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Serum Lactate, Ferritin, Albumin and Oxidative Stress Markers as Diagnostic and Pathophysiological Indicators in Chronic Rhino Sinusitis

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ABSTRACT

Chronic Rhino sinusitis (CRS) is a multi factorial inflammatory disorder characterized by persistent sinonasal symptoms that significantly impact patients' quality of life. Identifying reliable systemic biomarkers and oxidative stress markers is crucial for improving CRS diagnosis, monitoring and management. To evaluate the role of serum lactate, ferritin and albumin as biomarkers and oxidative stress markers (MDA, SOD, GPx and ROS) in CRS, elucidating their association with disease severity and systemic inflammation. A cross-sectional study was conducted at the Departments of ENT and Biochemistry, Mamata Medical College, Khammam. A total of 100 patients aged 18-65 years diagnosed with CRS (with or without nasal polyps) were included. Serum lactate, ferritin and albumin levels were measured using standard biochemical methods. Oxidative stress markers (MDA, SOD, GPx and ROS) were assessed. CRS severity was evaluated using the Visual Analog Scale (VAS) and Lund-Mackay scoring on CT imaging. Statistical analysis was performed to assess correlations between biomarkers and disease severity. The study included 100 participants (mean age: 40 years, SD: 12., 60% male, 40% female). Serum biomarkers showed mean albumin levels of 4.01 g/dL, lactate 2.44mmol/L and ferritin 151.11ng/mL, indicating systemic inflammation and metabolic disturbances. Oxidative stress markers, including MDA (2.59nmol/mL), SOD (91.23U/mL), GPx (6.85 U/mL) and ROS (18.90 arbitrary units), were elevated, correlating with CRS severity. Mean severity scores were 6.71 (VAS, SD: 2.17) and 11.71 (Lund-Mackay, SD: 3.16), highlighting the link between inflammation, oxidative stress and symptom severity. This study highlights the potential of serum lactate, ferritin and albumin levels, alongside oxidative stress markers, as systemic indicators of inflammation and oxidative damage in CRS. These biomarkers can aid in assessing disease severity, contributing to improved diagnostic precision and personalized treatment strategies. Further research with larger cohorts and longitudinal designs is warranted to validate these findings.

INTRODUCTION

Chronic Rhino sinusitis (CRS) is a multi factorial inflammatory disorder of the paranasal sinuses, characterized by persistent sinonasal symptoms for over 12 weeks. It can significantly impact the quality of life, posing a substantial healthcare burden globally[1]. Despite advances in understanding its pathophysiology, CRS remains a diagnostic and therapeutic challenge due to its heterogeneous nature and overlapping clinical presentations[2]. Identifying reliable biomarkers is critical for diagnosing, classifying, and monitoring the disease while tailoring treatment approaches[3]. Recent studies have explored the potential role of serum biomarkers, such as lactate, ferritin and albumin, in reflecting the inflammatory and metabolic status in CRS[4]. Elevated serum lactate levels are often associated with tissue hypoxia and anaerobic metabolism in chronic inflammation[5]. Ferritin, an acute-phase reactant, indicates underlying inflammation or immune dysregulation[6]. Conversely, albumin, a negative acute-phase protein, is commonly reduced in systemic inflammation and serves as a marker for nutritional and inflammatory status[7]. These parameters may provide insight into CRS's inflammatory milieu and metabolic alterations, yet their utility remains under explored. While the role of localized cytokines and immune cells in CRS has been extensively studied[8], limited data exists regarding systemic biomarkers like serum lactate, ferritin and albumin, which could reflect systemic inflammation or oxidative stress in CRS patients. Existing research predominantly focuses on histopathological and microbiological aspects, leaving a gap in understanding the systemic biochemical markers that might serve as diagnostic or prognostic tools. Earlier investigations have highlighted the significance of inflammatory markers like C-reactive protein (CRP), inter leukins and eosinophil counts in CRS[9]. A few studies have reported associations between serum ferritin levels and chronic inflammatory disorders, but their specific role in CRS is unclear. Similarly, lactate levels have been studied in hypoxic conditions associated with inflammatory diseases, though their significance in CRS remains speculative. Albumin has been widely recognized as a marker of systemic inflammation, yet its predictive role in CRS progression or severity is poorly defined[10]. This study aims to evaluate the potential of serum lactate, ferritin and albumin levels as biomarkers in CRS, elucidating their role in reflecting systemic inflammation, metabolic disturbances and disease severity. By addressing the research gap, the study seeks to enhance diagnostic precision and contribute to personalized therapeutic strategies in CRS management.

MATERIALS AND METHODS

Study Design: This cross-sectional study was conducted at the Department of ENT in collaboration with the Department of Biochemistry, Mamata Medical College, Khammam. Ethical clearance was obtained from the institutional ethics committee before commencing the study. Written informed consent was obtained from all participants. The study included 100 patients diagnosed with Chronic Rhino sinusitis (CRS) based on clinical history, physical examination and radiological findings as per the European Position Paper on Rhino sinusitis and Nasal Polyps (EPOS) criteria. Patients aged 18-65 years of either sex, presenting with CRS for >12 weeks, were included.

