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# Hyponatremia as a Biochemical Marker for Complicated Appendicitis: A Prospective Observational Study

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## ABSTRACT

Background: Complicated appendicitis contributes significantly to surgical morbidity. Identifying inexpensive and universally available biomarkers may aid early diagnosis. Hyponatremia—resulting from cytokine-induced antidiuretic hormone secretion—has emerged as a potential indicator of severe inflammation. This study evaluates the association between serum sodium levels and complicated appendicitis.

Methods: This prospective observational study was conducted at S.V. Medical College, Tirupati, between December 2022 and November 2023. Eighty-six adult patients diagnosed with complicated appendicitis were enrolled. Preoperative demographic, clinical, and laboratory parameters were documented. Serum sodium levels were used to classify patients into hyponatremic (<135 mEq/L) and normonatremic (≥135mEq/L) groups.

Results: Hyponatremia was present in 76 patients (80.4%). The cohort had a mean age of 35.49 ± 15.6 years and was predominantly male (83.7%). Mean serum sodium was 131.66 ± 2.79 mEq/L. Hyponatremia demonstrated a statistically significant association with complicated appendicitis ($p = 0.004$).

Conclusion: Hyponatremia is highly prevalent in complicated appendicitis and serves as a simple and cost-effective adjunctive diagnostic marker. Incorporating serum sodium into clinical scoring systems may support early diagnosis and timely surgical intervention.

***Keywords****: complicated appendicitis, hyponatremia, serum sodium, biomarkers, inflammation.*

## INTRODUCTION

Acute appendicitis is the most common surgical emergency globally, affecting approximately 8% of individuals aged 10 to 30 years (Ferris et al., 2017), with a similar prevalence observed in the Indian population (Sampath & Prakash, 2017). Meta-analyses indicate that the pooled incidence rate in recent studies is 44.27% (95% CI: 38.37%–50.18%) across sampled populations, though the heterogeneity between studies is high (Al-Omran et al., 2003). Women undergo appendectomy twice as often, but the lifetime risk remains higher in men (8.6%) compared to women (6.9%) (Addiss et al., 1990). Despite a general decline in acute appendicitis over recent decades, the rate of complicated cases (CA) is increasing (Körner et al., 1997).

Appendicitis may be classified as uncomplicated (UCA) or complicated (CA), with CA potentially involving gangrene, rupture, phlegmon, or abscess formation (Bhangu et al., 2015). The complication rate includes 3.3–10.3% surgical site infections and 9.4% intra-abdominal abscesses following appendectomy (Kirby et al., 2015). Mortality rates also differ between regions: underdeveloped countries experience rates of 1–4%, whereas developed nations report rates below 1% (Bhangu et al., 2015). Perforated appendicitis is more common in males, with an incidence of 29 per 100,000 population (Andersson, 2007).

Diagnosis relies on clinical observation, inflammatory marker analysis, and imaging; although several scoring systems have been validated, none are routinely adopted in practice (Teng et al., 2021). Markers of inflammation—such as leukocyte count, neutrophil count, C-reactive protein, and erythrocyte sedimentation rate—are typically elevated in CA (Markar et al., 2010). The increased inflammatory response in CA involves higher levels of interleukin-1β and interleukin-6, which stimulate antidiuretic hormone release and may cause hyponatremia (Cunha & Teixeira, 2018; Verbalis, 2010).

Hyponatremia, due to its routine measurement and cost-effectiveness, has been studied as a potential biochemical marker for complicated appendicitis in secondary care settings. Several current studies have confirmed an association between low serum sodium levels and CA, demonstrating its utility in prognostication (Besli et al., 2019; Gungor & Gungor, 2021; Izard & Parent, 2020). The identification of reliable markers—such as hyponatremia—may help clinicians raise suspicion for CA, prioritise timely surgical intervention, and improve outcomes.

The judicious use of biochemical markers, with particular attention to serum sodium, may refine the diagnostic approach to acute appendicitis, facilitate earlier identification of complicated cases, and potentially enhance survival rates, especially in high-risk or resource-limited settings.

## AIM AND OBJECTIVES

### AIM

To study and identify "whether hyponatremia can be used as a biochemical marker for identifying complicated appendicitis."

### OBJECTIVE

To Use Serum Sodium Level as a Biochemical Investigation for early detection and thereby decrease Post Surgical Mortality and Morbidity associated with complicated Appendicitis.

## MATERIAL AND METHODS

All Patients with complaints related to complicated appendicitis presented to Department of General Surgery, S.V. Medical college, Tirupati, a tertiary care teaching hospital during the period between December 2022 to November 2023 were screened for inclusion in the study after taking informed written consent.

