

Research article

Vitamin C status and associated biochemical alterations in tuberculosis patients: A cross-sectional study

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Abstract: Tuberculosis (TB) remains a major global public health concern and is among the leading causes of mortality from infectious diseases worldwide. Ascorbic acid (vitamin C) plays an important role in host defense through its antioxidant properties, immune modulation, and protective activity against pathogenic infections. The present cross-sectional study was conducted to evaluate the impact of tuberculosis infection on serum vitamin C levels and selected biochemical parameters in TB patients. Serum ascorbic acid concentrations and other biochemical markers were measured using standard biochemical techniques. The results demonstrated significantly reduced levels ($p < 0.005$) of vitamin C (0.24 ± 0.01 mg/dL), total cholesterol (124.94 ± 0.80 mg/dL), high-density lipoprotein cholesterol (34.50 ± 0.40 mg/dL), low-density lipoprotein cholesterol (71.28 ± 0.61 mg/dL), very-low-density lipoprotein cholesterol (19.78 ± 0.17 mg/dL), triglycerides (99.88 ± 0.81 mg/dL), total serum proteins (6.75 ± 0.05 g/dL), and albumin (2.78 ± 0.03 g/dL) in tuberculosis patients compared with healthy controls. In contrast, serum globulin levels (3.97 ± 0.04 g/dL) were significantly elevated in TB patients. These findings indicate that tuberculosis infection is associated with marked alterations in vitamin C status and biochemical parameters, which may contribute to disease-related complications. Monitoring and correction of these biochemical disturbances may be important for improving clinical management and outcomes in patients with tuberculosis.

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Introduction

Tuberculous Bacillosis (TB) is caused due to infection by *Mycobacterium tuberculosis* is highly prevalent chronic disease. *Mycobacterium tuberculosis* is an aerobic intracellular bacterium (Bacillus); due to this property, those tissues are preferred by it which is in contact with high oxygen levels as in lungs. Transmission of Bacillus is by tiny droplets of saliva, disease can be developed in infected person depending upon its immunological state if bacillus is inhaled [1].

Vitamin C also named as L-Ascorbic acid ($C_6H_8O_6$) is in extracellular fluids, it is considered to be the most important antioxidant [2]. The chemical name of vitamin C is 2-oxo-L-threo-hexono-1,4-lactone-2,3-enediol. The most important nutritive types of vitamin C are L-

ascorbic and dehydroascorbic acid [3]. The L-Ascorbic acid is an important co-factor for hydroxylases and mono oxygenases, the enzymes which are involved in the production of collagen, carnitine and some neurotransmitters [4].

The resistance of the body to a variety of diseases which include contagious disorders can be increased by Vitamin C. It protects and makes the immune system strong by increasing the activity of antibodies and cells of immune system such as phagocytes and neutrophils [5]. Vitamin C acts by exciting the immune system and defending against harm by the free radicals released by the body in its competition counter to the infection [6].

The new regular daily consumption level that is adequate to encounter the nutritious need of ascorbic

acid or recommended daily allowances (RDA) for adults greater than 19 years are 90 mg per day for men and 75 mg per day for women [2]. Ingestion of 100 mg per day of ascorbic acid is estimated to be sufficient to fill the body pools (neutrophils, leukocytes and other tissues) in healthy persons. It has been recommended on the basis of medical and epidemiological studies that a dietary consumption of 100 mg per day of ascorbic acid is related with decreased occurrence of death from heart diseases, stroke and cancer. However, stress, smoking, alcoholism, fever, viral infections can originate a quick drop in blood levels of ascorbic acid [7].

Ascorbic acid shows an important role in wound healing and repair /regeneration procedure as it excites collagen formation. Sufficient amounts of vitamin C are essential for common healing process particularly for post-operative patients. It has been recommended that there will be quick consumption of vitamin C for the production of collagen at the location of wound/ burns during post-operative duration of time [8].

Material and methods

Sample collection and storage

In present study, blood samples of 100 recently diagnosed tuberculosis individuals were collected from District Head Quarter Sargodha. Blood samples from 50 normal individuals were also collected to serve as control. 5ml blood sample of each individual was collected by 5ml syringe. 3ml blood was transferred to gel tube for serum and 2ml was transferred to EDTA tube for complete blood count. Gel tube and EDTA tube were centrifuged at 3000 rpm to collect serum and plasma for estimation of LFTs, lipid profile, RFTs and Vitamin C.

