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Original Article

Internal Medicine Section

Haematological Changes in Patients with Pulmonary and Extrapulmonary Tuberculosis: A Cross-sectional Study

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ABSTRACT

Introduction: *Mycobacterium tuberculosis* interacts with the body's immune system, resulting in the migration of neutrophils, followed by monocytes and macrophages, which activate T cells and eventually lead to clinical symptoms. Anaemia and other thrombocytic and leukocytic parameters are the most common haematological alterations analysed in tuberculosis. Both Pulmonary Tuberculosis (PTB) and Extrapulmonary Tuberculosis (EPTB) are associated with changes in haematological parameters, which are typically reversible with antituberculosis medication.

Aim: This study aims to analyse the haematological changes observed in patients with pulmonary and extrapulmonary tuberculosis visiting a tertiary care hospital in Vadodara, Gujarat.

Materials and Methods: A cross-sectional study was conducted from April 2023 to January 2024 in the Department of Respiratory Medicine at Sumandeep Vidyapeeth/Dhiraj Hospital, Vadodara, Gujarat, India. Haematological examinations and comparisons were performed on all 100 newly diagnosed pulmonary and extrapulmonary tuberculosis patients. Data were analysed using the Chi-square test.

Results: In the present study, out of a total of 100 patients, 64 were males and 36 were females, with a mean age of 38.55±5.8 years. Anaemia was found in 68.96% of pulmonary tuberculosis patients and in 47.61% of extrapulmonary tuberculosis patients. The prevalence of leukocytosis was higher in pulmonary tuberculosis (82.75%) compared to extrapulmonary tuberculosis (28.57%). Thrombocytosis was more prevalent in extrapulmonary TB (80.95%) than in pulmonary TB (50%). Thrombocytopenia was more common in pulmonary TB (24.13%) than in extrapulmonary TB (21.4%).

Conclusion: This study confirms that both pulmonary and extrapulmonary tuberculosis disrupt haematological parameters, highlighting the systemic effects of the disease on various organ systems. These markers are useful for assessing illness severity, monitoring treatment response, and guiding patient management.

Keywords: Anaemia, Complete blood count, Thrombocytopenia

INTRODUCTION

In India, tuberculosis is considered a significant public health issue, being the most common infectious disease caused by *Mycobacterium tuberculosis*. Tuberculosis affects various body systems, among which pulmonary tuberculosis is the most prevalent type. Other forms include disseminated tuberculosis, cutaneous tuberculosis, abdominal tuberculosis, lymph node tuberculosis, ear tuberculosis, bone tuberculosis, and tuberculous meningitis [1]. There are numerous non-specific and specific diagnostic modalities available. The non-specific tests include the Mantoux test and chest radiography; however, microbiological confirmation remains the gold standard test [2].

A Complete Blood Count (CBC) is considered the most accessible and cost-effective test in a developing country like India, especially compared to other diagnostic modalities such as GeneXpert and Interferon Gamma Release Assay (IGRA). Changes in haematological parameters can be evaluated, as *Mycobacterium tuberculosis* interacts with the host's immune system, resulting in the migration of neutrophils, followed by monocytes and macrophages, which activate T cells and eventually lead to clinical symptoms [3-6]. The inflammatory response observed in tuberculosis also results in the release of cytokines like Tumour Necrosis Factor-alpha (TNF-α) from monocytes, which blunts the response of erythropoietin and reduces the ability to utilise iron stores in the bone marrow. Hence, anaemia is the most prevalent haematological finding seen in both pulmonary and extrapulmonary tuberculosis [5].

Studies have shown variations in other parameters, such as leukocytosis, lymphocytosis, thrombocytosis, and thrombocytopenia in some cases [4-6]. Therefore, both PTB and EPTB are associated with changes in haematological parameters, which are typically reversible with antituberculosis medications [5]. These blood changes can serve as important indicators for the detection and continuous elimination of acid-fast bacilli and can be used as a treatment modality for tuberculosis patients. Kahase D et al., published a cross-sectional study in 2020, assessing haematological parameters in a total of 40 patients with TB and 40 non-TB patients as controls [4]. According to the study, haemoglobin and Mean Corpuscular Haemoglobin Concentration (MCHC) were lower in TB patients compared to controls.

