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Assessment of Cytokine (α-TNF) with Erythropoietin and their Correlation in Pulmonary Tuberculosis with Anaemia

Priti Yadav [a#], V. S. S Ramavataram Divvi [a*†] and Tejas Shah [a‡]

[a] Department of Biochemistry, Smt. BK Shah Medical Institute and Research Center and Dhiraj General Hospital (DGH), Sumandeep Vidyapeeth (Deemed to be University), Piperia, Vadodara, Gujrat, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Globally tuberculosis is the 9th leading cause of death worldwide. As pulmonary tuberculosis (PTB) is a chronic disease, anaemia of inflammation due to bacterial burden play a vital role in pathophysiology of anaemia. Inflammation interferes with erythropoietin (EPO) function.

Methods: The present study was an analytical type of case control study. The study included 100 newly diagnosed anaemic PTB cases and 50 newly diagnosed non anaemic PTB controls. The PTB was confirmed by microscopic examination of sputum specimen for the detection of Acid-Fast Bacilli (AFB). Both cases and controls were subjected to hematological analysis by automated cell counter and serum α-TNF and EPO by ELISA method.

Results: Statistically significant difference was observed in levels of both α-TNF and EPO in anemic and non-anemic PTB groups ($p<0.001$). α-TNF (214.56±82.30) levels were found to be significantly higher in anaemic PTB group while EPO level (58.44 ±14.97) were found to be significantly higher in non anaemic PTB group. Significant inverse correlation (r1=cases,

[#] *PhD Scholar*
[†] *Professor & Head*
[‡] *Professor*
**Corresponding author: E-mail: dvss.ramavataram@gmail.com;*

r2=controls) was observed between α-TNF and EPO (r=-0.257, p<0.05) and α-TNF and Hb (r=-0.202, p<0.05) in both the groups.
Conclusion: Increased α-TNF with decreased EPO and hemoglobin infers that inflammation interferes with normal functioning of EPO and probably contributes in induction of anemia in tuberculosis patients.

Keywords: Cytokine; anemia; inflammation and pulmonary tuberculosis.

ABBREVIATIONS

PTB : Pulmonary tuberculosis;
Hb : Haemoglobin;
RBC : Red blood cell;
PCV : Packed cell volume;
MCV : Mean corpuscular volume;
MCH : Mean corpuscular haemoglobin;
MCHC : Mean corpuscular haemoglobin concentration
WBC : White blood cell;
α –TNF : Tumor necrosis factor-alpha;
EPO : Erythropoietin,
CBNAAT : Cartridge based nucleic acid amplification test.

1. INTRODUCTION

Pulmonary tuberculosis is one of the major chronic infectious disease caused by mycobacterium tuberculosis pathogen and key cause of mortality and morbidity in the world [1,2,3]. Globally tuberculosis is the 9th leading cause of death worldwide [2,3]. Mycobacterium tuberculosis pathogen has the ability to live in latent state in humans and approximately 95% humans build up latent infection and can develop tuberculosis in their life [3,4]. It means that these latent infectious people cannot spread MTB to other person but they can developed active TB in future [5]. India's TB incidence was 27 lakh and 21.5 lakh in 2017 and 2018 respectively as reported by RNTCP [3]. PTB is a known inflammatory condition of chronic type and these types of chronic inflammatory diseases are mostly associated with anaemia [6,7]. In various studies prevalence of mild to moderate anemia was shown to be ranging from 16-76% in chronic inflammatory disease like PTB [8-12]. The precise mechanism of anemia in chronic inflammatory disease like PTB is not clearly known [8,13]. however, anemia due to iron deficiency and inflammation have been implicated in these types of conditions [8,11].