Hematologic parameters

Hematologic parameters like Total Leucocyte count (TLCs) Erythrocyte sedimentation rate (ESR) and Lymphocyte were performed by an automated analyzer that calculates the number and kinds of different cells present within the blood. It extracts a little quantity of the sample through the narrow tubes. Within these tubes, there are sensors that count the number of cells passing through it, and can recognize the type of cell. This technique is called flow-cytometry. For detection light detectors are used to measure the electrical impedance [9].

Serum Glutamate pyruvate transaminase (SGPT)

The change of 2-oxoglutarate and L-alanine into L-glutamate and pyruvate is catalyzed by the enzyme GPT [10].

Serum Glutamate oxaloacetate transaminase (SGOT)

GOT is the enzyme which catalyzes an equilibrium reaction in which 2-oxoglutarate and L-aspartate are converted into L-glutamate and oxaloacetate [10].

Serum Alkaline phosphatase (ALP)

When magnesium and zinc ions are present, hydrolysis of p-nitrophenyl phosphate takes place by phosphatases and phosphate and p-nitrophenol are formed. The p-nitrophenol formed is proportional to the ALP activity and can be estimated with the help of Spectrophotometer [11].

Serum Total protein (Tp)

The total protein was calculated by using the Potassium iodide, Sodium hydroxide, Sodium potassium tartrate, cupric sulphate and stabilized protein solution. When alkaline medium is used, cupric ions react with protein peptide bonds forming a colored complex. The intensity of color depends upon protein concentration which is estimated by photometer [12].

Albumin

The albumin-BCG-complex was estimated at 578nm spectrophotometrically [13].

Globulin

Amount of globulin was calculated by subtracting value of albumin from total protein [14].

Creatinine

Creatinine changes to a yellow-orange colored complex when reacts with picric acid in the presence of an alkaline solution. The concentration of creatinine was quantified at 540nm photometrically.

Urea

Hydrolysis of Urea takes place in the presence of water and urease and ammonia. Carbon dioxide is produced as a result of the reaction. The ammonia which is formed first reaction binds with α -oxoglutarate and NADH when glutamate dehydrogenase (GLDH) is present to produce glutamate and NAD^+ . Test was done at 340nm on UV spectrophotometer [15].

Total cholesterol

Total cholesterol was measured by using cholesterol esterase and cholesterol oxidase at 546nm on spectrophotometer [11].

Triglycerides

Triglycerides were estimated by using Pipes buffer (pH 7.2), p-Chlorophenol Lipoprotein lipase, Glycerolkinase, Glycerol-3-P-oxidase, Peroxidase, 4-Aminoantipyrin, ATP at 546nm on spectrophotometer [11].

HDL Cholesterol

R1 was mixed with Supernatant and incubated at 37°C for 5 minutes. Absorbance (ΔA) of HDL Cholesterol was taken at 546nm using reagent blank on spectrophotometer [16].

VLDL Cholesterol

It was measured by calculation method [17].

LDL cholesterol

The establishment of a formula by Fredrickson in 1972 has led to the use of a calculated LDL cholesterol. The formula is based on the assumption that the VLDL is the carrier only and the ratio of triglycerides/cholesterol remains constant (2.2/1) [17].

LDL cholesterol= Total cholesterol- (HDL cholesterol + VLDL)

Blood Glucose level

The glucose concentration was estimated at 546nm on spectrophotometer [11].

Results and discussion

Ascorbic acid (Vitamin C)

In present study Vitamin C status of TB patients and normal individuals was investigated and values obtained were compared by using independent sample t-test. Results obtained are represented in **figure 1** which show that Vitamin C level of the patients of tuberculosis was decreased significantly ($p= 0.00$) when these were compared with normal, healthy subjects by using independent sample T-test. An overall comparison between diseased and control subjects is made irrespective of the sex and a decrease in Vitamin C level is found in patients. Mean value of Vitamin C in control and diseased subjects is 0.042 ± 0.01 and 0.24 ± 0.01 respectively. There is a significant decrease ($p=0.000$) in Vitamin C level in male patients when compared with control male subjects and mean values of Vitamin C in normal and diseased male patients are 0.4423 ± 0.014 and 0.2370 ± 0.012 respectively. There is also a significant decrease ($p=0.000$) in Vitamin C levels when female patients of TB are compared with normal females of the

locality. The mean values of vitamin C in normal and diseased females are 0.399 ± 0.012 and 0.237 ± 0.008 respectively. [18] Bakaev & Duntau (2004) studied the effect of tuberculous infection on Vitamin C level and reported a decrease in Vitamin C level in patients as compared to healthy individuals. [19] Madebo., et al. (2013) carried out a study and found a significant decrease in Vitamin C level in TB patients when compared with normal Ethiopian subjects. Vitamin C level in TB patients was 0.3mg/dl and in healthy Ethiopians was 0.8mg/dl [20].

