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(RESEARCH ARTICLE)

Biochemical Analysis of Urine in Pulmonary Tuberculosis Patients at the Kondima Health Center in the Mangobo Health Zone in Kisangani (DR Congo)

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Abstract

Introduction: This study focused on the biochemical analysis of urine from pulmonary tuberculosis patients at the Kondima Health Center in the Mangobo Health Zone of Kisangani (Democratic Republic of Congo). It aimed to measure biochemical parameters in the urine of these patients, including urea, protein, glucose, ketones, red blood cells, nitrites, bilirubin, urobilinogen, and sugar, in order to evaluate the effectiveness of treatment.

Methods: A descriptive cross-sectional study was conducted at the Kondima Health Center in the Mangobo Health Zone from January 1st to May 31st, 2025. Thirty urine samples were collected from tuberculosis patients screened for pulmonary tuberculosis and submitted for biochemical analysis.

Results: Ketone levels, urine specific gravity, and pH were all found to be within the normal range in 100% of urine samples collected from tuberculosis patients. Glycose and nitrite levels were tied at 96.7%, while bilirubin was found at 93.3%. Urobilinogen and vitamin C were also tied at 90.0%. No variable analyzed showed a value above the normal range in our laboratory tests.

Conclusion: Patients should request regular urine tests to analyze chemical parameters for optimal outcomes and to prevent treatment resistance.

Keywords: Biochemical analysis; Urine; Pulmonary tuberculosis; Tuberculosis

1. Introduction

Tuberculosis is an infectious disease that most often affects the lungs. It is caused by a type of bacterium that spreads through the air when infected people cough, sneeze, or spit. Mycobacterium tuberculosis is transmitted via the airborne route with varying clinical signs, most commonly affecting the lungs and sometimes other organs [1]. This disease is preventable and curable. It is estimated that about one-quarter of the world's population is infected with the tuberculosis bacterium, and about five to ten percent of infected individuals will eventually develop symptoms and tuberculosis [2].

Tuberculosis (TB), caused primarily by Mycobacterium tuberculosis, remains a major public health problem worldwide, requiring prolonged and often complex treatments [3]. The standard first-line treatment regimen involves a combination of potent antituberculosis agents such as isoniazid (INH), rifampicin (RMP), pyrazinamide (PZA), and ethambutol (EMB). While these drugs are essential for eradicating the infection and preventing transmission, they are not without side effects, including potential liver and kidney toxicity.

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According to Ngama CK, & al [4], urine chemistry is a routine examination that helps guide diagnosis by highlighting potential abnormalities such as pH, protein, glucose, ketone bodies, erythrocytes, bilirubin, urobilinogen, and hematuria. The chemical examination is performed using a urine dipstick test. Urine analysis provides a biochemical overview of urine composition, kidney function, and any ongoing infectious or inflammatory processes in the urology [5].

Diallo S, & al [6] report that monitoring patients' conditions is therefore crucial to optimizing treatment efficacy while minimizing the risk of serious adverse effects. Traditionally, this monitoring relies heavily on blood liver and kidney function tests (transaminases, creatinine, etc.) [7]. However, biochemical urine analysis (or uroanalysis) offers a non-invasive and early window into the patient's physiological status, particularly renal integrity and overall metabolic balance. The kidneys play a central role in the elimination of drug metabolites and electrolyte homeostasis, making urine a particularly rich source of information [8,9]. Early alterations in urinary composition, such as proteinuria, glycosuria, or variations in electrolyte excretion or markers of oxidative stress, could signal subclinical damage even before blood parameters change significantly [10].

Despite the importance of this treatment and its potential toxicity, the specific literature studying the systematic impact of antituberculosis treatment regimens on the urinary biochemical profile is limited. The present study therefore aims to fill this gap by performing a comprehensive biochemical analysis of urine in patients receiving standard antituberculosis treatment [11].