PTB is known to be associated with complications and anemia is a commonly associated one with major risk factor for mortality [1]. Generally pulmonary tuberculosis is coupled with major abnormality in heamopoiesis [8,14]. In chronic PTB abnormal hemoglobin levels is considered to be multifactorial and attributable to the fundamental chronic inflammation. Decrease red blood cell survival, disturbance in iron metabolism and reduced EPO action have been implicated in the pathogenesis of PTB anemia [15]. In some infectious disease and chronic inflammatory disorders EPO act as anti-inflammatory cytokine [16]. Erythropoietin primarily act as a regulator of erythropoiesis or red blood cell production [16-20]. EPO affect the production of red blood cells by stimulating differentiation and proliferation of erythroid cells in bone marrow [21-24]. Previous studies mentioned EPO activity is affected by cytokine mediated proinflammatory signaling [6].

Inflammation in PTB is mainly due to bacterial burden leading to increased production of proinflammatory cytokines like TNF-α, [25] which is known to contribute to anemia by decreased erythropoietin production, [7,26] suppressed action of bone marrow to erythropoietin and its interference with metabolism of iron [1,25].

Looking into above aspects, the present study was taken up to assess the effect of extent of chronic inflammation on Haemoglobin and Erythropoietin.

2. MATERIALS AND METHODS

The present study was an analytical type of case control study conducted at Smt. BK Shah Medical Institute and Research Center and Dhiraj General Hospital (DGH) Sumandeep Vidhyapeeth, Piperia, Vadodara, Gujrat, India from April 2019 to April 2020 year. The study enclosed 150 newly diagnosed PTB subjects which were classified as 100 newly diagnosed anemic PTB cases and age and sex matched 50 newly diagnosed non anemic PTB controls. PTB clinical diagnosis of cases and control was diagnosed by pulmonologist and microscopic examination of sputum for of Acid-Fast Bacilli

(AFB)detection and by CBNAAT (Cartridge based nucleic acid amplification test).

2.1 Patients' Selection

Newly diagnosed anaemic Pulmonary Tuberculosis subject of either gender having age group of 18-70years who were sputum smear positive for Acid Fast Bacilli (Z-N staining) and CBNAAT positive with following Hb levels (acc to WHO) [27]; Males: ≤13 g/dL and Females: ≤12 g/dL.

2.2 Exclusion Criteria

The patients with extra-pulmonary TB and/or patients requiring surgical intervention, patients with history of prior anti TB treatment, pregnant women, patients with HIV, patients with chronic kidney disease, heart disease, Cancer or any other inflammatory conditions were excluded from the study.

2.3 Sample Collection and Processing

5 ml blood was collected from each study group individual under all aseptic precautions. Out of which one part of blood (2 ml) was transferred in EDTA vial for CBC count using automated cell counter Nihon Kohden (3-part cell counter) by flow cytometry method. Remaining blood (3 ml) was transferred in plain vial and left to clot for 30 min and then centrifuged at 3000 RPM. Separated serum samples were stored at -20°C in research lab for erythropoietin and α-TNF analysis. The patient confidentiality was maintained at each and every level. Serumα-TNF and EPO were estimated by sandwich ELISA method using commercially available kits according to manufacturer instructions.

2.4 Statistical Analysis

Data were analyzed with the help of software SPSS version 20. The mean values are represented as mean and SD. The statistical difference between cases and control were determined by Student independent sample t-test. Relationship betweenα-TNF, EPO and Hb were determined by Pearson's correlation analysis. The p-value <0.05 were considered as statistically significant.

3. RESULTS

In present study 100newly diagnosed sputum positive anemic PTB subjects with mean age of 42.0±14.5 years (age range 18-70) and 50 newly diagnosed sputum positive anemic PTB controls 42.98±14.21 years (age range 18-70 years) were included. The data of present study was presented in the form of mean and standard deviation (SD) as (Mean ± SD).