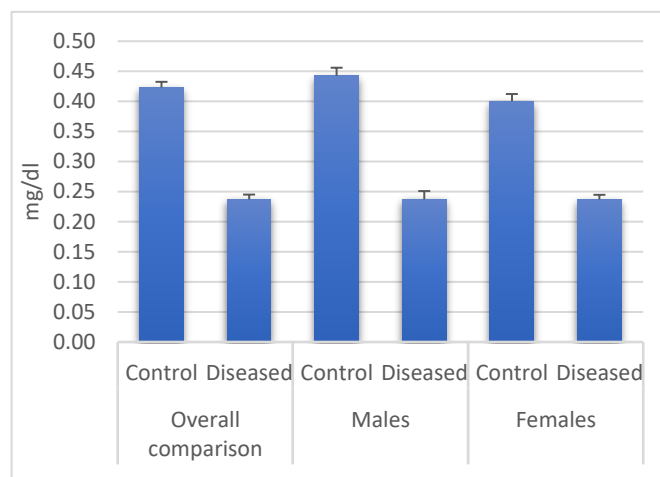


Figure 1. Comparison of mean of Vitamin C between control and diseased subjects.

Total Leucocyte count (TLCs)

Significant ($p<0.001$) increase in total leucocyte count (TLC) values was seen when a comparison is made between Overall control and diseased subjects and male subjects by using independent sample t-test. There was a very highly significant increase ($p<0.001$) in mean values of TLC when overall comparison is made and also when normal males are compared with diseased males. When control females are compared with diseased subjects infected with Tuberculosis infection then a significant increase is found ($p < 0.01$). [21] Akpan et al, (2012) found relation between tuberculosis infection and hematological parameters. TLCs value of patients was 5.3 ± 2.2 and in control subjects value was 4.9 ± 1.5 . There was an increase in TLCs in patients but this increase was not significant and both the results resemble to my results that an increase in TLCs was found and were contradictory to present findings in such a way that increase was not significant. In present study a significant increase was found in TLCs in all groups. [22] Famodu et al., (2007) monitored hematological parameters in newly diagnosed pulmonary tuberculosis patients. There were significantly lower ($p<0.0001$) total white blood cell count (TLCs) contradictory to results of

present study. These differences in results can be attributed to various factors such as age variation, severity of disease, different dietary habits and variations in living conditions and life style of the peoples (Figure 2).

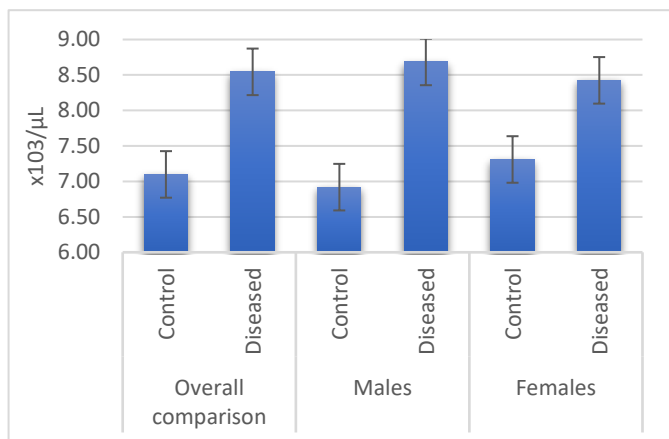


Figure 2. Comparison of mean of TLCs between control and diseased subjects.

Erythrocyte sedimentation rate (ESR)

Table 1 shows the comparison of ESR in two different groups. One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is a very highly significant change ($p < 0.001$) in values of ESR in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Comparison shows that as a result of tuberculosis infection values of ESR are increased in diseased subjects when compared to normal subjects. [22] *Famodu et al., (2007)* found that erythrocyte sedimentation rate (ESR) was significantly higher ($p < 0.0001$) in pulmonary tuberculosis patients when compared with controls. In controls the value was 9 ± 7.8 mm/hr and in patients these values were increased and were 73.0 ± 40.0 mm/hr. These results were similar to present study. [21] *Akpan et al., (2012)* found that erythrocyte sedimentation rate (ESR) showed significantly higher values in Pulmonary Tuberculosis patients than that of control subjects. The ESR values in TB patients were 44.0 ± 40.0 mm/hr. These were significantly higher than control where the values were 8.0 ± 7.8 mm/hr. This was similar to present study in such a way that an increase is found.

