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EPIDEMIOLOGICAL PROFILE AND PREVALENCE OF HYPONATREMIA IN PULMONARY TUBERCULOSIS: A CROSS-SECTIONAL STUDY FROM RAJASTHAN, INDIA

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ABSTRACT

Background: Hyponatremia is one of the most common electrolyte disturbances seen in hospitalized pulmonary tuberculosis (PTB) patients and may reflect disease severity. Indian data are limited, particularly from high-burden states such as Rajasthan.
Objectives: To determine the prevalence and severity of hyponatremia in newly diagnosed sputum smear–positive pulmonary tuberculosis patients and to describe their demographic and clinical profile.
Methods: This descriptive cross-sectional study was conducted in the Department of Respiratory Medicine, Institute of Respiratory Diseases, tertiary care hospital in Rajasthan. A total of 140 newly diagnosed sputum smear–positive PTB patients were included over one year. Serum sodium levels were measured at diagnosis and categorized as mild (130–134 mmol/L), moderate (125–129 mmol/L), and severe (<125 mmol/L). Sociodemographic and clinical parameters were recorded and analyzed.
Results: The prevalence of hyponatremia (<135 mmol/L) was 45%. Severe hyponatremia was seen in 10%, moderate in 14%, and mild in 21% of patients. Most participants were aged 41–60 years (53.6%), male (80.7%), and from rural areas (90%). A statistically significant association was observed between serum sodium and age group ($p = 0.00001$), gender ($p = 3.35\times10^{-5}$), BMI ($p = 6.22\times10^{-4}$), occupation ($p = 2.36\times10^{-4}$), chest X-ray findings ($p = 6.12\times10^{-4}$), and sputum AFB grading ($p = 0.02$).
Conclusion: Hyponatremia is highly prevalent in PTB patients, particularly among females, underweight individuals, and those with advanced radiological and bacteriological disease. Routine sodium monitoring is recommended for early detection and management.

Keywords: *Hyponatremia, Pulmonary Tuberculosis, Prevalence, Epidemiology, Rajasthan, SIADH.*

INTRODUCTION

Tuberculosis (TB) remains a global health challenge, with India accounting for 28 % of incident cases. Among the various complications associated with TB, hyponatremia is one of the most common electrolyte abnormalities encountered in clinical practice. Its mechanisms include the syndrome of inappropriate antidiuretic hormone secretion (SIADH), adrenal insufficiency, central nervous system involvement, and renal sodium loss. Reported prevalence varies from 8 % to 49 % in different Indian studies. Rajasthan, a high-TB-burden state, lacks adequate data on this topic. This study was designed to determine the prevalence and severity of hyponatremia in PTB patients and describe their clinico-epidemiological profile.

MATERIALS AND METHODS

Study Design and Setting: Hospital-based descriptive cross-sectional study conducted in the Department of Respiratory Medicine, Institute of Respiratory Diseases, tertiary care hospital in Rajasthan

Study Duration:One year. Sample Size:140 patients, calculated assuming a 40 % prevalence of hyponatremia, 95 % confidence level, and 9 % allowable error.

Inclusion Criteria:
1. Adults ≥18 years
2. Newly diagnosed sputum smear–positive, drug-sensitive PTB
3. Provided informed consent

Exclusion Criteria:
1. HIV-positive patients
2. Patients on drugs affecting sodium metabolism
3. Pregnant females
4. Chronic cardiac, renal, or hepatic disease

Data Collection: Demographic, clinical, and radiological data were collected using a structured proforma. Serum sodium was measured using standard biochemical methods.
Statistical Analysis: SPSS was used. Quantitative data were presented as mean ± SD. Categorical data were expressed as frequencies and percentages. Chi-square test and t-tests were applied; $p < 0.05$ was considered significant.