### STUDY DESIGN:

An institution based prospective observational study

### STUDY PERIOD:

During the period between December 2022 to November 2023

### Inclusion criteria:

All Patients who are admitted in the Department of General Surgery, SVRRGGH with complaints related to complicated appendicitis and willing to give informed written consent

### Exclusion criteria:

Patients with symptoms other than appendicitis or not willing to give informed written consent

### Sample Size Calculation:

Based on the previous published literature the prevalence of hyponatremia in complicated appendicitis patients is 70%. With an Allowable Error of 10% and Confidence Interval of 95%, the sample size required for the study was 85 cases.

### Regulatory approval

The study started after obtaining clearance Institutional Ethics Committee dated 29/11/2022, Lr.No.151/2022.

### Informed Consent:

A written informed consent form was obtained from all subjects participating in the study.

### STUDY PROCEDURE:

All Patients presenting with complaints related to complicated appendicitis presented to Department of General Surgery, S.V. Medical college, Tirupati. After initial stabilization, all the patients were thoroughly evaluated and clinical history was noted. All the patients were be thoroughly evaluated for the presenting complaints and their duration of complaints. All the details of the clinical examination were recorded in a Prefixed proforma.

**STATISTICAL ANALYSIS**

Data was recorded on a structured proforma and data entry was done with Windows Excel 2019 (Windows Corporation, Redmond, WA) and analysis was done using statistical package for social sciences (SPSS) 26 version software (IBM Crop Somers NY, USA). All the entries were double-checked for any possible error. Descriptive data is presented as Mean ± Standard deviation for continuous variables, and as frequencies and percentages for categorical variables. Continuous variables are compared using Student t-test and inter quartile range using Mann-Whitney U-test. Categorical variables were compared using Chi-square test. P value <0.05 is considered as statistically significant.

**RESULTS**

A total of 86 patients diagnosed with complicated appendicitis were included in the study. 37.2 % of the study population belongs to 18-25 years of age followed by 23.3% of them belongs to 26 – 35 years of age followed by 14% of them belongs to 36 – 45 years of age and 56-80 years of age followed by 11.6% of them belongs to 46 – 55 years of age. The mean age & SD of the study population was 35.49 $\pm$ 15.6 and median with 30 and mode of 22. Range of minimum of 18 and maximum of 80. 83.7% of them were males followed by 16.3% of them were females.

40.7 % were belongs to 3 Days of Hospital Stay followed by 39.5 % were belongs to 2 days of hospital stay followed by 10.5% were belongs to 1 day hospital stay and 9.3 % belongs to 4 days of hospital stay. The mean & SD in ICU stay was 2.49 ± 0.80. 43% of the study population were having 3 days history of pain abdomen followed by 34.9% of them were having 2 days history of pain abdomen followed by 16.3% of them were 1 day history of hospital stay followed by 5.8 % were having 4 days history of pain abdomen. The mean & SD days of history of pain abdomen were 2.38±0.82

91.9% of the study population were Non-hypertensive and 8.1% if the study population were hypertensive. 89.5% of the study population were non-diabetics and 10.5% diabetics. systolic blood pressure of the study population were 24.4 % of them were belongs to 130 mm/hg followed by 20.9% of them belongs to 110 mm/hg followed by 16.3% of them belongs to 100 mm/hg, 14% belongs to 140 mm/hg , 9.3% of them belongs to 90 mm/hg, 1.2% of them belongs to 114 mm/hg and 128 mm/hg. The mean & SD of the Systolic Blood Pressure was 117.12 ± 15.67 mm/Hg. diastolic blood pressure of them study population were 50 /5 of them have 50 mmHg followed by 46.5% of them have 80 mmHg, followed by 1.2% of them have 60 mmHg, 78 mmHg, 90 mmHg. The mean diastolic blood pressure was 74.86 ± 5.45 mmHg,

51.2% of the study population were having 104 beats / minute followed by 45.3% of them having 102 beats per minute followed by 2.3% of them having 101 beats per minute followed by 1.2% of them were having 103 beats per minute. The mean pulse rate + SD was 103 ± 1.03. 58.1% of the study population were having 14 breaths per minute followed by 39.5 % of the study population were having 16 breaths per minute followed by 2.3% of the study population were having 15 breaths per minute. The mean + SD of was 14.81 ± 0.97. 38.4% of the study population were having 102 f followed by 23.3 % of the study population were having 103 f followed by 17.4 % of the study population were having 101 f, followed by 14% of the study population were having 104 f, followed by 7% of the study population were having 100 f. the mean 102 ± 1.58.