Table 1. Comparison of variation in ESR between control and diseased subjects.

Statistical parameters	ESR (mm/hr)					
	overall comparison		Males		Females	
	Control	Diseased	Control	Diseased	Control	Diseased
Mean	12.46	102.81	11.1111	102.0556	14.0435	104.0222
S.E	0.40	1.76	.43472	2.50261	.56048	2.52072
t-value	-49.94		-35.804		-34.845	
p-value	0.00**		0.000**		0.000**	

Level of significance as (**=0.01 Highly Significant and *=0.05 Significant). While non-significant is indicated by (ns).

Lymphocytes

Table 2 shows the comparison of Lymphocytes in two different groups. One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is a very highly ($p < 0.001$) significant change in values of lymphocytes in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Comparison shows that as a result of tuberculosis infection levels of lymphocytes were decreased when compared to normal subjects. [23] *Shareef & Amin (2012)* found haematological abnormalities in patients of TB as compared to normal subjects. Total white blood cell and differential counts in Kirkuk Pulmonary TB patients were

also investigated. No significant difference was observed in lymphocytes between all patients and healthy group. Mean values in patients were 1.85 ± 0.58 and in control subjects were 2.56 ± 1.05 . Mean values of patients were decreased but no significant variation was found. The results resemble to results of present study that a decrease in lymphocytes was found and were contradictory to present findings in such a way that decrease was not significant. [22] *Famodu et al., (2007)* carried out a study that was aimed at monitoring haematological parameters in newly diagnosed pulmonary tuberculosis patients. There were no significant variation ($p > 0.05$) in lymphocytes between control and diseased groups when comparison was made. [21] *Akpan et al., (2012)* found a relation between tuberculosis infection and hematological parameters.

He found no significant change in lymphocytes between control and diseased. According to present study, a significant change was found in overall comparison, males and females. So, these results were contradictory to present study. These variations in results can be

attributed to various factors such as age variation, severity of disease, different dietary habits and variations in living conditions and life style of the peoples of different societies.

Table 2. Comparison of variation in lymphocytes between control and diseased subjects.

Statistical parameters	Lymphocytes (%)					
	Overall comparison		Males		Females	
	Control	Diseased	Control	Diseased	Control	Diseased
Mean	32.88	21.75	30.5185	21.6685	35.6522	21.8444
S.E	1.42	0.84	1.63506	1.05639	2.31135	1.38022
t-value	7.17		4.687		5.439	
p-value	0.00**		0.000**		0.000**	

Level of significance as (**=0.01 Highly Significant and *=0.05 Significant). While non-significant is indicated by (ns).

Glutamic pyruvate transaminase (GPT) and Glutamic oxaloacetate transaminase (GOT)

In present study GPT levels of patients and control subjects were evaluated and results obtained are shown in **table 2**. These reveal the comparison of Glutamic pyruvate transaminase (GPT) in two different groups. One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* applying the independent sample t-test, results depict that there is no significant increase ($p > 0.05$) in GPT in overall, males and females of diseased group as compared to overall normal male and female groups. [24] Edalo et al (2012) reported there was no significant variation in levels of GPT in newly diagnosed patients of tuberculosis and control subjects. As a result of anti-tuberculosis treatment values of liver enzymes are deranged but remain normal when patient is suffering from TB but not undergoing treatment of the disease. In present study only considered newly diagnosed patients of TB were considered not taking any treatment and found no significant change in liver enzymes levels in control and diseased subjects. These results are in agreement with above mentioned study. They calculated mean value of GPT to be 23.68 ± 9.582 iu/L and same was in control subjects with no significant change. similarly GOT levels of patients and control subjects and results obtained are shown in **table 2**. Result in the Table revealed the comparison of Glutamic oxaloacetate transaminase (GOT) in two different groups. One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results depict that there is no significant change ($p > 0.05$) in values of GOT in overall, males and females of diseased group as compared to overall normal, normal

male and normal female groups. [24] Edalo et al., (2012) stated there was no significant variation in levels of GOT in newly diagnosed patients of tuberculosis and control subjects. As a result of anti-tuberculosis treatment values of liver enzymes are deranged but remain normal when patient is suffering from TB but not undergoing treatment of the disease. In present study only newly diagnosed patients of TB were considered not taking any treatment and found no significant change in liver enzymes levels in control and diseased subjects. These results are in agreement with above mentioned study in case of GOT. Mean levels of GOT were 24.12 ± 8.679 iu/L and same was the value for normal healthy subjects.