RESULTS
The age distribution table (Table 1) of the study participants shows that the majority belong to the 41–60 years age group, which constitutes 53.85% (75) of the total sample. This is closely followed by the 21–40 years age group, accounting for 27.85% (39). Participants aged above 60 years make up 19.28% (21), while those under 20 years are the least represented, with only 3.57% (5 participants). This indicates that the sample is predominantly comprised of adults aged 21 to 60 years, with relatively fewer participants from the younger (<20 years) and older (>60 years) age groups. Such a distribution suggests that the study primarily reflects findings relevant to the adult and middle-aged population

The gender distribution table (Table 2) indicates a marked male predominance among the study participants. Out of the total 140 subjects, 113 (80.71%) are male and only 27 (19.28%) are female. This significant disparity suggests that males constitute the majority of the sample, and any findings of the study may primarily reflect the characteristics and outcomes of the male population.

The table 3 presents the distribution of serum sodium levels among a total of 140 individuals. It reveals that 10% of the participants had serum sodium levels below 125 mmol/L, indicating severe hyponatremia. An additional 14% had sodium levels between 125–129 mmol/L (moderate hyponatremia), while 21% had levels ranging from 130–134 mmol/L (mild hyponatremia). Thus, a total of 45% of the study population exhibited some degree of hyponatremia. The remaining 55% of individuals had serum sodium levels greater than 135 mmol/L, which is considered within the normal range. This suggests that hyponatremia is a relatively common biochemical abnormality in the study population, with a significant proportion exhibiting mild to moderate sodium deficiency.

The table 4 demonstrates a statistically significant association between age group and serum sodium levels. Severe hyponatremia (<125 mmol/L) and moderate hyponatremia (125–129 mmol/L) were most prevalent in the youngest age group (<20 years), where all individuals had low sodium levels. In contrast, the 21–40 yr group showed a mixed pattern, with some individuals having low sodium and a majority maintaining normal levels. The 41–60 yr group had the highest proportion of normal or mildly low sodium levels, indicating greater electrolyte stability in middle age. However, the >60 yr group again showed a higher frequency of hyponatremia, reflecting increased vulnerability in elderly individuals. Overall, these findings highlight that both the youngest and oldest age groups are more prone to hyponatremia, while middle-aged individuals exhibit relatively better sodium balance.

The table 5 shows a statistically significant association between gender and serum sodium levels. Among females, the majority had low serum sodium levels, with only 4 out of 27 (14.8%) having values above 135 mmol/L, whereas among males, 73 out of 113 (64.6%) had normal sodium levels. Conversely, hyponatremia (serum sodium <135 mmol/L) was much more prevalent in females (85.2%) compared to males (35.4%). This significant disparity indicates that female patients in the study were far more likely to present with low serum sodium levels, suggesting a potential gender-related physiological or clinical susceptibility.

The table 6 illustrates the relationship between comorbidity status and serum sodium levels, with the Chi-square test result indicating no statistically significant association. Among patients with diabetes, the majority had normal serum sodium levels (>135 mmol/L), while a substantial number exhibited varying degrees of hyponatremia. Similarly, in hypertensive individuals, 24 out of 47 had normal sodium levels, and 23 had levels below 135 mmol/L. In the group without any comorbidities, most participants had normal sodium levels, with fewer cases of hyponatremia. Although hyponatremia appears more frequent among those with comorbidities, the observed differences across the groups were not statistically significant.

The table 7 shows a statistically significant association between BMI and serum sodium levels. Among underweight individuals a large proportion had hyponatremia, with 35 out of 56 (62.5%) showing sodium levels below 135 mmol/L. In contrast, normal-weight individuals had a more balanced distribution, with 56 out of 80 (70%) having normal sodium levels (>135 mmol/L). Interestingly, among overweight individuals (BMI 25–29.9), all had some degree of hyponatremia, with none having serum sodium above 135 mmol/L. These findings indicate that both extremes of BMI — underweight and overweight — may be associated with higher risk of hyponatremia, whereas individuals with normal BMI tend to have more stable sodium levels.

