primary or secondary, the latter being associated with an underlying lung disease, namely COPD and Tuberculosis.[1] Even in the absence of an obvious etiology, abnormalities like apical blebs and bullae may be seen on CT scan in up to 90% cases.[2]

Current guidelines recommend conservative management for small and asymptomatic cases of Pneumothorax, where, the rate of lung re-expansion was found to be 1.4% -3 % (average rate being 2.2%) per day.[3] Tube thoracostomy (intercostal Tube Drainage-ICD) is the treatment of choice when there is a large, symptomatic, non-resolving, traumatic or tension pneumothorax.[4] The patient is then followed up clinically and radiologically to check whether lung has expanded.[5,6]

Several factors, both etiological and tube-related, can prolong the duration of ICD. In case of a persistent air leak, possibility of a bronchopleural fistula has to be considered.[7] Complications like tube malposition, blocked drain, chest drain dislodgement, subcutaneous emphysema, fistulae and empyema during the course of intercostal tube drainage, may delay early and prompt tube removal.[8] Delayed lung expansion requires treatment with low-pressure high-volume suction and occasionally, measures like pleurodesis, ambulatory one-way valve (Heimlich valve) or surgery.[9] Studies on spontaneous pneumothorax and tube thoracostomy duration are

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limited and identification of the factors responsible for prolonged treatment is relevant.

MATERIALS AND METHODS

Objectives of the study were to find out the overall duration of tube thoracostomy required for lung expansion in patients with spontaneous pneumothorax and to study the factors predisposing to delayed lung expansion after intercostal tube insertion in spontaneous pneumothorax. Consecutive adult patients, who underwent tube thoracostomy for spontaneous pneumothorax between 1st April 2021 and 31st April 2022 were studied after getting permission from Institutional review board and written informed consent. Exclusion Criteria were traumatic pneumothorax, hemothorax, post-lung resection patients on chest drain, younger than 18yrs and older than 80 years, empyema and pneumothorax resulting from positive pressure ventilation in ICU.

Sample size was calculated using the formula $(1.96)^2(SD)^2/(d)^2$, where SD was the standard deviation from an unpublished study titled "Predictors of prolonged Intercostal Tube Drainage in Pneumothorax" by Harsha PV (SD= 15.4 with margin of error, d = 4).Sample size was 56. All cases were followed up and demographic and clinical details, as well as comorbidities were recorded. Tube thoracostomy was done with a 28 F intercostal tube tube under local anesthesia. Complete blood count, chest X-ray, sputum AFB and CBNAAT, Rapid Antigen Test and RTPCR for COVID-19 were done. Lung expansion was assessed radiologically by comparing distance of collapsed lung margin from chest wall at the level of hilum in subsequent chest X-rays. Repeat chest X-ray was taken at 24 hours, 72 hours, seventh day and when indicated. The chest Xray is termed "not expanded" (comparable to day 0 CXR prior to chest drain insertion), "fully expanded" (with lung margins well apposed and hence not separately distinguishable with regards to chest wall) or "partially expanded" (in between the aforementioned stations). High Resolution Computerised Tomogram (HRCT) thorax was also taken to assess lung parenchyma. After ICD insertion, continued bubbling within tube thoracostomy bag after 5 days was taken as persistent air leak for the purpose of this study. Low pressure (15-20 cm water pressure) high volume suction was applied by day 4-5 if air leak was present and a thoracic surgeon's opinion was obtained if it had not subsided by 5-7 days in accordance with BTS and ATS guidelines. Any drain developing within ICD tube was sent for culture. When there was no bubbling even on forced expiration and chest X-ray confirmed lung expansion, ICD tube was clamped for 24 hours and chest X-ray repeated. If there was no evidence of Pneumothorax, ICD tube was removed. For the purpose of this study, delayed lung expansion was considered, when air leak persisted for more than 14 days from day of initiation of chest tube drainage.

All data were entered into Microsoft excel and were analyzed using SPSS version 25. Results were expressed in proportions, percentages or as mean with standard deviation. Association between delayed lung expansion and related factors, was calculated by means of chi-squared test, Fisher's exact test or student t test.