Alkaline phosphatase (ALP) and Serum Total protein

In present study levels of Alkaline phosphatase (ALP) patients and control subjects were evaluated. These results reveal the comparison of alkaline phosphatase (ALP) in two different groups. One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is a significant change ($p < 0.05$) in values of ALP in overall and females of diseased group as compared to overall normal and normal female groups but in case of male's results are not significant ($p > 0.05$). [24] Edalo et al (2012) reported there was no significant variation in levels of ALP in newly diagnosed patients of tuberculosis and control subjects. As a result of anti-tuberculosis treatment values of liver enzymes are deranged but remain normal when patient is suffering from TB but not undergoing treatment of the disease. In present study only newly diagnosed patients of TB were considered not taking any treatment and found no significant

change in liver enzymes levels in control and diseased subjects. In present study values of ALP were deranged in females and in case of overall comparison. So, these results are contradictory to present study in case of females and in overall patients' comparison. In present study results obtained were in agreement with above mentioned study in case of males. Before drugs administration mean plasma concentration of ALP was normal in patients. The mean values of ALP in newly diagnosed patients of TB are 57.14 ± 19.899 u/l respectively.

[19] *Madebo et al., (2013)* reported ALP level in patients to be 316.1 ± 307.7 and in control subjects' level of ALP was 187.7 ± 48.4 u/l and found a significant increase in ALP levels in patients. According to present study the values of ALP were increased significantly in females and overall diseased subjects. So, these results were comparable to my studies in case of overall and female patients but in male's results were contradictory. These differences in results can be attributed to various factors such as age variation, severity of disease, different dietary habits and variations in living conditions and life style of the peoples of different areas.

Serum Total protein

One is the normal group while other is the diseased affected by *Mycobacterium tuberculosis* by applying the independent sample t-test. Results show that there was a very highly significant change ($p < 0.001$) in values of total protein in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Values of Total Protein were decreased in case of tuberculosis infection as compared to healthy subjects. [25] *Akiibinu et al., (2007)* reported that the mean levels of total protein were significantly low when tuberculosis patients were compared with control subjects. In patients mean values of Total protein, were 7.13 ± 1.06 g/dl and in control subjects these values were 7.6 ± 0.7 g/dl. These results were in agreement with present study. [26] *Oyedeji et al., (2013)* carried out a study and reported that patients of TB had a decrease in values of total protein as compared to control subjects. They reported mean values of total protein in patients and control subjects as 6.9 ± 0.5 g/dl and 7.5 ± 0.8 g/dl respectively and results were similar to present study. *Khan & Warke (2012)* reported that total protein levels of patients were decreased significantly as compared to normal subjects. In control subjects mean value of total protein was 7.84 ± 0.1 g/dl which was significantly high as compared to pretreated TB patients where mean value was 7.1 ± 0.5 g/dl. All these findings were similar to current study.

Albumin and Globulin

One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is a very highly significant ($p < 0.001$) decrease in values of Albumin in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Levels of Albumin were decreased significantly in diseased subjects when compared to healthy subjects. [26] *Oyedeji et al., (2013)* reported a decrease in albumin level in patients of TB when compared to control subjects. Mean values of albumin in patients and control subjects were found as 2.9 ± 0.05 g/dl and 4.2 ± 0.25 g/dl respectively and results were similar to present study. Globulin was studied in two different groups. One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is a significant change in values of Globulin in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Levels of globulin were increased very highly significantly ($p < 0.001$) in diseased subjects in comparison to control subjects. [25] *Akiibinu et al., (2007)* reported that the mean levels of globulin were significantly high when tuberculosis patients were compared with control subjects. In patients mean values of Globulin were 3.9 ± 0.84 g/dl and in control subjects these values were 3.4 ± 0.6 g/dl. These results were in correlation with above mentioned study. [14] *Khan & Warke (2012)* also reported that globulin level rose in patients when compared to normal subjects. In diseased subjects mean value of globulin was 4.24 ± 0.01 g/dl which was significantly high as compared to control subjects where mean value was 3.58 ± 0.572 g/dl. These results were similar to present study.