Urine analysis in tuberculosis patients is an important diagnostic and monitoring tool for several reasons: assessing disease severity, monitoring treatment, detecting side effects, and identifying co-infections [12]. This analysis is essential not only for the diagnosis and monitoring of the disease but also for evaluating treatment efficacy and detecting potential complications [13]. However, most tuberculosis patients do not realize the need to evaluate their antituberculosis treatment and focus solely on taking the medication, thus overlooking the importance of biochemical analysis of their urine [14].

According to Wobeser W, & al [15], it is essential to identify and quantify any changes in key urinary parameters (e.g., markers of tubular or glomerular damage, specific metabolites) and to correlate these changes with the phase of treatment and the doses administered. The ultimate goal is to determine whether biochemical urinalysis can serve as a complementary or early monitoring tool to detect adverse effects of treatment and personalize the management of tuberculosis patients [16].

Based on the above, the present study aims to determine the biochemical parameters isolated from the urine of pulmonary tuberculosis patients in the city of Kisangani. Specifically, the study aims to measure the biochemical parameters in the urine of pulmonary tuberculosis patients, including urea, protein, glucose, ketones, red blood cells, nitrites, bilirubin, urobilinogen, and sugars.

2. Methods

2.1. Materials

2.1.1. Description of the research site

This research was conducted in the biomedical laboratory of the Kondima Health Center, located in the Mangobo Health Zone in Kisangani, The Democratic Republic of Congo.

Geographically, the Kondima Health Center is bordered to the east by the Baptist Community of the Congo River, to the west by the BEGO/Congo Company, to the north by the Tshopo River, and to the south by the Mangobo Institute.

2.1.2. Population and sample

Our study population consisted of 30 pulmonary tuberculosis patients aged 20 to 65 years who were receiving anti-tuberculosis treatment.

Given the size of our population, we included all 30 tuberculosis patients selected for our sample. Thus, the sample is exhaustive, consisting of 30 urine samples from tuberculosis patients who were screened for pulmonary tuberculosis and subjected to biochemical analyses of urine such as proteins, glucose, bilirubin, nitrite, urobilinogen, pH, urine density by the strip and photometric method.

2.2. Methods

2.2.1. Study Type

We used a descriptive cross-sectional method, conducted at the Kondima Health Center in the Mangobo Health Zone from January 1st to May 31st, 2025.

2.2.2. Description of the Analysis

To collect biomedical data in the laboratory, we used the sample observation technique. This method involves dipping a test strip into the urine and then comparing the color of the corresponding box on the packaging to the color indicated on the packaging when the strip was removed from the urine container. Photometric analysis was also performed.

2.2.3. Study Type

We used a descriptive cross-sectional method, conducted at the Kondima Health Center in the Mangobo Health Zone from January 1st to May 31st, 2025.

2.2.4. Description of the Analysis

To collect biomedical data in the laboratory, we used the observation technique. This method involves dipping the test strip into the urine and then comparing the color of the box corresponding to the element in question, upon removal of the strip from the urine container. The strip test is based on colorimetry; it is a rapid test for detecting pH, protein, glucose, bilirubin, urobilinogen, red blood cells, urine specific gravity, leukocytes, etc. Photometry, on the other hand, measures the intensity of light received as it passes through a transparent container (a cuvette whose material must be adapted to the specific wavelength). We used the urine strip test to analyze urine samples collected from tuberculosis patients undergoing anti-tuberculosis treatment.

Principle of the Urine Test Strip

It is based on the colorimetric principle: the color of the cell corresponding to the element or parameter being tested changes once the strip is immersed in urine.

Procedure

The procedure using the urine test strip consists of:

- Carefully reading the manufacturer's instructions;
- Thoroughly washing hands and the genital area with soap and water;
- Asking the patient to start urinating in the toilet and then stop;
- Collecting at least 30 ml of urine in the container;
- Removing one test strip from its packaging;
- Immersing the test strip in the urine sample for the recommended time, generally a few seconds;
- Removing the test strip from the urine and gently tapping it to remove excess urine;
- Wait the recommended time (generally 45 seconds) for the test result to develop (Linda M, 2023).

Spectrophotometry

- Principle

The spectrophotometer is simply the instrument that measures the intensity of the light it receives once it passes through the transparent container (cuvette containing the solution).