The table 8 shows a statistically significant association between occupation and serum sodium levels. Among the **not skilled** group, a high proportion had hyponatremia, with only 7 out of 28 individuals (25%) having normal sodium levels. In contrast, the **semi-skilled** group showed a healthier sodium profile, with 60 out of 80 (75%) having normal levels. The **skilled** and **professional** groups had more balanced or mildly skewed distributions but still showed notable variability in sodium levels. These differences suggest that occupation, potentially reflecting differences in socio-economic status, nutritional access, or disease severity, has a significant impact on serum sodium level

The table 9 presents the distribution of serum sodium levels based on residence and shows no statistically significant association between the two variables (Chi-square = 5.09, df = 3, p = 0.165). Among rural residents, the majority (73 out of 126) had normal serum sodium levels (>135 mmol/L), while 53 had varying degrees of hyponatremia. In contrast, urban residents showed a relatively even distribution across sodium categories, with no strong concentration in any specific range. Although hyponatremia (<135 mmol/L) appears more common in rural residents numerically, the difference was not statistically significant, suggesting that **residence (rural vs urban)** does **not have a meaningful impact** on serum sodium levels in this study population

The table 10 presents a statistically significant association between chest X-ray findings and serum sodium levels (Chi-square = 17.30, DF = 3, $p = 6.12 \times 10^{-4}$). Among patients with **consolidation**, the majority (75 out of 128) had normal serum sodium levels (>135 mmol/L), while only a small proportion had severe hyponatremia. In contrast, among those with **fibro-cavity lesions**, most individuals (10 out of 12) had serum sodium levels <135 mmol/L, including 4 patients with sodium <125 mmol/L. This marked disparity indicates that patients with fibro-cavitary lesions are significantly more prone to hyponatremia compared to those with simple consolidation.

The table 11 shows a statistically significant association between sputum AFB grading and serum sodium levels (Chi-square = 15.02, DF = 6, $p = 2.01 \times 10^{-2}$). Among patients with Grade 1 AFB, the majority (22 out of 26) had normal serum sodium levels (>135 mmol/L), with very few showing hyponatremia. In contrast, those with Grade 2 and Grade 3 AFB had a progressively higher proportion of low serum sodium levels, especially in the <125 and 125–129 mmol/L categories. Notably, Grade 3 cases accounted for 11 of the 14 patients with severe hyponatremia (<125 mmol/L). This trend suggests that increasing AFB grade, which indicates higher mycobacterial load, is associated with greater likelihood of hyponatremia, potentially reflecting more severe systemic involvement or disease burden.

TABLE NO. 1 : DISTRIBUTION OF STUDY PARTICIPANTS AS PER AGE

VARIABLES	FREQUENCY	**PERCENTAGE %**
< 20 YR	5	3.57%
21- 40 YR	39	27.85%
41 - 60 YR	75	53.57%
> 60 YR	21	19.28%
TOTAL	**140**	**100%**

TABLE NO. 2: DISTRIBUTION OF STUDY PARTICIPANTS AS PER GENDER

Variables	**Frequency**	**Percentage %**
Female	27	19.28%
Male	113	80.71%
Grand Total	140	100%

TABLE NO.3: DISTRIBUTION OF STUDY PARTICIPANTS AS PER SERUM SODIUM LEVEL

Variables	Frequency	Percentage%
<125	14	10 %
125-129	19	14 %
130-134	30	21%
>135	77	55%
GrandTotal	**140**	**100%**