RESULTS

Fifty eight patients with age between 18 to 80 years, (mean of 56.28±16.1 years) were included. Primary Spontaneous Pneumothorax was seen in younger people, average age being 23.2 years (range 18 – 39 years); whereas, spontaneous pneumothorax was more common in the elderly. Males were more in number when compared to females, with a male: female ratio of 13.5: 1. Breathlessness was the most common presenting complaint, seen in 93.1 % of patients (n=54), followed by chest pain (n=40, 69%), cough (n=34, 58.6%), expectoration (n=24, 41.4%), wheezing (n=11, 19%), fever (n=6, 10.3%), loss of weight and appetite (n=10, 17.2%) and hemoptysis (n=2, 3.4%).

Risk Factors for Pneumothorax:

The majority of patients gave a history of smoking, with 26 out of 58 (44.8%) being current smokers, whereas 21 out of 58 (36.2%) were ex-smokers. Non-smokers were few (n=11, 19%). The 10 patients (17.2%) with previous history of pneumothorax, were treated with either tube thoracostomy alone (n=6, 10.3%) or with tube thoracostomy along with pleurodesis (n=4, 6.9%). Among the 10 cases of recurrent pneumothorax, current admission was for third episode of secondary spontaneous pneumothorax in 4 patients, whereas the remaining 6 presented for the second time. In those with the third episode, two had previously underwent tube thoracostomy alone, whereas the other two had history of treatment with medical pleurodesis along with tube thoracostomy. Among patients, a majority had COPD (n=31, 53.4%), followed by PTB (n=25, 43.1%), T2DM (n=13, 22.4%) and COVID-19 (n=12, 20.6%). Of the 25 cases with history suggestive of PTB, 17 had a history of Pulmonary Tuberculosis (PTB) in the past (29.3%), whereas 8 had active PTB (13.8%). Among the study subjects, Mycobacterium tuberculosis was recently detected in the sputum NAAT samples of 7 patients (12.1%). The confirmed cases of PTB were on anti-tuberculous therapy during the study. One patient with recent history of category C COVID 19 pneumonia treated with non-invasive ventilation within the previous month, had pneumomediastinum at the time of COVID 19 infection, which was confirmed with CT Thorax and managed conservatively. No clear etiology could be identified in 5 cases (8.6%), and these were considered as primary spontaneous pneumothorax. One female patient had lymphangioleiomyomatosis with multiple cysts on CT Thorax. Two patients had pneumonia,

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Four out of five patients with primary spontaneous pneumothorax had tall stature, in one of whom apical bullae was seen on CT Thorax. On sputum gram staining, culture and sensitivity and AFB smear, 17 out of 58 patients had organisms, 5 out of 17 were gram positive organisms, 7 were gram negative organisms and 5 were AFB smear positive. Culture and sensitivity yield was low, with Pseudomonas aeruginosa, Klebsiella pneumoniae and Acinetobacter baumannii being the only organisms identified. Most patients were diagnosed with left sided pneumothorax (n=31, 53.4%), some with right sided pneumothorax (n=25, 43.1%) and one with bilateral pneumothorax (n=1, 1.7%).

Outcome:

Three of the study subjects died during follow up, two from acute coronary events and one from COPD and respiratory failure. The overall tube thoracostomy duration was 13.2±7.6 days (3 to 32 days), while mean hospital stay was 14.03±7.9 days. During their hospital stay, lung expansion was monitored clinically. Mean air leak duration in terms of bubbling in chest drain was 8.67±7.7 days [Table 1]. Thirty two out of 58 cases (55.1%) had persistent air leak, lasting more than 5 days. In few of the cases, a turbid drain was noted within the chest drain (n=18, 31%) and the same was sent for culture and sensitivity, with organisms identified in only 2 cases (3.4%), one of which was Pseudomonas aeruginosa. The chest Xray findings in terms of whether lung was "not expanded", "fully expanded" or "partially expanded" were as follows, with the category "not applicable" including cases no longer on chest drain or where chest X ray was not available. This is shown in [Figure 1] In cases with persistent air leak, a low-pressure high-volume suction was given, as per existing guidelines. It was applied in 39.7%, starting as early as 4 days, and going as far as 15 days, the latter carried out in a patient who developed air leak after clamping the chest drain prior to removal, for a lung that was thought to have expanded. In view of thoracostomy tube blockage, malposition, kinking and dislodgement, and in cases with multiple loculated pneumothoraces, change of intercostal drainage bag (n=5, 8.6%) or chest drain reinsertion (n=11, 19%) were done, as and when indicated. To prevent recurrence of pneumothorax, medical chemical pleurodesis was done with either 10% povidone iodine (betadine) or 4g of Medical grade talc (Steritalc), depending on availability of drug. 10.3% (n=6) and 5.2% (n=3) of patients, underwent pleurodesis with povidone iodine and Medical grade talc, respectively. One patient with a bronchopleural fistula, was sent home on Heimlich valve attached to intercostal tube, with a partially expanded lung. Among the 58 cases of spontaneous pneumothorax, lung was fully expanded in most cases (n=49, 84.5%), partially expanded in 5 (8.6%) and not expanded in one (1.7%). The latter case resulted from accidental expulsion of chest drain following which; the patient refused a second tube thoracostomy procedure. Of the cases with partially expanded lung, one with radiologically proven bronchopleural fistula opted for ambulatory management on Heimlich valve, whereas the rest had only a small pneumothorax, amenable to conservative management. This is shown in [Figure 2]. The overall duration of tube thoracostomy was greatest with current COVID 19 infection (COVID 19 RTPCR positive cases), followed by, cases with previous history of PTB, recurrent pneumothorax, COPD, previous history of COVID 19, active PTB and T2DM [Table 2]. Delayed lung expansion was noted in 33% of patients (n=18).

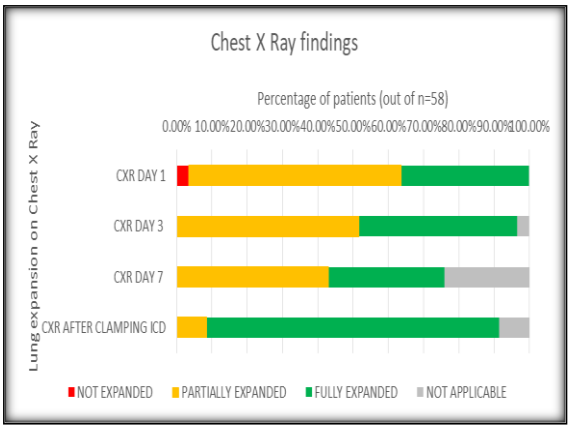

Figure 1

Factors Associated with Delayed Lung Expansion:

Delayed lung expansion showed no association with the age (p value= 0.76). The relationship of other factors with regard to delay in lung expansion is given in [Table 3]. There was significant association between delayed expansion and tube-related factors like infection, blockage, malposition, kinking and dislodgement. There was no difference among those cases who received early suction (<5 days) and those that received suction after 5 days of persistent air leak, with respect to lung expansion. Of the 18 cases labelled as delayed lung expansion, 14 of them fully expanded in due course and 4 of them partly expanded, with most of the latter group having only a small pneumothorax treatable by conservative measures. One was discharged on Heimlich valve.

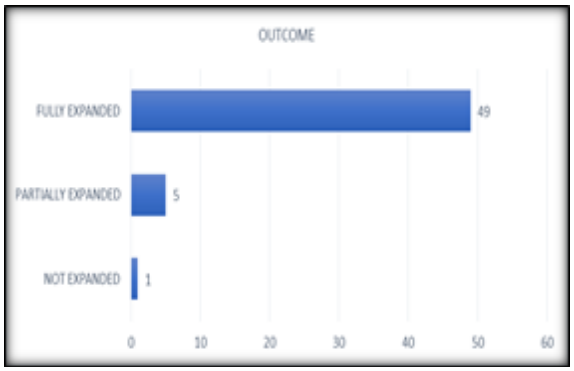

Figure 2

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Table 1: Mean ICD duration, air leak duration, hospital stay

	Number of days
Mean ICD duration	13.2 (±) 7.6
Mean air leak duration	8.67 (±) 7.7
Mean hospital stay	14.03 (±) 7.9

Table 2: Overall duration of tube thoracostomy with respect to each etiological factor