- Procedure
- Circle the letter of the solution you need to prepare in the table;
- Recall the dilution formula and then deduce the formula used to calculate the volume;
- Calculate the volumes of the stock solution to be taken to correctly prepare the daughter solution A to G, and complete the table;

Write the dilution protocol for the chosen standard solution.

Specify the name and volume of the glassware.

Test Strip Reader

- Operating Procedure
- Turn on the test strip reader by pressing the ON button;
- Information appears on the test strip reader screen;
- Pour the urine from the sterile container into the test tube;
- Remove the test strip from the collection container;
- Dip the urine test strip into the test tube;
- Pull the test strip out of the container;
- Remove any excess urine from the test strip;
- Insert the test strip into the reader cartridge;
- Press the Enter button to advance the test strip into the machine;

After 60 seconds, the machine will eject the test strip and then print the result.

Table 1 Urine analyzer test gradient (continued) parameter

Parameter	**Convention**	**International System**
Glucose	Negative 100mg/dl – 1000mg/dl	Negative 5.5mmol/l – 55mmol/l
Bilirubin	Negative 1mg/dl – 6mg/dl	Negative 17mol/l – 100mol/l
Ketone	Negative 5mg/dl – 80mg/dl	Negative 0.5mmol/l – 8.0mmol/l
SG	1.030	
pH	5.0 – 9.0	5.0 – 9.0
Protein	Negative 10mg/dl – 300mg/dl	Negative 0.1g/l – 3.0gl/l
Urobilinogen	Negative 0.2mg/dl – 1mg/dl	Negative 3.3Umol/L-16 Umol/L
Nitrite	Negative and positive	Negative and positive
Blood	Negative 15Ca Cells/Ul – 500 Cells/Ul	Negative 10Ca Cells/Ul – 200 Cells/Ul
Leukocytes	Negative 15Ca Cells/Ul – 500 Cells/Ul	Negative 15Ca Cells/Ul – 500 Cells/Ul
Vitamin C	Negative 0mg/dl – 100mg/dl	Negative 0 mmol/L – 5.6mmol/L

2.2.5. Method of Analysis

We used urine dipsticks as the instrument for biochemical analysis of urine samples, including the following parameters: protein, glucose, urobilinogen, bilirubin, nitrite, pH, specific gravity, ketones, blood, and vitamin C.

2.2.6. Data Processing

The collected data were then processed, transformed by scoring, and analyzed using percentage analysis.

2.3. Challenges Encountered

Conducting this study presented several challenges, notably the lack of a brand-name dipstick reader at the Kondima Health Center. This led us to shift our focus to the Matete Reference Health Center to perform biochemical analyses on urine samples collected from patients undergoing anti-tuberculosis treatment.

3. Results

3.1. Identification of patients on anti-tuberculosis drugs

Table 2 Distribution of cases according to identification criteria

Variables	Effectives (n=30)	Percentage (%)
Gender		
Male	19	63.3
Female	11	36.7
Marital status		
Married	24	80.0
Single	6	20.0
Occupation		
Taxi driver	9	30.0
Unemployed	7	23.3
Student	7	23.3
Civil servant	5	16.7
Military personnel	2	6.7
Education level		
Primary	9	30.0
Secondary	17	56.7
Higher education	4	13.3

Reading this table reveals that 63.3% of the subjects in the study are male, compared to 36.7% female; the majority of whom are married (80.0%) and 30.0% taxi drivers, the majority of whom (56.7%) have a secondary education.