While TB continues to be a major health issue in India, particularly in the context of extrapulmonary cases, haematological investigations offer a promising approach to improving early detection and management of the disease. Blood tests, although not definitive on their own, can serve as valuable adjuncts to clinical suspicion, helping to identify patients at risk for TB and guiding the need for more specialised diagnostic testing. The differences in haematological profiles between PTB and EPTB patients also provide valuable insights into the pathophysiology and clinical presentation of these two forms of TB. For instance, TB of the lymph nodes (lymphadenitis) may result in mild changes in blood parameters, while TB meningitis can cause significant leukocytosis and other haematological abnormalities due to severe systemic involvement [7]. Understanding these differences can help clinicians better interpret haematological data and make more informed decisions regarding further diagnostic testing and management.

Considering all this, the present study was done with an aim to analyse the haematological changes observed in pulmonary and

extrapulmonary tuberculosis patients visiting Sumandeep Vidyapeeth/Dhiraj Hospital, a tertiary care hospital in Vadodara, Gujarat, India.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Respiratory Medicine at Sumandeep Vidyapeeth/Dhiraj Hospital, Vadodara, Gujarat, India, from April 2023 to January 2024. The ethical committee of the institution approved the study (SBKS/IEC/APPROVAL/October 27, 23/78).

Sample size calculation: A total of 100 patients with newly diagnosed pulmonary and extrapulmonary tuberculosis were included for haematological assessment and comparison. Previously published literature by Morris CD et al., [8]. reported various deranged haematological and biochemical parameters among tuberculosis patients, ranging from 17% (lymphopenia) to 80% (elevated ESR). Considering these reported prevalences for sample size calculation, along with a 7% absolute error and a 95% confidence interval, sample size calculation was performed using an online calculator (Statulator) for the estimation of a single proportion. Thus, the sample size was calculated to be n=90. Taking into consideration a 10% drop-out rate due to failure to follow-up and refusal to complete the procedure after giving consent, a total of 100 samples were considered for the study.

Inclusion criteria:

* Newly diagnosed cases of pulmonary tuberculosis based on sputum reports and/or clinically diagnosed using chest X-ray.
* Newly diagnosed cases of extrapulmonary tuberculosis confirmed by various reports.
* Patients providing informed and written consent for participation in the study.
* Patients aged above 18 years.

Exclusion criteria:

* All patients refusing to provide informed and written consent.
* Pregnant women.
* Patients with a recent history of myocardial infarction.
* All patients with other haematological conditions, such as sickle cell disease or previously diagnosed anaemia.

Study Procedure

Various socio-demographic factors-such as age, gender, occupation, and lifestyle risk factors-along with haematological parameters including Haemoglobin (Hb), platelet count, haematocrit, Total Leukocyte Count (TLC), Mean Corpuscular Haemoglobin (MCH) and MCHC—were assessed.

Leukocytosis denotes an age-appropriate rise in the White Blood Cell (WBC) count. Leukopenia typically refers to a decrease in circulating WBCs. A WBC count of less than 4×10^9/L indicates leukopenia. A WBC count of more than 11×10^9/L indicates leukocytosis. Typically, a WBC count surpassing 11,000 cells/µL in adults is deemed leukocytosis, and a WBC count >100,000 cells/µL is termed hyperleukocytosis. Neutropenia was defined as a count below 2.0×10^3/µL and neutrophilia as a count above 7.0×10^3/µL. Lymphocytopenia, monocytopenia and eosinopenia was considered as counts below 0.80×10^3/µL, 0.12×10^3/µL and 0.02×10^3/µL, respectively [9]. Counts above 4.0×10^3/µL, 1.20×10^3/µL and 0.50×10^3/µL for lymphocytes, monocytes and eosinophils were termed as lymphocytosis, monocytosis and eosinophilia, respectively [9]. Erythropenia and erythrocytosis was defined by counts below 3.50×10^6/µL and above 5.50×10^6/µL, respectively. Mild anaemia was defined by haemoglobin values between 11.0-12.9 g/dL whereas moderate anaemia ranged between 8.0-10.9 g/dL. Haemoglobin values below 8.0 g/dL were considered as severe anaemia [9,10]. Counts below 150×10^3/µL and above 450×10^3/µL for platelets were considered as thrombocytopenia and thrombocytosis, respectively [9]. Based on Body Mass Index (BMI) calculated according to Indian Guidelines, patients were categorised as underweight, normal and overweight [11].