Serum Urea and Serum Creatinine

One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is no significant change ($p > 0.005$) in values of Urea in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. [24] *Edalo et al., (2012)* found there was no significant variation in levels of urea in newly diagnosed patients of tuberculosis and control subjects. As a result of anti-tuberculosis treatment values of urea were deranged but remained normal when patient was suffering from TB but not undergoing treatment of the disease. In present study I have only studied newly diagnosed patients of TB not taking any treatment and found no significant change in urea levels in control and diseased

subjects. So, these results were in correlation with above mentioned study. Mean value of urea was 25.5 ± 7.552 mg/dl in newly diagnosed patients of TB and was same when compared with control subjects. One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is no significant change ($p > 0.05$) in values of Creatinine in overall and females of diseased group as compared to overall and female control groups. But in case of males these values differ significantly ($p < 0.05$) and were decreased in case of diseased males as compared to healthy males. [24] Edalo et al., (2012) found there was no significant variation in levels of creatinine in newly diagnosed patients of tuberculosis and control subjects. As a result of anti-tuberculosis treatment values of creatinine were deranged but remained normal when patient was suffering from TB but not undergoing treatment of the disease. In present study only newly diagnosed patients of TB were studied not taking any treatment and found no significant change in creatinine levels in control and diseased subjects. So, my results are in correlation with above mentioned study. Mean value of creatinine was 0.696 ± 0.164 mg/dl in newly diagnosed patients and was similar to control subjects with no significant variation.

Total Cholesterol

One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is a very highly significant change ($p < 0.001$) in values of Total Cholesterol in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Comparison shows that as a result of tuberculosis infection levels of Total cholesterol were decreased when compared to normal subjects. [26] Oyedeji et al., (2013) studied lipid profile in TB patients and found that lipid profile was also deranged in TB. Total cholesterol levels were decreased in patients with pulmonary tuberculosis. Total cholesterol level was 180 ± 5.0 mg/dl in control subjects and 125 ± 1.0 mg/dl in TB patients. These results were similar to results of present study.

Triglycerides

One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is a significant change ($p < 0.001$) in values of triglycerides in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Comparison shows that as a result of

tuberculosis infection levels of triglycerides were decreased when compared to normal subjects. [26] Oyedeji et al., (2013) found triglycerides levels were decreased significantly in patients with pulmonary tuberculosis. Triglycerides level in control subjects was 147 ± 2.0 mg/dl and in TB patients was 96 ± 2.0 mg/dl. The above results are in agreement to the present findings. [27] Metwally and Raheem (2012) compared overall TB patients having different forms of TB (pulmonary TB, pleural, TB lymphadenitis, TB peritonitis with control group and found that triglycerides level was significantly lowered and in patients mean values \pm SD of triglycerides were 80.1 ± 23.5 mg/dl and in control subjects these values were 113.6 ± 39.8 and in patients of pulmonary tuberculosis these values were 78 ± 20.8 mg/dl respectively and in pulmonary tuberculosis levels of cholesterol and triglycerides were lowered significantly and results were in agreement with the findings of present study.

High Density Lipoprotein Cholesterol (HDL Cholesterol)

One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is a highly significant change ($p < 0.001$) in values of HDL Cholesterol in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Comparison showed that as a result of tuberculosis infection levels of HDL Cholesterol were decreased when compared to normal subjects. [26] Oyedeji et al., (2013) performed a study to find effect of TB infection on lipid profile in patients of TB and found a significant decrease in levels of total Cholesterol when compared to healthy subjects. HDL cholesterol levels were decreased in patients with pulmonary tuberculosis. The HDL- Cholesterol level was 45 ± 4.0 mg/dl in control subjects and 38 ± 2.7 mg/dl in patients with TB. These results resemble to present study.

Low density Lipoprotein Cholesterol (LDL Cholesterol)

One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there was a very highly significant change ($p < 0.001$) in values of LDL Cholesterol in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Comparison shows that as a result of tuberculosis infection levels of LDL Cholesterol were decreased when compared to normal

subjects. [26] Oyedeji et al., (2013) reported LDL cholesterol levels were decreased in patients with pulmonary tuberculosis. The LDL- Cholesterol level in patients of TB was 91 ± 3.0 mg/dl and in control subjects was 115 ± 4.0 mg/dl. These results are in agreement to my studies. [25] Akibiinu et al., (2007) stated a significant decrease in levels of LDL Cholesterol when compared to healthy subjects. In diseased subjects LDL Cholesterol level was 65.5 ± 15.1 mg/dl and in control subjects LDL cholesterol was 107.8 ± 27.5 mg/dl. These results were comparable to present study.