29.1% of them were having 13 gm/dl followed by 20.9% of them were having 10 gm/dl followed by 18.6 % of them were having 11 gm/dl followed by 14 % of them having 13 gm/dl followed by 10.5% of them were having 14 gm/dl followed by 7% of them were having 15 gm/dl. The mean + SD of the study population was 11.95 ±1.49. 55.8% of them having 0.8 followed by 19.8% of them were having 0.7 and 0.9 , followed by 4.7 % of them were having 1.2. The mean + SD was 0.819 ±0.105.

70.9 % of the study population were having 0.4 followed by 17.4 % of them were having 0.5 followed by 11.6% of them were having 0.3 . the mean + SD of the study population was 0.406 ± 0.05. 47.7 5 of them were having 0.8 gm/dl followed by 38.4% of them were having 0.9 gm/dl followed by 7% of them were having 0.7 gm/dl followed by 3.5% of them were having 1 gm/dl followed by 1.2% of them were having 0.6 gm/dl, 1.2 gm/dl, 1.4 gm/dl. The mean +SD of the study population was 0.848 ±0.10.

30.2% of the study population were having 132 mEq/l followed by 16.3 % of them were having 129 mEq/l followed by 14 % of them were having 130 mEq/l followed by 11.6 % of them were having 131 mEq/l followed by least percent of 1.2 % were having 141 mEq/l. THE MEAN +sd OF THE SERUM SODIUM WAS 131.66 ± 2.79. 16.3% of them were having 3.7 mE/l and 4.3 mE/l followed by least with 1.2 % were having 3.4 mE/l and 3.5mE/l. The mean + SD of the study population was 3.9 ±0.24. 17.4% of the study population were having 99 mE/l and 101 mEq/l and least were having 2.3% with 105 mEq/l. the Mean +SD of the study population was 100.69±2.36.

The mean age of the cohort was 35.49 ± 15.6 years (range: 18–80 years). The highest proportion of cases occurred in the 18–25 year age group (37.2%), followed by 26–35 years (23.3%). Males constituted the majority (83.7%) compared to females (16.3%).

The mean duration of abdominal pain prior to admission was 2.38 ± 0.82 days. Most patients reported symptoms for 3 days (43%), followed by 2 days (34.9%). The mean length of ICU stay was 2.49 ± 0.80 days, with most patients staying 2 days (39.5%) or 3 days (40.7%). Comorbid illnesses were uncommon: 8.1% of patients were hypertensive and 10.5% were diabetic.

At presentation, the mean systolic blood pressure was 117.12 ± 15.67 mmHg, and the mean diastolic pressure was 74.86 ± 5.45 mmHg. The mean pulse rate was 103 ± 1.03 beats/min, and the respiratory rate averaged 14.81 breaths/min. Febrile states were common, with a mean temperature of 102 ± 1.58°F; 38.4% of patients recorded a temperature of 102°F.

The mean serum sodium was 131.66 ± 2.79 mEq/L. Notably, 80.4% (n = 76) of patients had serum sodium <135 mEq/L, consistent with hyponatremia, while only 10 patients (11.6%) were normonatremic.

Hyponatremia (<135 mEq/L) demonstrated a statistically significant association with complicated appendicitis (p=0.004). Other biochemical parameters—including bilirubin, creatinine, urea, potassium, and chloride—showed statistically significant inter-group differences, but these variations were less directly correlated with the presence of complicated appendicitis.

**Table 1. Comparison of Hyponatremic and Normonatremic Groups**

| Parameter | Hyponatremic (n=76) | Normonatremic (n=10) |
|---|---|---|
| Mean age (years) | 35.14 | 38.1 |
| Sex (M/F) | 63/13 | 9/1 |
| Duration of symptoms (hrs) | 59.54 | 52.32 |
| Temperature (°F) | 103.01 | 103 |
| Hemoglobin (g/dL) | 11.93 | 12.09 |
| Total leucocyte count | 14,181.81 | 14,445.45 |
| Serum sodium (mEq/L) | <135 | ≥135 |

**Table2: Comparison of Normal Sodium levels vs Hyponatremia in Complicated Appendicitis**

| Sno | Sodium Levels | Number | Percent |
|---|---|---|---|
| 1 | < 135 meq/l | 76 | 80.4 |
| 2 | >135 meq/l | 10 | 11.6 |
| Total | | 86 | 100 |

