Original Article

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Prevalence of Pulmonary Hypertension as Post-tuberculosis Lung Sequelae: A Hospital-based Cross-sectional Study

Internal Medicine Section

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ABSTRACT

Introduction: Pulmonary Tuberculosis (PTB) remains a major global health burden, particularly in developing countries. Even after microbiological cure, a significant proportion of patients develop post-tuberculosis (post-PTB) lung sequelae, which may predispose them to Pulmonary Hypertension (PH), a condition associated with increased morbidity and mortality.

Aim: To determine the prevalence and severity of pulmonary hypertension in patients with post-tuberculosis lung sequelae.

Materials and Methods: This hospital-based cross-sectional study was conducted at BJ Government Medical College (GMC) and Sassoon Hospital, Pune, Maharashtra, India, from October 2022 to March 2023. A total of 70 patients with post-tuberculosis lung sequelae were included. Clinical profile, chest radiographic findings, Electrocardiographic (ECG) changes, and echocardiographic parameters, including Right Ventricular Systolic Pressure (RVSP), Tricuspid Regurgitation Velocity (TRV), were assessed. Data were analysed using descriptive statistics.

Results: There were 55 males and 15 females. The majority of patients were middle-aged males with a high proportion of smokers. PH was detected in 29 (41.43%) patients. Mild, moderate, and severe PH were observed in 4 (5.71%), 17 (24.29%), and 8 (11.43%) patients, respectively. The mean RVSP was 39.86±17.74 mmHg and the mean TRV was 2.75±0.58 m/s in patients with extensive radiological lung involvement.

Conclusion: The present study highlights a high prevalence (41.43%) of PH among post-PTB patients. Echocardiographic screening revealed elevated RVSP in patients with PH, and TRV was elevated in a significant proportion of cases. Thus, PTB patients require long-term follow-up to diagnose and treat functional impairment after cure.

Keywords: Echocardiography, Pulmonary circulation, Right ventricular dysfunction

INTRODUCTION

Mycobacterium tuberculosis, discovered by Robert Koch in 1882, contributes substantially to the global burden of disease [1,2]. Despite modern and efficient treatment, Tuberculosis (TB) continues to cause significant morbidity and mortality [1]. TB remains one of the leading causes of death from a single infectious agent worldwide [3]. Moreover, India accounts for approximately 25% of the global TB burden [4]. Despite the high success rate of modern antitubercular drugs, studies have demonstrated >50% of residual lung function impairment in treated PTB patients. Apart from obstructive and restrictive abnormalities, hemoptysis, aspergilloma, bronchiectasis, fibrothorax, pleural thickening, and TB empyema are known complications in treated patients of PTB. In addition to the permanent lung damage that frequently results from active and previously treated PTB, pulmonary vascular disease is likely an under-recognised and significant PTB-associated complication [5-7].

Pulmonary Hypertension (PH) is a syndrome resulting from restricted flow through the pulmonary arterial circulation, resulting in increased pulmonary vascular resistance and ultimately in right heart failure [8]. The pathophysiology of the development of PH in treated PTB cases involves residual structural lung damage and functional abnormalities leading to gas exchange abnormalities and chronic hypoxia [9]. Patients with post-tubercular pulmonary fibrosis must be evaluated for PH using a multimodality approach, which includes a series of investigations ranging from a thorough clinical evaluation, non invasive imaging, and Right Heart Catheterisation (RHC), which is considered the “gold standard” for the diagnosis of PH. Transthoracic echocardiography provides several measures that can be used to estimate right heart hemodynamics, like Pulmonary Artery Systolic Pressure (PASP), calculated from the TRV and is used to alert suspicion of PH. The estimation of PASP is based on the peak TRV, taking into account the Right Atrial Pressure (RAP) as described by the simplified Bernoulli equation [1]. In a study by Chatterjee R et al., Out of the 60 patients of PTB with varying degrees of radiologically confirmed lung fibrosis, 8 (13.33%) patients were found to have PAH [9]. In a study by Kumar S et al., out of 80 patients of PTB, 38 (47.5%) patients had low probability of PH, 18 (22.5%) patients had intermediate probability of PH and 24 (30%) patients had high probability of PH [1]. Pulmonary Tuberculosis (PTB) is not traditionally classified as a direct pulmonary cause of PH in Western literature. However, India still being a country with a high TB burden, PH due to post-TB lung fibrosis is not a very uncommon entity [10]. Moreover, the prevalence estimates of PTB-associated PH vary according to patient population, lung disease severity, and clinical setting [11]. Despite India bearing a high burden of tuberculosis, data on the prevalence and severity of pulmonary hypertension among patients with post-tuberculosis sequelae remain limited, especially from tertiary care settings [9]. Most available studies are small, region-specific, or focus on active disease, underscoring the need for further evidence in treated post-TB populations [1,5]. Thus, the present study was undertaken with the aim of determining the prevalence of PH in post-PTB sequelae.