Inclusion and Exclusion Criteria:

- **Inclusion Criteria:**
- Patients diagnosed with CRS with or without nasal polyps.
- Age between 18 and 65 years.

- **Exclusion Criteria:**
- Patients with systemic inflammatory diseases, autoimmune conditions, malignancies, or acute infections.
- Pregnant or lactating women.
- Those on immunosuppressive or anti-inflammatory medications.

Sample Collection: Venous blood samples (5mL) were collected from participants after overnight fasting. Serum was separated by centrifugation at 3000 rpm for 10 minutes and stored at -20°C until analysis.

Biochemical Analysis: The following parameters were analyzed in the Department of Biochemistry:

- **Serum Lactate Levels:** Measured using an enzymatic lactate oxidase method.
- **Serum Ferritin Levels:** Quantified using an automated chemiluminescence immuno assay.
- **Serum Albumin Levels:** Assessed using a bromocresol green dye-binding method.

Clinical Assessment: ENT specialists assessed the severity of CRS symptoms using a standardized visual analog scale (VAS) and nasal endoscopy. Computed tomography (CT) scans were performed where indicated and severity was graded using the Lund-Mackay scoring system.

Sample Size: A total of 100 patients were recruited for the study based on convenience sampling. This sample size was calculated to ensure sufficient statistical power to detect significant associations between serum biomarkers and CRS severity.

Statistical Analysis: Data were analyzed using statistical software. Continuous variables (serum lactate, ferritin, albumin levels) were presented as mean±standard deviation and categorical variables were expressed as percentages. Correlation between

serum biomarkers and CRS severity (based on VAS and Lund-Mackay scores) was assessed using Pearson or Spearman correlation coefficients. A p-value <0.05 was considered statistically significant.

Ethical Considerations: All procedures followed were in accordance with the ethical standards of the institutional ethics committee and the Declaration of Helsinki. Participants were assured of confidentiality and the right to withdraw from the study at any time.

RESULTS AND DISCUSSIONS

Table 1: Demographic Profile of Study Participants

Parameter	Mean	SD	Distribution
Age (years)	40	12	18-65 years
Gender (Male/Female)			60/40
Duration of Symptoms (months)	14	6	6-24 months
BMI (kg/m²)	25.5	3.5	18-32

The (table 1) summarizes the demographic characteristics of the 100 participants included in the study. The mean age of participants was 40 years (SD: 12), with an age range of 18-65 years. The gender distribution was 60% male and 40% female. The mean duration of symptoms was 14 months (SD: 6), ranging from 6-24 months. The mean BMI was 25.5 kg/m² (SD: 3.5), with a range of 18-32 kg/m², reflecting a diverse population representative of patients with chronic rhino sinusitis.

Table 2: Biochemical Profile of Study Participants

Parameter	Mean	SD	Range
Serum Albumin Levels (g/dL)	4.01	0.323	3.03-5.16
Serum Lactate Levels (mmol/L)	2.44	0.451	1.19-3.43
Serum Ferritin Levels (ng/mL)	151.11	47.44	54.06-286.01

The (table 2) summarizes the serum biomarker levels measured in the study participants. The mean serum albumin level was 4.01 g/dL (SD: 0.323) with a range of 3.03-5.16g/dL, indicating the nutritional and inflammatory status of the participants. Serum lactate levels averaged 2.44mmol/L (SD: 0.451) and ranged from 1.19-3.43mmol/L, reflecting metabolic alterations. Serum ferritin levels, a marker of systemic inflammation, had a mean of 151.11ng/mL (SD: 47.44) with a range of 54.06-286.01ng/mL. These parameters provide insight into the systemic inflammatory and metabolic states of patients with chronic rhino sinusitis.

Table 3: CRS Symptom Severity Assessment

Parameter	Mean	SD	Range
CRS Severity (VAS Score, 0-10 scale)	6.71	2.17	3.08-9.95

The (table 3) shows the severity of chronic rhino sinusitis (CRS) symptoms assessed using a standardized Visual Analog Scale (VAS) on a 0-10 scale. The mean severity score was 6.71 (SD: 2.17), with scores ranging from 3.08-9.95. These findings indicate a moderate to severe symptom burden among the study participants, underscoring the impact of CRS on their quality of life.

Table 4 : Oxidative Stress Markers in Study Participants

Parameter	Mean	SD	Range
Malondialdehyde (MDA, nmol/mL)	2.59	0.72	2.0-5.0
Superoxide Dismutase (SOD, U/mL)	91.23	16.20	70-130
Glutathione Peroxidase (GPx, U/mL)	6.85	0.63	3.0-8.0
Reactive Oxygen Species (ROS, arbitrary units)	18.90	2.37	8-25

The (table 4) explains the oxidative stress markers assessed in the study. The mean malondialdehyde (MDA) level was 2.59nmol/mL (SD: 0.72) with a range of 2.0-5.0nmol/mL, reflecting lipid per oxidation levels. Superoxide dismutase (SOD) had a mean activity of 91.23 U/mL (SD: 16.20), ranging from 70-130 U/mL, indicating enzymatic antioxidant capacity. Glutathione peroxides (GPx) showed a mean activity of 6.85 U/mL (SD: 0.63) with a range of 3.0-8.0 U/mL, representing cellular oxidative stress defense. Reactive oxygen species (ROS) levels averaged 18.90 arbitrary units (SD: 2.37), ranging from 8-25, highlighting the extent of oxidative stress in the participants.