Table 1. Comparison between mean of different parameters in PTB cases and controls

Parameter	Non-Anemic PTB Control (n= 50) (Mean ± SD)	Anemic PTB cases (n=100) (Mean ± SD)	p-value
Hb (g/dl)	13.13± 0.63	9.78±1.53	0.000 *
RBC (millions/μL)	4.59±0.85	3.95±1.02	0.000 *
PCV (%)	39.44±2.19	29.70±4.52	0.000 *
MCH (Pg/cell)	27.99±9.99	24.83±3.23	0.005*
MCV (fl)	88.17±6.74	80.28±8.57	0.017 *
MCHC (g/dl)	32.24±1.09	29.93±3.13	0.000*
WBC(Cells/cumm)	9758.00±3115.53	11137.70±3171.49	0.013 *
Platelets (lakhscells)	2.38±0.56	2.7818±0.82	0.003*
EPO(mIU/mL)	58.44 ±14.97	47.28± 6.40	0.002*
α-TNF(pg/mL)	55.32±24.18	214.56±82.30	0.000*

**p<0.05 is significant*

Table 2. Correlations between the Parameters in anemic PTB cases

Parameters	α-TNF r value	Hb r- value	EPO r-value
α-TNF(pg/mL)	-		-0.257
Hb(g/dl)	-.202	-	_
EPO(mIU/mL)	-	0.106	-