MATERIALS AND METHODS

This hospital-based cross-sectional study was conducted at the BJ Government Medical College and Sassoon Hospital, Pune, Maharashtra, India, from October 2022 to March 2023. A total of

70 patients with post-tuberculosis lung sequelae were included after taking approval from the Institutional Ethics Committee [Ethical approval number:0922162-162] and written informed consent from each patient.

Sample size calculation: The sample size (n) was calculated according to the formula [12]:

$$N = \frac{(Z_{\frac{\alpha}{2}}^2)^2 \; P\,(1-P)}{d^2}$$

$n=(Z^2 \times P \times (1-P)) / d^2$

where Z=1.64 (90% confidence level),

P=6.55% (0.0655),

d=0.05.

$n=(1.64^2 \times 0.0655 \times 0.9345) / (0.05^2)$

n=65.85

The final sample size was rounded to 70.

Inclusion criteria: Patients aged ≥18 years of either gender with h/o PTB, patients with a h/o long standing breathlessness with or without cough.

Exclusion criteria: Patients with extra-pulmonary TB, active PTB, chronic obstructive pulmonary disease or emphysema, restrictive lung disease, connective tissue disease, chronic pulmonary embolism, pulmonary artery obstruction, idiopathic PH, cardiac valvular lesion, coronary artery disease, cardiac arrhythmia and congenital heart disease; Patients who were human immunodeficiency virus positive; Pregnant women; Patients who refused to sign informed consent form. Out of 74 screened patients, 70 were included and four were excluded {Human Immunodeficiency Virus (HIV) positive =1, refusal =1, others =2}

Study Procedure

Upon enrollment, demographic data were noted. A detailed history was obtained, and a complete physical examination was carried out on all the patients. Subsequently, a chest X-ray and electrocardiographic examinations were performed, and findings were recorded. Echocardiography was performed and the diagnosis of PH was reached. The chest X-ray was evaluated for various radiological signs of TB-related parenchymal changes, including fibrosis, fibrothorax, bronchiectasis, bullae, etc. All the findings were noted. Patients were classified into "current smoker," "ex-smoker," and "never smoker" categories based on the following definitions:

- **Never smoker:** someone who had never smoked, Ex-smokers: Those who had stopped smoking at least 12 months before the interview, and
- **Current Smokers:** Persons who had smoked greater than 20 packs of cigarettes in a lifetime or greater than 1 cigarette per day for a year [13].

Apart from detecting and excluding patients of ischemic heart disease, following signs suggestive of PAH were recorded: (a) sinus tachycardia, (b) right axis deviation, (c) P pulmonale, (d) Right Bundle Branch Block (RBBB), (e) RVH as evident by R/S ratio in V1 >1, (f) QT prolongation defined as QT interval >440 ms, (g) low voltage complexes as defined by QRS complex, voltage <0.5 mV in frontal plane leads. All patients in the study were subjected to a 2D echocardiography, done by a VIVID 7 model of GE Systems with a multi-frequency probe with a range of 2–3.5 MHz transducer. Both 2D Echo and M-mode studies were done. M-Mode echo was used for evaluating right ventricular dimensions specifically Right Ventricle Internal Diameter at End-Diastole (RVID-ED). Right Ventricular Systolic Pressure (RVSP) was estimated by measuring maximum jet velocity with the help of Doppler.

RVSP was noted as a measure of pulmonary hypertension. The calculated RVSP can then be interpreted by itself or further converted to Mean Pulmonary Arterial Pressure (mPAP) using the following formula: mPAP=0.61×RVSP + 2 mmHg. mPAP >25 mmHg is suggestive of PH [14]. The presence of PH was defined as RVSP ≥35 mmHg. Moreover, the severity of PH was categorised as normal, mild, moderate, and severe based on RVSP values of <35, 35 – 45, 46 – 60, and >60 mmHg, respectively [15].

The peak TRV was used in conjunction with the presence of other echo PH symptoms to determine the probability of PH. The patients were separated into three groups based on their PH risk: low, intermediate, and high. Low PH-risk was defined as TRV<2.8 m/s (or not measurable); intermediate risk was defined as TRV 2.9–3.4 m/s; and high risk was defined as TRV >3.4 m/s [16].

STATISTICAL ANALYSIS

Data was entered and analysed using Microsoft Excel 2021 and Jeffrey's Amazing Statistics Program (statistical software) (JASP) software (version 0.95.2). Descriptive statistics were expressed as mean, standard deviation, and n (%).