STATISTICAL ANALYSIS

The recorded data were compiled and entered into a spreadsheet programme (Microsoft Excel 2019) and then exported to the data editor page of Statistical Package for the Social Sciences (SPSS) version 19 (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were described as means and standard deviations or medians and interquartile ranges based on their distribution. Qualitative variables were presented as counts and percentages. For all tests, the confidence level and level of significance were set at 95% and 5%, respectively.

RESULTS

In the present study, out of a total of 100 patients, 64 were males and 36 were females, with a mean age of 38.55±5.8 years [Table/Fig-1]. Among these, the majority belonged to the rural population (83%). According to the BMI calculated for the study population, 44% were underweight, 28% were normal, and 28% were overweight.

Variables	Value
Total participants (N)	100
Male participants (N)	64
Female participants (N)	36
Mean age (years)	38.55±5.8
Minimum age (years)	12
Maximum age (years)	75

[Table/Fig-1]: Demographic profile of study participants.

[Table/Fig-2] describes the age-wise distribution of study participants. Most of the patients with both PTB (37 or 63.79%) and EPTB (27 or 64.28%) were in the age group of 18-39 years, followed by 40-60 years (17 or 29.3% in PTB and 7 or 16.6% in EPTB) and above 60 years. The least representation was observed in the age group below 18 years (0 in PTB and 2 or 4.76% in EPTB).

Age (years)	PTB N (%)	EPTB N (%)
Below 18	0	2 (4.76)
18-39	37 (63.79)	27 (64.28)
40-60	17 (29.3)	7 (16.6)
Above 60	4 (6.89)	6 (14.28)
Total	58 (100)	42 (100)

[Table/Fig-2]: Age-wise distribution of PTB and EPTB patients.

[Table/Fig-3] illustrates the occupational distribution of TB patients. The majority were farmers (30.00%) and labourers (28%), indicating a higher disease burden among those engaged in physically demanding or outdoor work. Homemakers (20%) and drivers (10.00%) formed the next major groups. Relatively fewer cases were seen among students (5%), electricians (4%), and plumbers (3%), possibly due to lower exposure risks or smaller representation in the sample.

[Table/Fig-4] presents the distribution of lifestyle-related risk factors among TB patients. The most prevalent exposure was to chulla smoke (40.00%), followed by tobacco chewing (34%) and a high smoking index (>100) observed in 26% of cases. These findings highlight the significant contribution of indoor air pollution and tobacco use to TB risk, especially in rural and low-resource settings.

[Table/Fig-5] highlights the categorisation of EPTB cases among the 100 participants. Among the 42 EPTB cases, the most common

Occupation	Number	Percentage (%)
Farmer	30	30
Labourer	28	28
Housemaker	20	20
Driver	10	10
Student	5	5
Electrician	4	4
Plumber	3	3

[Table/Fig-3]: Occupational distribution among TB patients.

Occupation	Number	Percentage (%)
Chulla smoke	40	40
Tobacco chewing	34	34
A high smoking index	26	26

[Table/Fig-4]: Distribution of lifestyle risk factors among TB patients.

form was pleural TB (24 or 57.14%), followed by disseminated TB (7 or 16.6%) and lymph node involvement (6 or 14.28%). Less frequent manifestations included pericardial, abdominal, and ear TB, each accounting for 2.38%. These findings reflect the diverse presentation of EPTB, with pleural and lymphatic forms being the most predominant.

Categorisation of EPTB	Number	Percentage (%)
Pleural	24	57.14
Lymph node	6	14.28
Pericardial	1	2.38
Abdominal	1	2.38
Bone	2	4.76
Ear	1	2.38
Disseminated	7	16.6
Total	42	100

[Table/Fig-5]: Categorisation of EPTB.