3.2. Biochemical Profile of Urine Samples

Table 3 Biochemical Analysis of Urine Samples from Tuberculosis Patients

Variables	Highest value		Average value		Lowest value		Total	
	f	%	f	%	F	%	f	%
Ketone	0	0.0	30	100	0	0.0	30	100
Urine specific gravity	0	0.0	30	100	0	0.0	30	100
Hydrogen potential (pH)	0	0.0	30	100	0	0.0	30	100
Blood	0	0.0	30	100	0	0.0	30	100
Glycose	1	3.3	29	96.7	0	0.0	30	100
Nitrites	1	3.3	29	96.7	0	0.0	30	100
Bilirubin	2	6.7	28	93.3	0	0.0	30	100
Urobilinogen	3	10.0	27	90.0	0	0.0	30	100
Vitamin C	3	10.0	27	90.0	0	0.0	30	100
Proteins	9	30.0	21	70.0	0	0.0	30	100

Analyzing this table, we note the presence of ketone, urine specific gravity, hydrogen potential (pH), and blood in 100% of urine samples taken from tuberculosis patients, with an average value of 96.7% for glucose and nitrite. Bilirubin has a score of 93.3%, and urobilinogen and vitamin C are also tied at 90.0%. Finally, protein levels were measured in 70.0% of cases. Furthermore, the highest values were observed for protein (30.0%), followed by vitamin C and urobilinogen, tied at 10.0%, and then bilirubin (6.7%) and glucose and nitrite, each at 3.3%. None of the variables analyzed showed a value higher than normal during our laboratory analyses.

4. Discussion

4.1. Urobilinogen

Following laboratory analyses, we observed the presence of urobilinogen in the urine samples of pulmonary tuberculosis patients, with a value exceeding 10%. According to the report of the National Tuberculosis Control Program, submitted by the South Katanga Provincial Tuberculosis Control Coordination [17], it is important to note that normal and pathological levels of urobilinogen in urine vary slightly depending on the laboratory and the analytical methods used. However, in general, the normal level of urobilinogen in urine is usually less than 1 mg/dL (0.2 - 1.0 mg/dL); an elevated level of urobilinogen in urine is greater than 2 mg/dL; and a low urobilinogen level in urine is less than 1.0 mg/dL (3.2 µmol/L).

According to Eholie SP, & al [17], urinary urobilinogen analysis in tuberculosis patients is not a routine test for the diagnosis of tuberculosis itself. However, it becomes relevant and should be performed in specific situations, primarily related to possible liver involvement: monitoring of antituberculosis treatment, the main reason for analyzing urobilinogen being the monitoring of drug-induced liver toxicity (such as isoniazid and rifampicin).

The parameter in question can lead to certain liver pathologies. An increase in urinary urobilinogen can be an early sign of hepatocellular dysfunction (hepatitis) or hemolysis, two potential complications in tuberculosis patients (hepatotoxicity being the most common during treatment). Although not a diagnostic test for tuberculosis, urobilinogen analysis is a useful tool for monitoring liver function in tuberculosis patients, especially during treatment or in the presence of liver symptoms.

4.2. Bilirubin

This series reveals that 6.6% of urine samples taken from pulmonary tuberculosis patients have elevated bilirubin levels. Bilirubin analysis is a crucial element in monitoring patients undergoing anti-tuberculosis treatment, due to the risk of hepatotoxicity (liver toxicity) induced by certain drugs, including isoniazid (INH), rifampicin (RMP), and pyrazinamide (PZA). Measurement of bilirubin (total and conjugated/direct) and transaminases (ALT, AST) is recommended before starting anti-tuberculosis treatment, especially in patients with risk factors for hepatotoxicity (advanced age, alcoholism, chronic viral hepatitis B or C, pre-existing liver disease, other hepatotoxic drugs) [16].

This is justified by the fact that bilirubin is a yellow pigment resulting from the breakdown of heme, a component of hemoglobin. A high level before treatment could contraindicate the use of certain medications or necessitate an adapted treatment regimen. Bilirubin monitoring is essential in patients undergoing anti-tuberculosis treatment, as it serves as a key and sometimes early indicator of potentially serious drug-induced hepatotoxicity.

4.3. Ketones

It was observed that all urine samples taken from tuberculosis patients, i.e., 100%, contained an average proportion of ketones. According to Mbayo MG., et al. [13], the presence of trace amounts of ketones in urine is normal, but a high level may indicate a serious complication of diabetes called ketoacidosis. Ketone bodies can be observed in individuals with type 1 diabetes. The National Tuberculosis Control Program [10] indicates that ketone body analysis (ketonuria or ketonemia) in patients undergoing antituberculosis treatment is relevant primarily due to the use of one of the key drugs: pyrazinamide. The most direct point is the known interference between pyrazinamide (PZA), a first-line antituberculosis drug, and tests for detecting ketone bodies (acetone and acetoacetic acid) in urine.