RESULTS

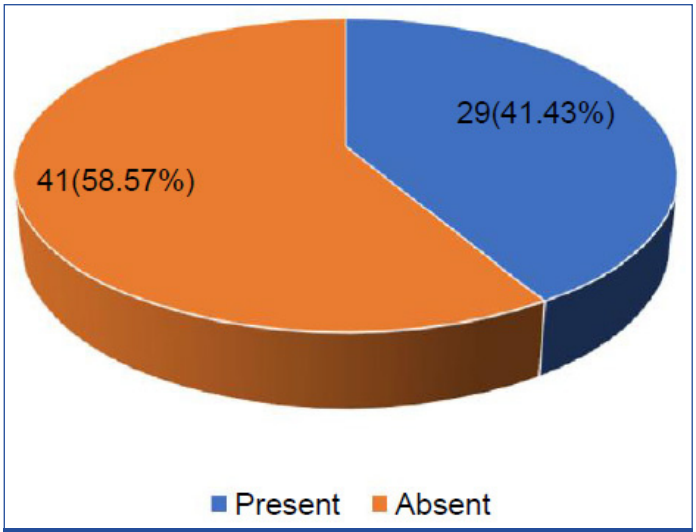
Distribution of patients according to demographic parameters was as depicted in [Table/Fig-1]. The majority of patients were middle-aged males with a high proportion of smokers. Clinical profile of patients was as shown in [Table/Fig-2]. The majority of the patients had their PTB diagnosed 4-7 years ago (72.86%). The mean duration since TB diagnosis was 7.04±2.69 years. Dyspnoea was universally present, followed by cough as the most common respiratory symptom. Fibrocavitary changes and fibrosis were the predominant radiological abnormalities among post-TB patients. Distribution of patients according to the prevalence of pulmonary hypertension was as per [Table/Fig-3]. Distribution of patients according to Echocardiographic parameters was as summarised in [Table/Fig-4].

Demographic parameters	Category	n (%)
Age range (in years)	41-50	24 (34.29)
	51-60	31 (44.29)
	61-70	15 (21.43)
Gender	Male	55 (78.57)
	Female	15 (21.43)
Smoking	Current smoker	51 (72.86)
	Ex-smoker	8 (11.43)
	Never smoker	11 (15.71)

[Table/Fig-1]: Demographic parameters (N=70).

Parameters	Category	n (%)
Duration since TB diagnosed	4-7 years	51 (72.86)
	8-12 years	14 (20.00)
	>12 years	5 (7.14)
Treatment completed	Yes	62 (88.57)
	No	8 (11.43)
Presenting complaints	Dyspnoea	70 (100.00)
	Cough	57 (81.43)
	Sputum	28 (40.00)
	Wheezing	26 (37.14)
Chest X-ray findings	Normal	17 (24.29)
	Fibrocavitary	28 (40.00)
	Fibrosis	21 (30.00)
	Destroyed lung	2 (2.86)
	Bronchiectasis	2 (2.86)
Zones of lung involved	0	17 (24.29)
	1	15 (21.43)
	≥2	38 (54.29)

[Table/Fig-2]: Clinical profile of patients (N=70).



[Table/Fig-3]: Distribution of patients according to prevalence of pulmonary hypertension (n=70).

Parameters	Severity of pulmonary hypertension	n (%)
RVSP (mmHg)	<35 [normal]	41 (58.57)
	35-45 [mild]	4 (5.71)
	46-60 [moderate]	17 (24.29)
	>60 [severe]	8 (11.43)
TRV (m/s)	<2.8 [Low PH-risk]	41 (58.57)
	2.9-3.4 [intermediate risk]	21 (30.00)
	>3.4 [high risk]	8 (11.43)

[Table/Fig-4]: Distribution of patients according to Echocardiographic parameters (N=70).

The mean RVSP was 39.86±17.74 mmHg and the mean TRV was 2.75±0.58 m/s. Distribution of patients with PH according to ECG findings was as shown in [Table/Fig-5]. The P pulmonale and right ventricular hypertrophy were the most frequent ECG abnormalities among patients with pulmonary hypertension.

ECG findings	n (%)
P pulmonale	14 (48.28)
RVH	12 (41.38)
Sinus tachycardia	11 (37.93)
RBBB	7 (24.14)
QT prolongation	2 (6.89)

[Table/Fig-5]: Distribution of patients with PH according to ECG findings (n=29).

DISCUSSION

Tuberculosis (TB) is a widespread disease and the leading cause of death from bacterial infections [17]. PH is associated with poor outcomes and higher mortality, regardless of its aetiology or clinical group [18,19]. Both active and treated PTB can lead to PH, possibly through different pathophysiological mechanisms [11]. Transthoracic echocardiography estimates right heart hemodynamics by calculating PASP from TRV. This method, which incorporates peak TRV and RAP, helps in identifying potential PH [1]. However, prevalence estimates of PTB- associated PH vary depending on patient population, lung disease severity, and clinical setting [11]. Therefore, this study aimed to determine the prevalence of PH in post-PTB sequelae.