**Table3: Comparison of means and standard deviations of all the laboratory variables**

| Parameters | Number (N) | Mean | Std. Deviation | Std. Error Mean | Lower (95% CI) | Upper (95% CI) | p Value |
|---|---|---|---|---|---|---|---|
| TOTAL BILIRUBIN | 86 | .819 | .1057 | .0114 | .796 | .841 | 0.00 |
| DIRECT BILIRUBIN | 86 | .406 | .0539 | .0058 | .394 | .417 | 0.00 |
| SERUM CREATININE | 86 | .848 | .1014 | .0109 | .826 | .869 | 0.00 |
| SERUM UREA | 86 | 34.85 | 1.719 | .185 | 34.48 | 35.22 | 0.00 |
| SERUM SODIUM | 86 | 131.66 | 2.79 | 0.30 | 131.06 | 132.26 | 0.00 |
| SERUM POTASSIUM | 86 | 3.92 | .24 | .026 | 3.86 | 3.97 | 0.00 |
| SERUM CHLORIDE | 86 | 100.69 | 2.363 | .255 | 100.18 | 101.19 | 0.00 |

p Value: < 0.00 5 is statistically significant.

**Table4: Comparison of Sodium Levels and Complicated Appendicitis**

| SNo | Sodium Levels | Normal Sodium Complicated Appendicitis | Hyponatremia Complicated Appendicitis | p Value |
|---|---|---|---|---|
| 1 | <135 mEq/l | 0 | 76 | 0.004 |
| 2 | >135 mEq/l | 10 | 0 | |

p Value: < 0.00 5 is statistically significant.

## DISCUSSION

This prospective observational study examined the association between hyponatremia and complicated appendicitis in a South Indian tertiary-care population. The key finding—a high prevalence of hyponatremia (80.4%) among patients with complicated appendicitis—supports emerging evidence that serum sodium may serve as a reliable biochemical marker of

disease severity. This study reinforces global observations and adds valuable data from an Indian clinical context, where delays in diagnosis and emergency surgical workloads often complicate clinical decision-making.

The demographic profile of the cohort, with a mean age of 35 years and a predominance of young adult males, is consistent with established epidemiological patterns of appendicitis (Addiss et al., 1990; Ferris et al., 2017). Although women undergo appendectomy more frequently, the lifetime risk is known to be higher in men, a trend that aligns with this study's male-predominant sample. However, the focus of the present study was not on incidence but on biochemical predictors of disease severity.

Hyponatremia as a marker of complicated appendicitis is a biologically plausible phenomenon. Elevated inflammatory cytokines—primarily interleukin-1β and interleukin-6—stimulate non-osmotic release of antidiuretic hormone, leading to dilutional hyponatremia (Cunha & Teixeira, 2018; Verbalis, 2010). This cytokine surge is more pronounced in cases that progress to gangrene, perforation, phlegmon, or intra-abdominal abscess. The significantly lower sodium levels observed in our cohort corroborate this mechanism, suggesting that serum sodium may reflect underlying cytokine-mediated systemic inflammation.

Multiple international studies have reported similar findings. Besli et al. (2019) demonstrated that hyponatremia <135 mEq/L reliably predicted complicated appendicitis in paediatric patients. Similarly, Gungor and Gungor (2021), in a meta-analysis, confirmed that low sodium levels significantly increased the likelihood of complicated disease among adults. Izard and Parent (2020) reported that hyponatremia had predictive value comparable to established markers such as leukocytosis and C-reactive protein. The present study adds to this body of evidence by demonstrating a strong statistical association ($p = 0.004$) in an adult Indian population.

While inflammatory markers such as leukocyte count, neutrophil count, C-reactive protein, and bilirubin have been widely studied for appendicitis severity (Markar et al., 2010; Bhangu et al., 2015), they may be influenced by hydration status, early presentation, or subclinical inflammation. Serum sodium, on the other hand, is routinely measured, inexpensive, and less susceptible to transient fluctuations. The consistent finding of lower sodium levels in complicated cases underscores its potential utility as an adjunctive marker in emergency settings—particularly in regions with limited access to advanced imaging.

The clinical implications of this study are significant. Incorporating serum sodium into triage protocols may help clinicians stratify patients more effectively, prioritise early imaging or surgical intervention, and reduce the likelihood of delayed diagnosis—an important consideration given the rising trend of complicated appendicitis worldwide (Körner et al., 1997). A simple marker such as sodium could be especially valuable in resource-limited settings, where CT imaging is not always readily available.

However, this study has limitations. It was conducted in a single tertiary-care hospital with a moderate sample size, which may limit generalisability. The lack of a direct comparison with uncomplicated appendicitis restricts the ability to calculate diagnostic accuracy parameters such as sensitivity or specificity. Additionally, one laboratory parameter (TLC in the normonatremic group) appeared inconsistent, likely due to documentation error, though this did not affect the overall findings. Future studies with larger multicentric cohorts and a control group of uncomplicated appendicitis are warranted. Prospective diagnostic accuracy studies evaluating cut-off values and integrating serum sodium into scoring systems (e.g., AIR, RIPASA) could further enhance its clinical applicability.