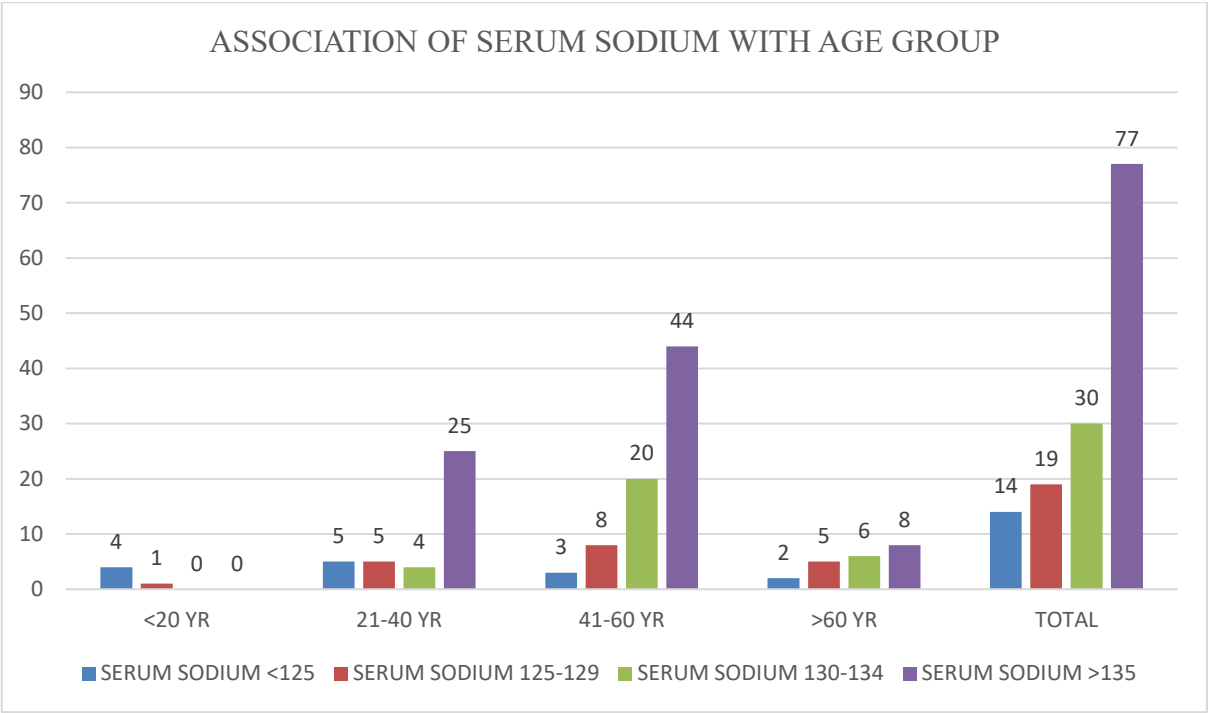

TABLE NO.4: ASSOCIATION OF SERUM SODIUM WITH AGE GROUP

VARIABLE		SERUMSODIUM			
AGEGROUP	<125	125-129	130-134	>135	TOTAL
<20 YR	4	1	0	0	5
21-40YR	5	5	4	25	39
41-60YR	3	8	20	44	75
>60 YR	2	5	6	8	21
TOTAL	14	19	30	77	140
CHISQAURE VALUE = 39.19DF= 9		P-VALUE=0.00001	SIGNIFICANT		

TABLE NO.5: ASSOCIATION OF SERUM SODIUM WITH GENDER

VARIABLE	SERUMSODIUM				
GENDER	<125	125-129	130-134	>135	TOTAL
FEMALE	6	8	9	4	27
MALE	8	11	21	73	113
TOTAL	14	19	30	77	140
CHISQAURE VALUE = 23.39	DF= 3	P-VALUE=3.35 × 10^{-5}S I G N I F I C A N T			
VARIABLE	SERUMSODIUM				
SPUTUMAFB	<125	125-129	130-134	> 135	TOTAL
GRADE1	0	1	3	22	26
GRADE2	3	5	12	18	38
GRADE3	11	13	15	37	76
TOTAL	14	19	30	77	140
CHISQAUREVALUE= 15.02DF= **6**	P-VALUE= 2.01 × 10^{-2}SIGNIFICANT				

TABLE NO. 6: ASSOCIATION OF SERUM SODIUM WITH COMORBIDITY

Variables	Sodiumserumlevel				
	<125	125-129		> 135	TOTAL
Diabetes	7	6	18	35	66
Hypertension	5	8	10	24	47

Don'tHaveAny	2	5	2	10	27
GrandTotal	14	19	30	77	**140**
Chi-square = 6.48DF=.6 **pvalue**=0.372 NOTSIGNIFICANT					

TABLE NO.7: ASSOCIATION OF SERUM SODIUM WITH BODY MASS INDEX

Variables	**Serumsodium**				
BMI	<125	125-129	**130-134**	> 135	**TOTAL**
<18.5	7	10	18	21	56
Normalweight18.5–24.9	5	8	11	56	80
Overweight25–29.9	2	1	1	0	4
GrandTotal	14	19	30	77	140
Chisquare= 23.59 DF= 6	PVALUE=6.22×10^{-4} SIGNIFICANT				