P ≤ 0.05

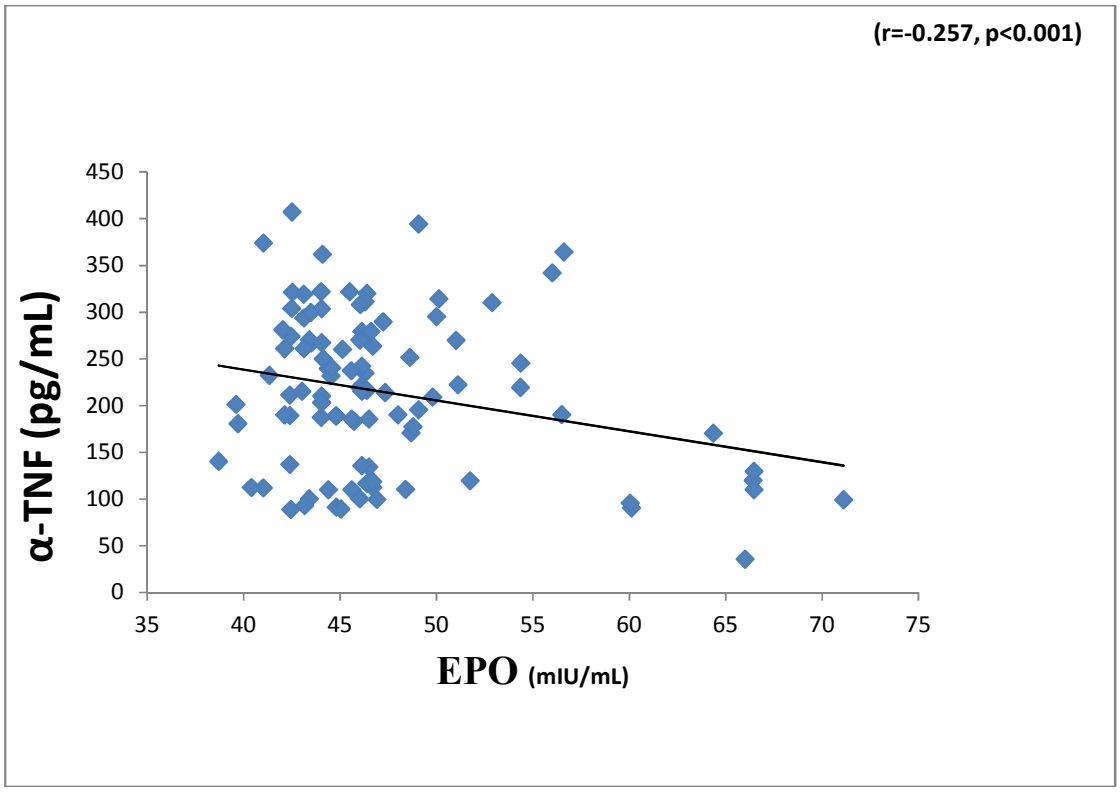

Fig. 1. Correlation between α-TNF and EPO in anemic PTB group

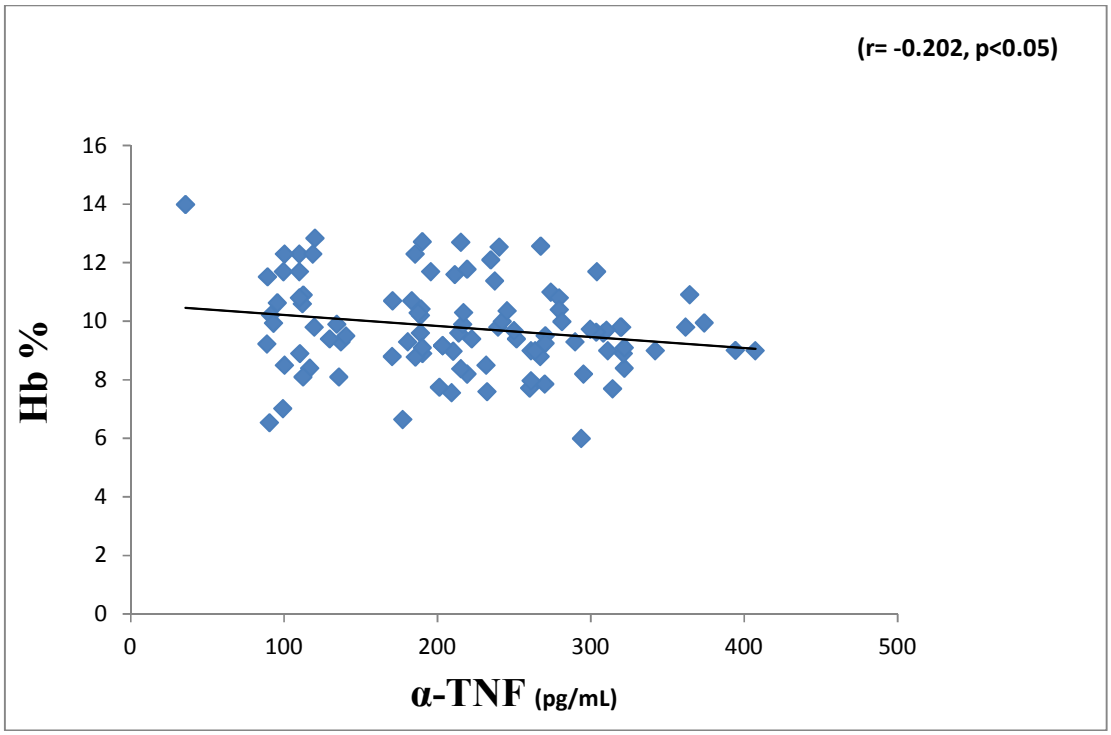

Fig. 2. Correlation between α-TNF and Hb in anemic PTB group

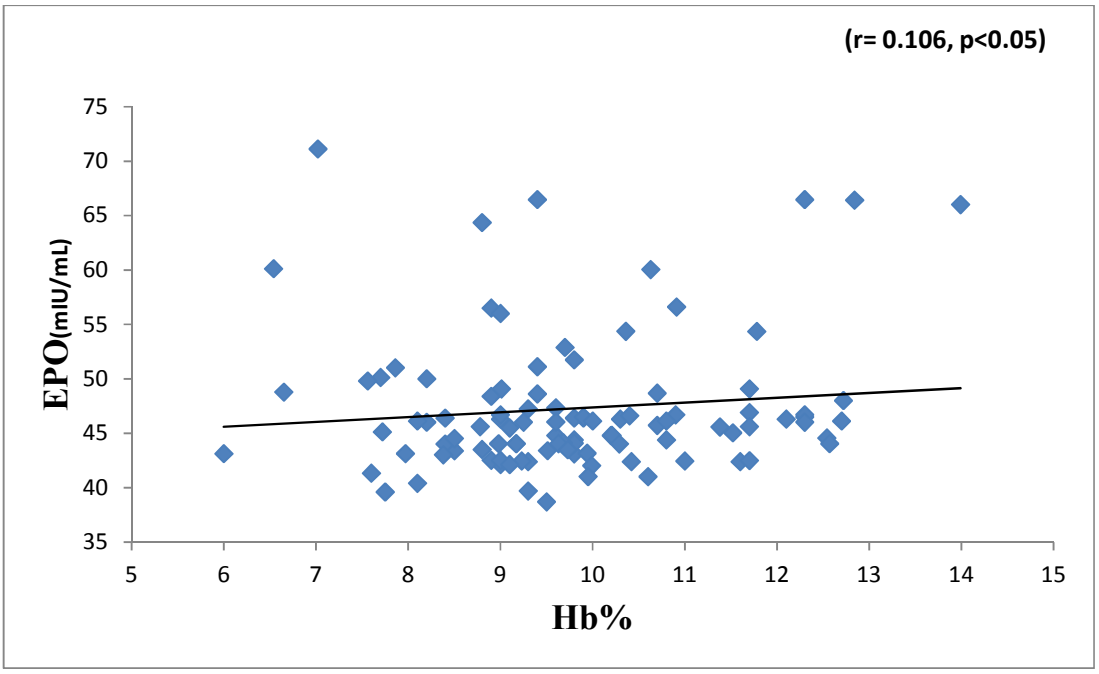

Fig. 3. Correlation between EPO and Hb in anemic PTB group

The mean level of Hb, Packed Cell Volume (PCV), RBC, Mean Corpuscular Hemoglobin (MCH) Mean Corpuscular Volume (MCV), and Mean Corpuscular Hemoglobin Concentration (MCHC) were lower in anemic PTB cases compared to non-anemic PTB controls while WBC values and platelets values were higher in anemic PTB case group compared to non-anemic PTB controls group. EPO (47.28± 6.40 mIU/mL) was found to be significantly lower in anemic PTB cases and observed higher (58.44 ±14.97 mIU/mL) in non-anemic PTB controls ($p<0.05$) as illustrated in [Table-1].α-TNF (214.56±82.30pg/mL) levels were found to be significantly higher in anaemic PTB group as compared to controls (55.32±24.18 pg/mL). Further, with respect to Hb, Hb was found to be significantly lower in cases as compared to controls as shown in [Table-1].

Pearson correlation's analysis of α-TNF, EPO and Hb were demonstrated in cases with anemic PTB [Table 2]. It was observed that statistically significant inverse correlation between serum α-TNF and Hb level ($r=-0.202$, $p<0.05$) in anemic PTB cases [Fig. 2]. A statistically significant inverse correlation was observed between serum levels of TNF-α and EPO ($r=-0.257$, $p<0.05$) in PTB cases [Fig.1] Furthermore, we observed statistically insignificant correlation between serum EPO and Hb level ($r=0.106$, $p>0.05$) in PTB cases [Fig-3].

4. DISCUSSION

Anemia is one of the most common abnormality seen in TB patients caused by poor nutritional [10] status and increased cytokines levels due to inflammation [11,28]. In this study, we aimed to assess levels of α-TNF and EPO and their correlation in anemic and non-anemic pulmonary tuberculosis with same age matched criteria.

A significantly higher mean levels of α-TNF in anemic PTB (cases) than that of non-anemic PTB (control) and have statistically significant difference ($p<0.05$) (Table-1). When compared with the study done Kulkarni et al (2015) [8] to demonstrate the levels of α-TNF and reveled that the levels were significantly higher than that of healthy controls. In Bhat H et al. (2018) [2] study also observed a similar pattern. PTB is a chronic disease which is correlated with increased cytokines such as α-TNF, which might be allied with anemia of chronic diseases. It may also be due to increased bacterial burden in case group compared to control group that α-TNF levels are significantly increased in cases [2].