In the present study, the majority of the patients were in the age group of 51-60 years (44.29%). The age of patients ranged from 42 to 70 years with mean age was 54.43±7.45 years. The patients were predominantly males (78.57%) with a male-to- female ratio of 3.67. These findings were in agreement with studies by Ahmed AEH et al., [20], Bhattacharyya P et al., [21], Chatterjee R et al., [9] and Louw E et al., [22]. In the present study, out of the total patients, the majority of the patients were current smokers (72.86%) followed by never smokers (15.71%), and ex-smokers (11.43%). Findings of the present study were in alignment with studies by Louw E et al., [22] and Bhattacharyya P et al., [21]. However, Ahmed AEH et al., observed that predominantly patients were non smokers (79%) [20].

In the present study, the majority of the patients had PTB diagnosed 4-7 years ago (72.86%). The mean duration since TB diagnosis was 7.04±2.69 years. Ahmed AEH et al., observed that the mean duration since the diagnosis of PTB was 9.4±10.9 years [20]. Louw E et al., reported that the median time since TB diagnosis was 4 years [22]. In the present study, 88.57% had completed the treatment, while the remaining 11.43% did not complete the treatment. Consistent with the findings of the present study, Ahmed AEH et al., reported that 57% of patients completed their treatment, while 43% did not [20].

In the present study, all the patients had dyspnoea (100.00%). Other frequent complaints included cough (81.43%) followed by sputum production and wheezing in 40.00% and 37.14% of the patients, respectively. Kumar S et al., reported that dyspnoea was the most common symptom, affecting 100% of patients [1]. However, Ahmed AEH et al., found that predominantly patients had cough (45.8%) [20]. In the present study, 24.29% patients had normal chest X-ray findings. The most common abnormal findings were fibrocavitary (40.00%) and fibrosis (30.00%). While the least common findings were destroyed lung and bronchiectasis (each 2.86%). Findings were in agreement with the study by Ahmed AEH et al., [20]. However, Kumar S et al., revealed that 60% of patients had fibrosis, while 40% had fibro-cavitary lesions [1]. In the present study, a significant proportion of patients had involvement in ≥2 lung zones (54.29%), while 21.43% had involvement in only 1 zone. These findings were in alignment with findings by Kumar S et al., [1]. and Akkara SA et al., [23].

In the present study, the mean RVSP was 39.86±17.74 mmHg. Among the patients, 58.57% had RVSP <35 mmHg, while the remaining 41.43% had RVSP ≥35 mmHg. The RVSP values ranged from 18 to 85 mmHg. In contrast, Akkara SA et al., reported that 94.74% patients had RVSP >35 mmHg. [23]. Allwood BW et al., reported the mean RVSP was 23.6±6.24 mmHg [24]. In the present study, 58.57% of patients had a low probability of PH with a TRV <2.8 m/s, 30.00% had an intermediate probability (TRV 2.9 – 3.4 m/s), and 11.43% had a high probability (TRV >3.4 m/s). The mean TRV was 2.75±0.58 m/s. These findings were in consensus with the findings by Kumar S et al., [1] and Parekh AB et al., [25].

In the present study, the prevalence of PH in the studied population was 41.43%. Among those with abnormal severity, 24.29% were categorised as moderate, 11.43% as severe, and 5.71% as mild. This was in agreement with studies by Ahmed AEH et al., [20] and Kumar S et al., [1] However, in studies by Chatterjee R et al., [9] and Patel V et al., [26] prevalence of PH was 13.33% and 12% of the patients in their study populations, respectively. In the present study, P pulmonale (48.28%) and RVH (41.38%) were the most common ECG findings, while the least common ECG finding was QT prolongation (6.89%). These findings were similar to findings by Parekh AB et al., [25] and Kotresh N et al. [27].

Limitation(s)

The present study was conducted at a single centre. Hence, the results cannot be generalised to the community. The study's cross-sectional nature limits the ability to establish causality or observe changes in PH prevalence over time. The present study was unable to distinguish between PH caused by newly diagnosed Chronic Obstructive Pulmonary Disease (COPD) and post-tuberculosis sequelae. The overlap in clinical presentation and the lack of specific diagnostic markers for differentiating these conditions represent a

limitation. Additionally, the absence of longitudinal follow-up data further complicates the identification of the primary cause of PH in these patients.

CONCLUSION(S)

The present study demonstrated a high prevalence (41.43%) of pulmonary hypertension among patients with post-tuberculosis lung sequelae. A substantial proportion of patients exhibited moderate to severe PH following completion of anti-tubercular therapy. Echocardiographic screening revealed elevated RVSP in patients diagnosed with PH, and TRV was elevated in a significant number of patients with PH. Thus, PTB patients require long-term follow-up to diagnose and treat functional impairment after cure. Routine cardiovascular evaluation may help facilitate early diagnosis.

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