Etiological factors	Overall duration of tube thoracostomy (days)
Previous pulmonary tuberculosis	15.25 (±) 9.2
Active pulmonary tuberculosis	10.75 (±) 6.8
Chronic obstructive pulmonary disease	13.79 (±) 8.0
Previous COVID 19 infection	11.20 (±) 7.3
Current COVID 19 infection	19.50 (±) 17.7
Type 2 Diabetes Mellitus	10.23 (±) 5.0
Recurrent pneumothorax	14.10 (±) 8.2

Table 3: Association between factors and delayed lung expansion on treatment with chest drain

Factors	n	Frequency % (Out of total n=58)	Cases showing delay	Delay as proportion of n (%)	P value w.r.t delay in lung expansion
Primary spontaneous pneumothorax	5	8.6	2	40	1
COPD	29	50	10	34.5	0.77
PTB (healed and active)	24	41.4	9	37.5	0.51
NAAT positive PTB	7	12	1	14.3	0.41
Previous pneumothorax	10	17.2	4	40	0.71
COVID19	12	20.7	3	25	0.73
T2DM	13	22.4	2	15.4	0.18
Smoking habit	44	75.9	15	34.1	0.08
Other risk factors for pneumothorax	7	12.1	3	42.9	0.67
Isolation of organism from sputum	17	29.3	6	35.3	0.79
Infection and presence of turbid drain within ICD tube	17	29.3	10	58.8	0.006
Need for ICD bag change / reinsertion (measure of tube blockage + malposition + kinking + dislodgement/ multiple encysted pneumothorax)	16	27.6	12	20.7	0.001

DISCUSSION

The literature on spontaneous pneumothorax with tube thoracostomy is limited. In our study of 58 consecutive patients, male: female ratio was 13.5: 1. This was in agreement with a study by Kim D et al., where the male: female ratio was 4-10: 1.[10] A study in the Indian population by Gupta D et al., also noted the increased incidence in male sex, with a ratio of 5: 1.[11] The mean age of our group was 56.28±16.1 years. Incidence of spontaneous pneumothorax as per our study, tended to fall after 18 – 30 years of age (n=5, 8.6%), only to rise again and reach a peak at 60 – 70 years (n=17, 29.3%). This biphasic distribution of pneumothorax, has found mention in previous studies, and the early and late peaks are due to primary spontaneous pneumothorax and secondary spontaneous pneumothorax, respectively.[10,11] Kim et al. reported high occurrence in the age group 15-34 years, which then declined with age, only to rise again ≥ 65 years of age.[10] The mean age of cases with primary and secondary spontaneous pneumothorax were 26.3±2.19 years and 53.42±2.07 years, respectively, as per a study by Dhua A et al.[12] Most patients presented with breathlessness (93.1%), followed by chest pain (69%) and cough (58.6%). These were also the most common symptomatology as per Ghimire et al.[13] There were ex-smokers (36.2%), current smokers (44.8%) and patients with COPD (53.4%), past history of PTB (29.3%), active PTB (13.8%), COVID-19 (20.6%), DM (22.4%), previous pneumothorax (17.2%) and primary spontaneous pneumothorax (8.6%) in our study. COPD seemed to be the commonest comorbidity in these patients, followed by pulmonary TB, COVID-19, DM and past history of pneumothorax, and majority of them were smokers. 12.1% patients had other risk factors, namely pneumonia, lymphangioleiomyomatosis and tall stature. Among the patient with tall stature, one had an apical bulla documented on HRCT Thorax. Smoking habit was a common risk factor (70%) in patients with pneumothorax in the present study. Similar observation was done by Dhua A et al. The commonest comorbidity associated with spontaneous pneumothorax was COPD, as per Kim D et al., Dhua A et al. and Ghimire R et al.[10,12,13] Meanwhile, studies by Gupta D et al., Patil S et al. and Gayatridevi Y et al. showed that PTB was more common than chronic obstructive pulmonary disease. The influence of COVID-19 on this matter is unknown. The mean tube thoracostomy duration was 13.2±7.6 days, and mean hospital stay was 14.03±7.9 days from our study. This is in agreement with the observation of a mean duration of drainage of 15.7 ± 11.3 days, and a mean duration of hospitalization of 9.2 ± 5.1 days, by Sevinc S et al.[14] The mean duration of ICD for each of the etiological factors, was also calculated, and was found to be greatest in spontaneous pneumothorax associated with current