Chronic inflammatory diseases have also been associated with decreased EPO levels due to various mechanisms [29] Chronic inflammation leads to increased expression of inflammatory cytokines like interleukin (IL-1) and α-TNF [29]. In chronic inflammatory disease like PTB, invading bacteria induces the production of TNF-α together with other inflammatory cytokines during the activation of T- lymphocytes and monocytes [2]. α-TNF inhibits EPO synthesis and interferes with differentiation and proliferation of erythroid progenitor cells [2,30,31]. α-TNF also induces the production of ROS [32,33]. which again interferes with EPO producing cells and affecting the binding affinity of EPO inducing transcription factors thus suppressing bone marrow response to EPO [8]. Inverse correlation between TNF-α and EPO observed in this study in case group ($p<0.001$, Fig-2) can be explained by above reasons. Other authors like Kulkarni RA et al., and Bhat H et al., also observed similar relation between α-TNF with EPO in PTB cases.

We have measured the concentration of EPO and observed a significantly lowered level in anemic PTB (cases) than that of non-anemic PTB (control) respectively and have statistically significant difference ($p<0.05$) (Table-1). Bhat H et al. (2018) [2]. conducted a study on PTB cases and healthy controls and observed significantly increased levels of EPO. When compared with the study done by Kulkarni et al (2015) [8]. has conducted a study on PTB cases and found increased EPO levels than healthy controls. Studies had also shown that in PTB, EPO levels generally increases as compared to healthy controls. As PTB is considered as chronic inflammatory disease, therefore increased EPO levels in both cases and controls can be attributed to chronic inflammation [8,29]. Also lower levels of EPO in case group as compared to control group of this study can be attributed to increased cytokine levels and bacterial burden in these subjects [2]. Bruno CM et al [34]. had observed increased EPO levels in anaemic as compared to non anaemic chronic inflammatory disease condition, but they have not explained any mechanism for such an observation.

Hemoglobin levels were taken as grouping variable in this study, hence statistical difference was observed among the groups. Decreased mean Hb levels in anemic PTB group because according to inclusion criteria Hb (males and female cases) and normal mean Hb levels in control group as compared to case group ($p<0.001$, Table-1) because of non anaemic nature (inclusion criteria of controls) of subjects.

TNF-α along with other cytokines also affects hemoglobin concentration in PTB cases [8]. Hemoglobin concentration is affected by iron concentration. TNF-α meddles with iron metabolism by efficiently withholding Iron from microbes as a protection against invading microbial pathogens and stimulate the iron storage which reduced the iron supply for erythroid cells, leading to decreased hemoglobin concentration [2,9]. The inverse correlation between TNF-α and Hb concentration observed in both the groups ($p<0.05$, Table-2) in this study can be because of bacterial burden [2].and meddling effect of TNF-α with iron metabolism [9].

EPO is a hormone responsible for erythropoesis [18] In normal healthy individuals [35]. and iron deficiency anaemia [36]. significant negative correlation is present between EPO and Hb concentration. In chronic inflammatory conditions, this correlation is disrupted and neither negative nor positive relation is seen [2,8]. In studies having PTB cases, no significant correlation is observed between the two because of the effect of cytokines and bacterial burden. In conjunction with other studies, present study also observed that there is no significant correlation between EPO and Hb ($p<0.05$, Fig-3). Thus, in this study we observed the subnormal Hb associated with the severity of cytokine α-TNF and their action of suppression of EPO which might be linked to underlying inflammatory mechanism and caused anemia in PTB.

5. CONCLUSION

The present study shows that anaemic or non anaemic PTB, both are associated with increased α-TNF and decreased EPO and Hb, but the extent of inflammation i.e., α-TNF levels are responsible for the development of anaemia. Thus, we conclude that though anaemia in PTB is a complication, but this complication can be reduced by reducing inflammation rather than focusing on treatment of anaemia, which will further increase the cost of treatment in PTB cases.

6. LIMITATION

Further comprehensive large sample size study would be needed to achieve firm conclusion. Restricted budget (cost of kits) and time, number of PTB subjects were restricted. In this study, we have not done follow-up of anemic and non-anemic PTB patients which could have been more enlightening in evaluating predictive applications of inflammatory cytokine and EPO.

ETHICAL APPROVAL AND CONSENT

The study protocol was approved by Institutional Ethics Committee (SVIEC/ON/MED/PhD/19023). After describing the study in details, the written consent was taken from all the patients before enrolment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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