The most frequently affected parameter was Red cell Distribution Width (RDW) (46.55% in PTB and 45.23% in EPTB), followed by Packed Cell Volume (PCV) (41.37% in PTB and 42.85% in EPTB). Abnormalities in MCHC and total RBC count were slightly less prevalent in both groups [Table/Fig-6]. These findings suggest significant alterations in red blood cell morphology and volume, reflecting the chronic inflammatory and nutritional burden commonly associated with tuberculosis.

Red cell indices	PTB N (%)	EPTB N (%)
PCV	24 (41.37)	18 (42.85)
MCV	22 (37.93)	16 (38.09)
MCH	20 (34.58)	15 (35.71)
MCHC	17 (29.71)	13 (30.95)
Total RBC count	18 (31.03)	12 (28.57)
RDW	27 (46.55)	19 (45.23)

[Table/Fig-6]: Distribution of abnormal red cell indices among TB patients.

In the present study, various haematological parameters found in 58 individuals with PTB and 42 patients with EPTB are elaborated in [Table/Fig-7]. Anaemia was found to be more common in patients with PTB (n=40; 68.9%) compared to those with EPTB (n=20; 47.61%) (p-value <0.05). Leukocytosis was more prevalent in PTB (n=48; 82.75%) compared to EPTB (n=12; 28.57%) (p-value <0.05). Neutrophilia was also statistically higher in PTB (n=48; 82.75%) compared to EPTB (n=26; 61.90%) (p-value <0.05). The majority of PTB patients demonstrated a normal lymphocyte count (n=22; 37.93%), followed by lymphocytopenia (n=19; 32.75%). Similarly, the majority of EPTB patients also had a normal lymphocyte count

Parameters	Assessment	PTB (n=58)	EPTB (n=42)	p-value
Haemoglobin	Anaemia	40 (68.9%)	20 (47.61%)	0.03*
	Normal	18 (31.03%)	22 (52.38%)	
	Polycythemia	0%	0%	
Total leukocyte count	Leukopenia	2 (3.44%)	5 (11.90%)	0.001*
	Normal	8 (13.79%)	25 (59.52%)	
	Leukocytosis	48 (82.75%)	12 (28.57%)	
Neutrophils	Neutropenia	9 (15.51%)	8 (19.04%)	0.007*
	Normal	1 (1.72%)	8 (19.04%)	
	Neutrophilia	48 (82.75%)	26 (61.90%)	
Lymphocytes	Lymphocytopenia	19 (32.75%)	7 (16.6%)	0.18
	Normal	22 (37.93%)	21 (50%)	
	Lymphocytosis	17 (29.31%)	14 (33.33%)	
Platelets	Thrombocytopenia	14 (24.13%)	3 (7.14%)	0.03*
	Normal	15 (25.86%)	5 (11.90%)	
	Thrombocytosis	29 (50%)	34 (80.95%)	
Eosinophils	Esonopenia	3 (5.17)	1 (2.38)	0.12
	Normal	53 (91.37)	38 (90.47)	
	Esonophilia	2 (3.44)	3 (7.14)	
Monocytes	Monocytopenia	1 (1.72)	3 (7.14)	0.09
	Normal	51 (87.93)	37 (88.09)	
	Monocytosis	6 (10.34)	2 (4.76)	

[Table/Fig-7]: Comparison of haematological changes in PTB vs. EPTB cases.
Test applied Chi-square test; *Indicate statistically significance at p≤0.05

(n=21; 50%), followed by lymphocytosis (n=14; 33.33%). On the other hand, thrombocytosis was found to be much more common in EPTB (n=34; 80.95%) compared to PTB (n=29; 50%) (p<0.05).

Out of the 40 PTB patients with anaemia, the majority were categorised as having moderate anaemia (45%), followed by mild anaemia (32.5%). Among the 20 EPTB patients with anaemia, the majority were categorised as having mild anaemia (50%), followed by moderate anaemia (45%). Severe anaemia was observed more in PTB patients (22.5%) as compared to EPTB patients (5%) [Table/Fig-8].

Anaemia	PTB (N=40)	EPTB (N=20)	Total
Mild	**13 (32.5%)**	10 (50%)	23 (38.33%)
Moderate	18 (45%)	9 (45%)	27 (45)
Severe	**9 (22.5%)**	1 (5)	10 (16.66%)

[Table/Fig-8]: Severity of anaemia.