Very low-density lipoprotein cholesterol (VLDL cholesterol)

One is the normal group while other is the diseased affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is a very highly significant change ($p < 0.001$) in values of VLDL Cholesterol in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. Comparison shows that as a result of tuberculosis infection levels of VLDL Cholesterol are decreased when compared to normal subjects. Oyedeji et al., (2013) found VLDL cholesterol levels were decreased in patients with pulmonary tuberculosis. The VLDL- Cholesterol level in patients of TB was 19 ± 3.0 mg/dl and in control subjects was 35 ± 4.0 mg/dl. These results were in correlation to present study. [25] Akibiinu et al., (2007) also found a significant decrease in levels of VLDL Cholesterol when compared to healthy subjects. In diseased subjects VLDL Cholesterol level was 25.5 ± 15.1 mg/dl and in controls VLDL cholesterol was 37.8 ± 27.5 mg/dl. These results were comparable to present study.

Blood Glucose Fasting

Figure 3 showed the comparison of fasting blood glucose in two different groups. One is the normal group while other is the diseased, affected by *Mycobacterium tuberculosis* by applying the independent sample t-test, results show that there is no significant change ($p > 0.05$) in values of fasting blood glucose in overall, males and females of diseased group as compared to overall normal, normal male and normal female groups. It was evident from the study that serum glucose level significantly increases in smear positive pulmonary tuberculosis patients. It was contradictory to present study. In present study no significant difference was found in fasting glucose level in both groups. These differences in results can be attributed to various factors such as age variation, severity of disease, different dietary habits and variations in living conditions and life style of the peoples.

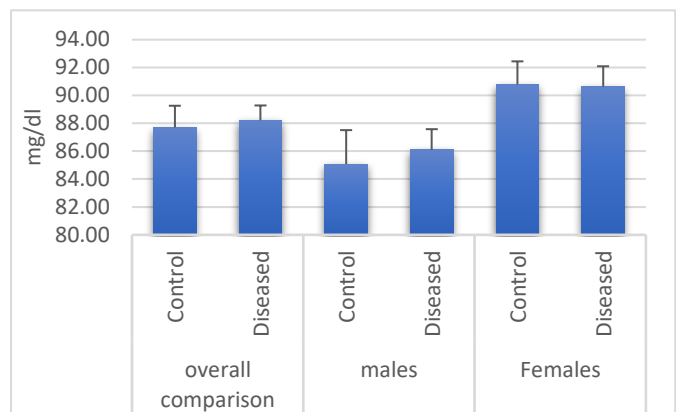


Figure 3. Comparison of mean of Glucose between control and diseased subjects.

Conclusion

The findings of this study demonstrate that tuberculosis infection is associated with a significant reduction in serum vitamin C levels along with marked alterations in lipid profile and protein metabolism. The observed decrease in total cholesterol, lipoproteins, triglycerides, total proteins, and albumin, accompanied by an increase in serum globulin levels, reflects the metabolic and immunological disturbances induced by active tuberculosis. These results highlight the importance of routine biochemical monitoring in tuberculosis patients and suggest that nutritional assessment and appropriate supplementation may support improved clinical management and patient outcomes. Further longitudinal and interventional studies are warranted to clarify the therapeutic implications of correcting vitamin C deficiency and associated biochemical abnormalities in tuberculosis.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Superior University.