TABLE NO.8: ASSOCIATION OF SERUM SODIUM WITH OCCUPATION

VARIABLE	SERUMSODIUM				
OCCUPATION	<125	125-129	130- 134	> 135	TOTAL
NOT SKILLED	5	7	9	7	28
SEMISKILLED	4	5	11	60	80
SKILLED	3	5	6	7	21
PROFESIONAL	2	2	4	3	5
TOTAL	14	19	30	77	140
CHISQAURE VALUE = 31.58 DF= 9 P-VALUE= 2.36×10^{-4} SIGNIFICANT					

TABLE NO.9: ASSOCIATION OF SERUM SODIUM WITH DOMICILE

VARIABLE	SERUMSODIUM				
RESIDENCE	<125	125-129	>130-134	>135	TOTAL
RURAL	11	16	26	73	126
URBAN	3	3	4	4	14
TOTAL	14	19	30	77	140
CHISQAURE VALUE =5.09 DF= 3 P-VALUE=0.165 NOTSIGNIFICANT					

TABLE NO.10: ASSOCIATION OF SERUM SODIUM WITH CHEST X RAY

VARIABLE	SERUMSODIUM				
CHESTX-RAY	<125	125-129	130-134	> 135	TOTAL
CONSOLIDATION	10	15	28	75	128
FIBROCAVITYLESSION	4	4	2	2	12
TOTAL	14	19	30	77	140
CHISQAURE VALUE = 17.30 DF= 3 P-VALUE= 6.12×10^{-4} SIGNIFICANT					

TABLE NO.11: ASSOCIATION OF SERUM SODIUM WITH SPUTUM AFB

VARIABLE	SERUMSODIUM				
SPUTUMAFB	<125	125-129	130-134	> 135	TOTAL
GRADE1	0	1	3	22	26
GRADE2	3	5	12	18	38
GRADE3	11	13	15	37	76
TOTAL	14	19	30	77	140
CHISQAUREVALUE= 15.02DF= **6** P-VALUE= 2.01×10^{-2}SIGNIFICANT					

DISCUSSION

Demographic and Socioeconomic Profile

In the present study, we analyzed 140 adult patients diagnosed with pulmonary tuberculosis (PTB), with a primary focus on evaluating the prevalence, severity, and clinical associations of hyponatremia. The majority of participants belonged

to the 41–60 years age group (53.57%), followed by those aged 21–40 years (27.85%), with a minor representation from the <20 years and >60 years categories. The study population showed a pronounced male predominance (80.71%) and rural residence (90%), reflecting the demographic pattern typical of TB burden in low-resource settings in India. Most patients were semi-skilled workers (61.4%), and only a small proportion (3.6%) were professionals, highlighting socioeconomic vulnerability as a contributing factor in TB epidemiology.

This demographic profile is in line with previous studies. For instance, **Sinha P. et al. (2023) [3]** also reported a male majority (74%) among 150 PTB patients, while **Dash M. et al. (2020)[4]** noted that males accounted for 42% of hyponatremic cases. Similarly, **Upadhyay A. et al. (2006)[5]** described a higher male prevalence and stressed the association between lower socioeconomic strata and increased TB burden

Prevalence and Severity of Hyponatremia

Hyponatremia, defined as a serum sodium level below 135 mmol/L, was observed in 45% of our study population. Severe hyponatremia (<125 mmol/L) occurred in 10% of cases, highlighting its relevance as a common and clinically important biochemical abnormality among PTB patients. These findings are comparable with prior literature, including **Sinha P. et al. (2023[3]),** who reported a 76% prevalence of hyponatremia in PTB patients, and **Shwetha M.S. et al. [6](2019),** who found that 76% of patients had hyponatremia, categorized as mild (39%), moderate (27%), or severe (9%).