When analyzing ketones in a patient undergoing antituberculosis treatment including pyrazinamide, it is important to bear in mind that urine tests are often prone to false positives. Blood ketone measurement (ketonemia, β-hydroxybutyrate) is more reliable in cases of clinical suspicion of ketosis or ketoacidosis.

4.4. pH

In this series, we observed that all urine samples from tuberculosis patients collected for laboratory biochemical analysis had an average pH value of 100%. According to Mbayo MG., & al. [13], pH is an indicator of acidity when it is below 7 or of alkalinity when it is above 7. If the urinary pH is consistently low and the patient presents with symptomatic hyperuricemia (gout or persistent joint pain) or signs of kidney stones, urine alkalinization (e.g., by administering potassium citrate) may be considered to increase the urinary pH and dissolve or prevent the formation of uric acid stones. Urinary pH analysis in a patient undergoing antituberculosis treatment is relevant primarily due to the use of pyrazinamide (PZA), one of the first-line drugs. Pyrazinamide impacts uric acid metabolism and indirectly contributes to the conditions that promote certain renal complications [19].

In summary, the effect of treatment (particularly PZA) on urinary acid-base balance is significant, as a low urinary pH (pH < 5.5) in the presence of hyperuricemia (due to PZA) increases the risk of uric acid kidney stones: the precipitation of uric acid crystals is highly dependent on an acidic urinary pH; and acute gout: although it is a joint complication, it is linked to the hyperuricemia caused by PZA.

4.5. Proteins

In our study, we observed that the biochemical parameters analyzed in urine samples from tuberculosis patients revealed an average protein level of 30%, compared to a higher value of 70% in some cases. This is explained by the fact that protein is a macromolecule. Borgdoff MW, & al [19] indicate that protein analysis in urine (proteinuria) in patients undergoing antituberculosis treatment is an important monitoring point, as it can be related to two main factors: kidney damage caused by tuberculosis itself or an adverse effect of the antituberculosis drugs.

Proteinuria in a patient undergoing antituberculosis treatment is a warning sign that necessitates a nephrological evaluation to determine whether it is a complication of the disease (renal tuberculosis, amyloidosis) or a side effect of the treatment, in order to adapt management and prevent chronic renal failure.

4.6. Glucose

Following our laboratory analyses, we found that only one tuberculosis patient (3.4%) presented with elevated urinary glucose levels, compared to 96.6% with average values. This is demonstrated by the fact that glucose is an essential energy source for the human body; it plays a central role in energy metabolism by providing the energy necessary for cell function.

According to Brudey K, & al [11], urinary glucose analysis (glycosuria) in patients undergoing antituberculosis treatment can be relevant for several reasons, primarily related to the potential coexistence of two pathologies (tuberculosis and diabetes) or the nephrotoxicity of certain medications. Some antituberculosis drugs (often used in combination) can potentially affect renal function and, consequently, cause glycosuria even in the absence of hyperglycemia.

In practice, in any tuberculosis patient, the detection of glycosuria should systematically lead to measurement of fasting blood glucose or HbA1c to screen for or assess the control of associated diabetes, given the high comorbidity between the two diseases. Monitoring renal function is also essential to detect any drug-induced nephrotoxicity.

4.7. Nitrites

Regarding nitrites, we observed that 3.4% of elevated values were detected in urine samples from tuberculosis patients, compared to an average value of 96.6%. According to Brudey K, & al [11], this is because the other microorganisms involved do not produce nitrites (Staphylococcus, Pseudomonas aeruginosa, Streptococcus B, Acinetobacter). Nitrites are not normally present in urine, and their presence, known as nitrituria, most often indicates a bacterial infection in the urinary tract. Nitrite ($NO2-$) analysis in urine of patients undergoing antituberculosis treatment (ATT) is a key indicator of the potential presence of a urinary tract infection (UTI).