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COVID-19 infection (19.5±17.7 days), followed by cases with previous history of tuberculosis (15.25±9.2 days), recurrent pneumothorax (14.1±8.2 days), patients having COPD (13.79±8 days), cases with past history of COVID-19 (11.2±7.3 days), active PTB (10.75±6.8 days) and T2DM (10.23±5 days). Studies comparing overall chest drain duration needed for isolated etiological risk factors were limited. The duration of chest drain in primary spontaneous pneumothorax was 9.9±7.8 days according to Namwaing P et al.[15] The mean air leak duration in the present study was 8.67±7.72 days, with prolonged air leak beyond 5 days noted in 55.2 % patients (n=32). Prolonged air leakage was noted in 26 (52.2%) cases by Sevinc S et al.[14] Chee C et al. have reported that a majority of air leaks resolved by 14 days of chest drain (100% of Primary Spontaneous Pneumothorax by 15 days and 79% of Secondary Spontaneous Pneumothorax by 14 days) and therefore suggested a conservative approach in management prior to this period.[16] Cerfolio R et al. have also concluded that by 14 days, chest expansion will be achieved in a majority of cases, and chest drain can therefore be removed safely, if patient is asymptomatic, with no subcutaneous emphysema and if pleural space deficit has not increased in size.[17] Hence we defined delayed lung expansion as cases where resolution of pneumothorax has not been achieved even by fourteenth day of chest drain insertion. Such a delay was seen in 31% of patients in the present study. This study found that delayed chest expansion with tube thoracostomy could be linked to tube-related factors, but had no association with COPD, PTB, COVID-19, past history of pneumothorax, DM, smoking, sputum positivity or primary spontaneous pneumothorax. Secondary infection and appearance of a turbid drain within the chest tube (29.3%, p value=0.006), as well as, a need for ICD bag change or chest tube reinsertion (27.6%, p value=0.001), had a significant association with delay. The latter could be taken as an indirect measure of tube blockage, malposition, kinking or dislodgement, and also of multiple encysted pneumothoraxes requiring multiple ICD insertions. A study by Chan J et al. also noted that failure of tube thoracostomy was associated with the presence of tube related complications (1.55; 1.0-2.3; p=0.03), with tube related complications encountered in 24 % of cases (n=214).[18] Further studies are required to comment on whether there will be a difference in the same, with the use of a small-bore chest drain, instead of the large-bore chest tubes used in these centers. By the end of our study, lung was fully expanded in most cases (84.5%), partially expanded in 8.6% and not expanded in one case (1.7%). One patient with partially expanded lung had a bronchopleural fistula and was managed with Heimlich valve, whereas the rest had only small pneumothoraxes. In the study by Dhua A et al, lung fully expanded in 91.67 % of cases, whereas, Chee et al. observed lung re-expansion in 87 % cases (9 of the other patients were discharged with residual pneumothoraxes whereas 5 needed surgery).[12,16] Three patients died due to other illnesses during follow-up, but nearly all other patients had a favorable outcome, even without surgical intervention. In a resource poor setting, a conservative approach might still yield good results, despite existing guidelines insisting on early surgical referral. In conclusion, the overall chest drain duration was maximum for spontaneous pneumothorax associated with current COVID-19 infection, followed by those with past history of TB, recurrent pneumothorax, COPD, history of COVID-19, active PTB and T2DM. Secondary infection, a need for ICD bag change or chest tube reinsertion, had a significant association with delayed lung expansion; the latter could be taken as an indirect measure of tube blockage, malposition, kinking or dislodgement, and also of multiple encysted pneumothoraxes requiring multiple ICD insertions. The need for surgical intervention was very less for complete expansion of the lung.

CONCLUSION

A mean duration of two weeks of intercostal is expected in spontaneous pneumothorax. The maximum duration of ICD was for COVID-19 cases, followed by previous TB patients, recurrent pneumothorax and COPD. Delayed lung expansion was associated with tube-related factors. In most cases with persistent air leak, lung expanded slowly without surgical management, indicating early surgical referral may not be necessary in resource limited setting.

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