The consistency across studies underlines that hyponatremia is not only prevalent in PTB but can range in severity and often goes unrecognized due to its subclinical presentation. Our findings reaffirm the need for routine sodium evaluation as part of PTB workup

Statistical Associations with Serum Sodium

Our study identified statistically significant associations between serum sodium levels and multiple variables:

- **Age Group ($p = 0.00001$):** Hyponatremia was more prevalent among the youngest (<20 years) and oldest (>60 years) patients. **Jafari N. et al. (2012)[7]** similarly reported a higher risk of hyponatremia in elderly patients ($P = 0.047$).
- **Gender ($p = 3.35 \times 10^{-5}$):** Female patients had a higher likelihood of developing hyponatremia. This is consistent with the gender stratification in **Sinha P. et al. 2023[3] and Jafari N.et al. 2012**'s**[7]** studies, although their findings suggested male predominance; this discrepancy may point to regional, genetic, or nutritional differences.
- **BMI ($p = 6.22 \times 10^{-4}$):** Both underweight and overweight individuals had higher rates of hyponatremia compared to those with normal BMI. This reflects the dual burden of malnutrition and chronic disease in TB patients.
- **Occupation ($p = 2.36 \times 10^{-4}$):** Unskilled workers showed the highest frequency of low sodium, reinforcing the association between poor socioeconomic status and disease burden.
- **Chest X-ray Findings ($p = 6.12 \times 10^{-4}$):** Patients with fibrocavitatory lesions exhibited significantly more hyponatremia than those with simple consolidation.
- **Sputum AFB Grade ($p = 2.01 \times 10^{-2}$):** A clear trend was observed, with higher AFB grades correlating with more severe hyponatremia.

These associations emphasize the multifactorial etiology of hyponatremia in PTB, including nutritional deficiencies, chronic disease stress, and advanced pulmonary pathology.

No statistically significant association was found between serum sodium levels and comorbidity status ($p = 0.372$) or residence ($p = 0.165$). Although patients with diabetes and hypertension tended to have lower sodium levels, these findings did not achieve statistical significance. This is partially corroborated by the findings of **Jafari N.et al. 2012[7]**, who found no association between hyponatremia and comorbidities. However, Sinha et al. did suggest a mild association between hyponatremia and chronic illness, indicating the need for larger multicentric studies to confirm this trend.

Pathophysiology and Mechanisms

Several mechanisms have been proposed to explain hyponatremia in PTB:

- **Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH):** As noted by **Lee P. et al. (2010)[8]**, SIADH is a common cause of hyponatremia in pulmonary infections, including TB.
- **Adrenal Insufficiency:** Addison's disease secondary to tubercular adrenalitis remains an important cause, especially in endemic regions. **Dabrowski A. et al. (2009)[9]** detailed how adrenal TB can lead to severe electrolyte disturbances.
- **CNS Involvement (e.g., TBM): Dian S. et al. (2024)[10]** and **Anderson NEet al. (2010) [11]** both found high rates of hyponatremia in TB meningitis, typically due to cerebral salt wasting or SIADH. Our study did not include patients with CNS TB, but the findings reinforce the broader relevance of sodium imbalance across TB manifestations.

Clinical Implications

The high prevalence and significant associations identified in this study underscore the clinical importance of detecting and managing hyponatremia in PTB. Severe hyponatremia was most frequent among underweight patients, females, and those with Grade 3 AFB, reflecting advanced disease and poor nutritional status. These insights are important for both prognosis and treatment planning.

While some literature (**Dian S. et al. 2024)[10]** suggests that aggressive correction of hyponatremia may not independently improve outcomes in CNS TB, our findings in PTB suggest that timely recognition and management may reduce morbidity. This is further emphasized by the observation in **Sinha P.[3]** that four patients required vasopressor support, highlighting the potential for life-threatening complications. The 45 % prevalence of hyponatremia in our study aligns with reports from other Indian centers (18 – 49 %). Female gender, malnutrition (low BMI), advanced radiological findings, and higher AFB smear grades were key correlates, underscoring the role of disease severity and host factors.

CONCLUSION

Hyponatremia is a frequent biochemical abnormality in PTB patients in Rajasthan. Screening and early management can prevent complications, especially in vulnerable groups such as females, underweight individuals, and patients with advanced disease. Mechanistically, SIADH is a major contributor in PTB, followed by adrenal involvement and renal losses. Clinically, hyponatremia is associated with longer hospital stay, increased ICU admissions, and higher mortality. Our findings reinforce the need for routine sodium estimation at diagnosis to detect subclinical disturbances.

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