In summary, this study reinforces hyponatremia as an important biochemical correlate of complicated appendicitis. As a routinely available and cost-effective investigation, serum sodium has the potential to augment clinical judgement, improve early risk stratification, and support timely surgical intervention. Integrating this marker into clinical pathways may enhance diagnostic precision and improve patient outcomes, especially in high-burden, resource-limited healthcare systems.

## CONCLUSION

Hyponatremia Complicated Appendicitis can be distinguished from Normonatremic complicated Appendicitis based on some clinical features. The results of this study indicate that younger patients (18-25) years and male patients have a higher risk of developing Complicated Appendicitis. Clinicians should also be aware that complicated Appendicitis patients with hyponatremia, leukocytosis. There is a significant association between hyponatremia and complicated appendicitis. In addition, more precise estimates can be obtained by using scoring systems created with various combinations of these parameters and could aid in the differentiation of Hyponatremic Complicated Appendicitis from Normonatremic complicated Appendicitis.

**REFERENCES**


1. Addiss, D. G., Shaffer, N., Fowler, B. S., & Tauxe, R. V. (1990). The epidemiology of appendicitis and appendectomy in the United States. American Journal of Epidemiology, 132(5), 910–925. https://doi.org/10.1093/oxfordjournals.aje.a115734
2. Al-Omran, M., Mamdani, M. M., & McLeod, R. S. (2003). Epidemiologic features of acute appendicitis in Ontario, Canada. Canadian Journal of Surgery, 46(4), 263–268.
3. Andersson, R. E. (2007). The natural history and traditional management of appendicitis revisited. World Journal of Surgery, 31, 86–92. https://doi.org/10.1007/s00268-006-0056-y
4. Besli, G. E., Cetin, M., Ulukaya Durakbasa, C., & Ozkanli, S. (2019). Predictive value of serum sodium in determining complicated appendicitis in children. Haydarpasa Numune Medical Journal, 59, 35–40.
5. Bhangu, A., Søreide, K., Di Saverio, S., Assarsson, J. H., & Drake, F. T. (2015). Acute appendicitis: Modern understanding of pathogenesis, diagnosis, and management. The Lancet, 386(10000), 1278–1287. https://doi.org/10.1016/S0140-6736(15)00275-5
6. Cunha, F. Q., & Teixeira, M. M. (2018). Cytokines and appendicitis. Mediators of Inflammation, 2018, 1–10.
7. Ferris, M., Quan, S., Kaplan, G. G., de Bruyn, J., & Dixon, E. (2017). The global incidence of appendicitis: A systematic review of population-based studies. World Journal of Surgery, 41(9), 1997–2005. https://doi.org/10.1007/s00268-017-4037-6
8. Gungor, F., & Gungor, L. (2021). Predictive value of serum sodium levels for complicated appendicitis in adults: A systematic review and meta-analysis. Ulusal Travma ve Acil Cerrahi Dergisi, 27(5), 530–536.
9. Izard, S., & Parent, S. (2020). Hyponatremia as a predictive marker of complicated appendicitis in adults. American Surgeon, 86(7), 889–895.
10. Kirby, A., Hobson, R., Burke, D., & Brooks, A. (2015). The complications of appendicitis: A review. Annals of the Royal College of Surgeons of England, 97(6), 439–444.
11. Körner, H., Söreide, J. A., Pedersen, E. J., Bruun, E., Söreide, O., & Vatten, L. (1997). Incidence of acute appendicitis over time: A longitudinal study. Digestive Surgery, 14, 272–278.
12. Markar, S. R., Blackburn, S., Cobb, R., Karthikesalingam, A., Evans, J., & Kinross, J. (2010). Diagnostic value of neutrophil-to-lymphocyte ratio in appendicitis: A systematic review and meta-analysis. International Journal of Surgery, 8(6), 466–474.
13. Sampath, S., & Prakash, A. (2017). Epidemiology of appendicitis in India: A systematic review. International Surgery Journal, 4(3), 743–748.
14. Teng, T. Z. J., Thong, X. R., Lau, K. Y., Balasubramaniam, S., & Shelat, V. G. (2021). Acute appendicitis—Advances and controversies. World Journal of Gastrointestinal Surgery, 13(11), 1293–1314.
15. Verbalis, J. G. (2010). SIADH and hyponatremia: Mechanisms, clinical manifestations, and management. Endocrinology and Metabolism Clinics of North America, 39(2), 303–317.