The presence of nitrites in the urine of a patient undergoing antituberculosis treatment should be considered a warning sign of a common bacterial UTI until proven otherwise. However, caution is advised due to the potential interference of rifampicin with the urine dipstick test. A urine culture (ECBU) is the essential confirmatory test to precisely identify the problem and guide appropriate antibiotic therapy, while ensuring good adherence to the antituberculosis treatment.

4.8. Blood

Laboratory analysis of urine samples reveals the absence of blood in the urine of all tuberculosis patients, with an average value of 100%. This is supported by Kakisingi NC, & al [12], who report in their study that blood is a fluid circulating in blood vessels (arteries, veins) that irrigate all the body's tissues, delivering nutrients and oxygen while collecting waste. It contains red blood cells, white blood cells, and platelets suspended in a liquid called plasma.

Analysis of blood samples from patients undergoing antituberculosis treatment is an essential component of therapeutic monitoring. Its primary aim is to assess the effectiveness of the treatment and to screen for any serious side effects, including hepatotoxicity (liver toxicity) and hematological or renal impairment [18].

Blood tests in patients undergoing antituberculosis treatment are not used to monitor drug concentration (except in specific cases), but primarily to prevent or detect early serious adverse effects, particularly hepatotoxicity, mainly by measuring transaminases. The frequency and type of tests are tailored to the patient's risk profile.

4.9. Urine Specific Gravity

During the study period, we observed an average urine specific gravity of 100% when analyzing urine samples from tuberculosis patients in the laboratory. This result is demonstrated by the fact that the normal range for analysis was found to be between 1.001 and 1.035. According to Mbayo MG., & al. [13], urine specific gravity (or urine specific weight) measures the concentration of solutes in the urine. It is primarily used to assess the kidneys' ability to concentrate or dilute urine, thus reflecting hydration status and, potentially, renal tubular function. Analysis of urine specific gravity in patients undergoing antituberculosis treatment (ATT) is not a routine examination specifically mentioned in monitoring protocols for this single parameter. However, it can be a relevant indirect indicator in the assessment of renal function and the patient's hydration status, two crucial points in this context [4].

Urine specific gravity analysis is part of the urinalysis (dipstick and sediment) which can reveal other important signs (proteinuria, hematuria, etc.) related to renal impairment or other complications, and it primarily serves as an indicator of hydration status. Interpretation should always be correlated with other laboratory parameters.

4.10. Vitamin C

In analyzing urine samples from tuberculosis patients in the laboratory, we observed that 90% of samples had an average vitamin C level, while 10% had a higher value. This result could be explained by the consumption of many foods containing vitamin C, such as fruits, in the urine of some tuberculosis patients.

According to Mariani F, & al [1], vitamin C analysis in patients undergoing antituberculosis treatment reveals two main aspects: the prevalence of deficiencies and its potential role as an adjunct treatment. Patients with tuberculosis often present with impaired nutritional status and lower levels of micronutrients, including vitamin C, than healthy individuals.

It is important to note that antituberculosis treatment, particularly isoniazid (INH), can lead to vitamin B6 (pyridoxine) deficiency, which can cause peripheral neuropathy. This is why systematic vitamin B6 supplementation is often administered to patients on INH, unlike vitamin C, the supplementation of which in this context is still being researched.

5. Conclusion

Pulmonary tuberculosis remains a serious public health problem, affecting all age groups, especially in developing countries. Therefore, for effective anti-tuberculosis treatment, patients are advised to request regular urine tests to analyze chemical parameters for optimal outcomes, with the ultimate goal of preventing treatment resistance.

In conclusion, the healthcare system for managing tuberculosis patients still needs improvement throughout the Democratic Republic of Congo in general, and in Tshopo Province in particular, if we hope to reduce tuberculosis-related morbidity and mortality.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there are no conflicts of interest.

Statement of informed consent

"Informed consent was obtained from all individual participants included in the study."

Author contributions

Bernard MALEMO LOFUTU conceived the research topic and organized data collection in the laboratory. The other authors performed data entry, processing, and text formatting.

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