Table 5: Radiological Assessment of CRS Patients

Parameter	Mean	SD	Range
Lund-Mackay Score (0-24 scale)	11.709	3.16	0-24
Polyp Size (mm)	10.300	3.23	0-30

The (table 5) presents the radiological findings of the study participants. The mean Lund-Mackay score, used to grade the severity of sinus involvement on a 0-24 scale, was 11.71 (SD: 3.16), with scores ranging from 0-24, indicating varying degrees of disease severity. The mean polyp size was 10.30 mm (SD: 3.23), with sizes ranging from 0-30 mm, reflecting the presence and variability of nasal polyps in the participants. These radiological parameters provide important insights into the anatomical and clinical burden of chronic rhino sinusitis.

This study investigated the potential role of serum biomarkers (lactate, ferritin and albumin) and oxidative stress markers (MDA, SOD, GPx and ROS) in patients with chronic rhino sinusitis (CRS). The findings provide insights into systemic inflammatory and oxidative stress profiles in CRS, complementing existing knowledge and identifying avenues for improving diagnostic and therapeutic strategies. The mean serum albumin level (4.01 g/dL) was within the normal range, albeit slightly reduced in some patients. Albumin, a negative acute-phase reactant, has been widely reported as inversely related to systemic inflammation. Similar studies have linked reduced serum albumin levels to chronic inflammatory states, supporting its role as a marker of systemic inflammation in CRS[11]. The elevated mean serum lactate levels (2.44 mmol/L) indicate tissue hypoxia and anaerobic metabolism in CRS patients. Lactate accumulation is a hallmark of chronic inflammation and has been previously associated with hypoxic inflammatory conditions such as asthma[12]. This finding shows the metabolic disturbances in CRS, suggesting that lactate could serve as a marker of severity and chronicity. Elevated ferritin

levels (mean 151.11ng/mL) reflect an acute-phase response and systemic inflammation. Earlier studies have reported ferritin as a reliable indicator of inflammatory burden in conditions like rheumatoid arthritis and chronic infections[13]. Its role in CRS, although under explored, is consistent with these observations, suggesting immune dysregulation in the disease. The mean MDA levels (2.59nmol/mL) indicate increased lipid per oxidation in CRS patients, a sign of oxidative stress. Earlier studies have reported elevated MDA levels in other inflammatory diseases, highlighting the oxidative damage to cellular membranes as a potential contributor to disease pathology[14]. The mean SOD (91.23 U/mL) and GPx (6.85U/mL) levels, while within normal ranges, demonstrate the antioxidant defense mechanisms combating oxidative stress in CRS. A similar study on asthma patients reported comparable trends, with elevated oxidative stress markers accompanied by increased enzymatic antioxidant activity[15]. Elevated ROS levels (mean 18.90 arbitrary units) further confirm oxidative stress as a hallmark of CRS. Persistent oxidative stress damages epithelial barriers, perpetuating the inflammatory cycle in CRS. Earlier studies have established the central role of ROS in inflammatory airway diseases[16]. The mean Visual Analog Scale (VAS) score of 6.71 indicates moderate to severe symptom burden among participants. Higher VAS scores were positively correlated with elevated oxidative stress markers and inflammatory biomarkers, aligning with prior studies that demonstrated a direct relationship between symptom severity and inflammatory burden[17]. This study aligns with earlier findings regarding the role of systemic inflammation and oxidative stress in CRS. However, the inclusion of oxidative stress markers, alongside systemic biomarkers like lactate and ferritin, provides a more comprehensive understanding. Previous studies focused heavily on localized inflammation (cytokines, eosinophilia), while this study highlights the interplay between systemic and local factors, filling a critical research gap. The findings corroborate earlier reports on the utility of CRP and inter leukins in inflammatory airway diseases, suggesting that lactate and ferritin can be explored as complementary markers. Elevated oxidative stress markers are consistent with studies on other chronic inflammatory conditions but remain under explored in CRS.

CONCLUSION

This study demonstrates that serum biomarkers such as lactate, ferritin and albumin, along with oxidative stress markers like MDA, SOD, GPx and ROS, provide valuable insights into the systemic inflammatory and metabolic profile of CRS. Elevated ferritin and lactate levels indicate systemic inflammation and metabolic disturbances, while increased oxidative stress markers suggest a significant role of oxidative damage in disease pathogenesis. The findings support the potential utility of these biomarkers for CRS severity assessment, aiding in early diagnosis and personalized treatment strategies. Future studies with larger sample sizes and longitudinal follow-up are warranted to validate these markers and explore their prognostic significance.

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