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References

1. Amin, Z. Clinical tuberculosis problems and management. *Acta medica Indonesiana*. **2006**. 38(2): 109-116.
2. Frei, B. and Traber, M.G. The new US Dietary Reference Intakes for vitamins C and E. Redox report. **2001**. 6(1): 5-9.
3. Pehlivan, F.E. Vitamin C: An antioxidant agent. *Vitamin C*. **2017**. 2: 23-35.
4. Harris, J.R., *Subcellular Biochemistry: Ascorbic Acid: Biochemistry and Biomedical Cell Biology*. Vol. 25. **2013**: Springer Science & Business Media.
5. Thomas, W. and Holt, P. Vitamin C and immunity: an assessment of the evidence. *Clinical and Experimental Immunology*. **1978**. 32(2): 370.
6. Jafari, D., Esmailzadeh, A., et al., Vitamin C and the immune system, in *Nutrition and immunity*. **2019**, Springer. p. 81-102.
7. Kaźmierczak-Barańska, J., Boguszewska, K., et al. Two faces of vitamin C—antioxidative and pro-oxidative agent. *Nutrients*. **2020**. 12(5): 1501.
8. Salman, M.M. and Hammad, S. Oxidative stress and some biochemical alterations due to scorpion (*Leiurus quinquestriatus*) crude venom in rats. *Biomedicine & Pharmacotherapy*. **2017**. 91: 1017-1021.
9. Ginandjar, P., Saraswati, L.D., and Widjanarko, B. Profile of glycated-hemoglobin, antioxidant vitamin and cytokine levels in pulmonary tuberculosis patients: A cross sectional study at Pulmonary Diseases Center Semarang City, Indonesia. *biomedical journal*. **2016**. 39(5): 354-360.
10. Rifai, N., *Tietz Textbook of Clinical Chemistry and Molecular Diagnostics-E-Book: Tietz Textbook of Clinical Chemistry and Molecular Diagnostics-E-Book*. **2017**: Elsevier Health Sciences.
11. Zaninotto, M. and Plebani, M. Understanding and managing interferences in clinical laboratory assays: the role of laboratory professionals. *Clinical Chemistry and Laboratory Medicine (CCLM)*. **2020**. 58(3): 350-356.
12. Carroll, R.J. and Ruppert, D., Transformation and weighting in regression. **2017**: Chapman and Hall/CRC.
13. Penickova, S., Benyaich, S., et al. Reliability of albumin bromocresol green colorimetric method and clinical impact. *Scandinavian Journal of Clinical and Laboratory Investigation*. **2024**. 84(7-8): 452-458.
14. HKHAN, Z. and SWARKE, S. Effect of antituberculosis drugs on levels of serum proteins in pulmonary tuberculosis patients. *International Journal of Pharmaceutical Research & Allied Sciences*. **2012**. 1(3): 94-100.
15. Weiner, I.D., Mitch, W.E., and Sands, J.M. Urea and ammonia metabolism and the control of renal nitrogen excretion. *Clinical Journal of the American Society of Nephrology*. **2015**. 10(8): 1444-1458.
16. Hirano, T., Ito, Y., et al. Clinical significance of small dense low-density lipoprotein cholesterol levels determined by the simple precipitation method. *Arteriosclerosis, thrombosis, and vascular biology*. **2004**. 24(3): 558-563.
17. Islam, S.T., Osa-Andrews, B., et al. Methods of low-density lipoprotein-cholesterol measurement: analytical and clinical applications. *Ejifcc*. **2022**. 33(4): 282.
18. Bakaev, V. and Duntau, A. Ascorbic acid in blood serum of patients with pulmonary tuberculosis and pneumonia. *The International Journal of Tuberculosis and Lung Disease*. **2004**. 8(2): 263-266.
19. Madebo, T., Lindtjørn, B., et al. Circulating antioxidants and lipid peroxidation products in untreated tuberculosis patients in Ethiopia. *The American journal of clinical nutrition*. **2003**. 78(1): 117-122.
20. Johnkennedy, N., Onyinyechi, A.S., and Chukwunyere, N.E. The antioxidant status and lipid peroxidation product of newly diagnosed and 6 weeks follow-up patients with pulmonary tuberculosis in Owerri, Imo state, Nigeria. *Asian Pacific Journal of Tropical Disease*. **2011**. 1(4): 292-294.
21. Akpan, P., Akpotuzor, J., and Akwiwu, E.C. Some haematological parameters of tuberculosis (TB) infected Africans: the Nigerian perspective. *Journal of Natural Sciences Research*. **2012**. 2(1): 50-56.
22. Awodu, O., Ajayi, I., and Famodu, A. Haemorrhological variables in Nigeria pulmonary tuberculosis patients undergoing therapy. *Clinical hemorheology and microcirculation*. **2007**. 36(4): 267-275.
23. Shareef, H.A. and Amin, N.R.M. Abnormalities of hematological parameters in newly diagnosed Pulmonary tuberculosis patients in Kirkuk city. *Journal of Babylon University/Pure and Applied Sciences*. **2012**. 20(5): 1386-1392.
24. Edalo, A.S., Ali, A., et al. Evaluation of effect of antituberculous drugs on the liver and renal function tests in a Sudanese cohort. *Asian J Pharm Clin Res*. **2012**. 5(SUPPL 1): 61-3.
25. Akiibinu, M., Arinola, O., et al. Non-enzymatic antioxidants and nutritional profiles in newly diagnosed pulmonary tuberculosis patients in nigeria. *African Journal of Biomedical Research*. **2007**. 10(3).
26. Oyedeji, S.O., Adesina, A.A., et al. Oxidative stress and lipid profile status in pulmonary tuberculosis patients in South Western Nigeria. *Greener Journal of Medical Sciences*. **2013**. 3(6): 228-232.
27. Metwally, M.M. and Raheem, H.A. Lipid profile in tuberculous patients: A preliminary report. *Life Science Journal*. **2012**. 9(1): 719-722.

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