Among the various types of EPTB, pleural TB exhibited the most significant haematological changes. Anaemia was observed in 58.33% of pleural TB patients, 33.33% of lymph node TB patients, 100% of pericardial TB patients, 100% of bone TB patients, and 14.28% of disseminated TB patients [Table/Fig-9].

Categorisation of EPTB	Anaemia N (%)	Normal N (%)	Total N (%)
Pleural TB	14 (58.33)	10 (4.67)	24 (57.14)
Lymph Node TB	2 (33.33)	4 (66.67)	6 (14.28)
Pericardial TB	1 (100)	0	1 (2.38)
Abdominal TB	0	1 (100)	1 (2.38)
Bone TB	2 (100)	0	2 (4.76)
Ear TB	0	1 (100)	1 (2.38)
Disseminated TB	1 (14.28)	6 (85.72)	7 (16.6)
Total	20 (48)	22 (52)	42

[Table/Fig-9]: Haemoglobin changes in EPTB cases.

Leukocytosis was the most common leukocyte change observed in EPTB; it was present in 33.33% of pleural TB cases, 16.67% of

lymph node TB cases, 100% of pericardial TB cases, 50% of bone TB cases, and 14.28% of disseminated TB cases [Table/Fig-10].

Categorisation of EPTB	Leukocytopenia N (%)	Leukocytosis N (%)	Normal N (%)
Pleural TB	5 (20.83)	8 (33.33)	11 (45.84)
Lymph Node TB	0	1 (16.67)	5 (83.33)
Pericardial TB	0	1 (100)	0
Abdominal TB	0	0	1 (100)
Bone TB	0	1 (50)	1 (50)
Ear TB	0	0	1 (100)
Disseminated TB	0	1 (14.28)	6 (85.72)
Total	5 (12)	12 (29)	25 (60)

[Table/Fig-10]: Leukocyte changes in various EPTB cases.

Neutrophilia was frequently observed in several types of EPTB. It was found in 75% of pleural TB cases, 66.67% of lymph node TB cases, and 100% of pericardial, abdominal, and bone TB cases [Table/Fig-11].

Categorisation of EPTB	Neutropenia (%)	Neutrophilia (%)	Normal N (%)
Pleural TB	6 (25)	18 (75)	0
Lymph Node TB	1 (16.67)	4 (66.67)	1 (16.67)
Pericardial TB	0	1 (100)	0
Abdominal TB	0	1 (100)	0
Bone TB	0	2 (100)	0
Ear TB	0	0	1 (100)
Disseminated TB	1 (14.28)	0	6 (85.72)
Total	8 (19)	26 (62)	8 (19)

[Table/Fig-11]: Neutrophil changes in various EPTB cases.

Lymphocytosis was found in 45.83% of pleural TB patients, 33.33% of lymph node TB patients, and 100% of pericardial TB patients [Table/Fig-12].

Categorisation of EPTB	Lymphocytopenia (%)	Lymphocytosis (%)	Normal N (%)
Pleural TB	7 (29.17)	11 (45.83)	6 (25)
Lymph Node TB	0	2 (33.33)	4 (66.67)
Pericardial TB	0	1 (100)	0
Abdominal TB	0	0	1 (100)
Bone TB	0	0	2 (200)
Ear TB	0	0	1 (100)
Disseminated TB	0	0	7 (100)
Total	7 (17)	14 (33)	21 (50)

[Table/Fig-12]: Lymphocyte changes in various EPTB cases.

Thrombocytosis was the most common platelet change seen across all types of EPTB, while only 12.5% of pleural TB patients showed thrombocytopenia [Table/Fig-13].

Categorisation of EPTB	Thrombocytopenia (%)	Thrombocytosis (%)	Normal N (%)
Pleural TB	3 (12.5)	18 (75)	3 (12.5)
Lymph Node TB	0	6 (100)	0
Pericardial TB	0	1 (100)	0
Abdominal TB	0	1 (100)	0
Bone TB	0	2 (100)	0
Ear TB	0	1 (100)	0
Disseminated TB	0	5 (71.43)	2 (28.57)
Total	3 (7.14)	34 (81)	5 (11.90)

[Table/Fig-13]: Platelet changes in various EPTB cases.

DISCUSSION

In the present study, out of a total of 100 patients, 64 were males and 36 were females, with a mean age of 38±5.8 years. These findings correlated well with other studies, such as those by Thatoi PK and Banerjee M et al., [12-13]. However, this result differed from a study conducted by Yasin A et al., where cases were reported to be more prevalent among women than men [14]. This study showed that most of the patients with both pulmonary and extrapulmonary tuberculosis were in the age group of 18-39 years, followed by those aged 40-60 years and above 60 years. This finding was consistent with other studies, like that of Yasin A et al., [14].

Anaemia is the most common complication observed in the haematological parameters among tuberculosis patients and is one of the risk factors for mortality. Anaemia was prevalent in both pulmonary TB (68.9%) and extrapulmonary TB (47.67%), with pleural TB showing the highest incidence among extrapulmonary cases (70%). These findings align with previous studies [8,14-17] indicating a high prevalence of anaemia in tuberculosis, attributed to chronic inflammation, impaired iron metabolism, and reduced erythropoietin production. The higher prevalence of anaemia in pulmonary TB compared to extrapulmonary TB underscores the significant impact of pulmonary inflammation on haematological parameters. The increased release of cytokines such as tumour necrosis factor-alpha (TNF-α), Interferon-gamma (IFN-γ), and interleukin-6 (IL-6) leads to a reduction in erythropoietin formation, resulting in bone marrow suppression. This alteration in iron metabolism further contributes to anaemia [8]. Some studies have posited that anaemia may be due to an absence of bone marrow iron, resulting in iron deficiency anaemia. TNF-α and IL-1 released by activated monocytes reduce erythropoietin production, leading to anaemia while also increasing iron uptake and ferritin synthesis [9,14,15]. In the present study, the severity of anaemia was assessed by measuring haemoglobin levels.

Leukocytosis is a characteristic feature of tuberculosis [9]. Leukocytosis was more common in PTB (82.75%) compared to EPTB (28.57%), with pleural TB showing the highest incidence among extrapulmonary cases. These findings support the traditional understanding that, in tuberculosis patients, WBC counts increase during infection, along with macrophages, as part of the body's defense mechanism [6]. Neutrophilia was prevalent in both types of tuberculosis, with a higher incidence observed in PTB (82.75%) compared to EPTB (61.90%). Similar findings have been reported in previous studies. In contrast, a study by Thatoi PK reported neutropenia as a predominant finding, which may be attributed to hypersplenism, excessive margination of neutrophils, or inhibition of granulopoiesis by T-lymphocytes [12].

Thrombocytosis was more common in EPTB (80.95%) than in PTB (50%), while thrombocytopenia was more prevalent in PTB (24.13%) compared to EPTB (7.14%). These findings correlate with those of Yasin A et al., and Banerjee M et al., [13,14]. Various cytokines like interleukin-6 (IL-6), involved in granuloma formation, promote platelet production and could explain the observed thrombocytosis [18]. Additionally, various morphological features of platelets, such as high Platelet Distribution Width (PDW) and Mean Platelet Volume (MPV), in patients with tuberculosis can reflect activated platelets, similar to other immune system cells [18].

The findings of the current study can be utilised to reduce morbidity and mortality rates and to prevent complications associated with the disease. They can also serve as important indicators of disease progression.

Limitation(s)

The sampling technique used in this study was non-random, which may have introduced potential selection bias. Since this study was conducted in a tertiary care centre that often receives referrals from lower centres, it is likely that more severe cases of tuberculosis

were included, complicating the generalisation of the results to all tuberculosis cases in the community.

CONCLUSION(S)

This study reinforces that haematological parameters were significantly deranged in both PTB and EPTB, reflecting the systemic nature of the disease and its impact on various organ systems. Monitoring these parameters can aid in assessing disease severity, treatment response, and overall patient management. Increasing awareness of haematological parameters and clinical features in PTB and EPTB may facilitate early diagnosis, reduce the severity of disease progression, and improve patient management, ultimately contributing to a decrease in disease-related mortality.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Apr 09, 2025
- Manual Googling: Jun 20, 2025
- iThenticate Software: Jul 10, 2025 (2%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

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