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Original Research Article

The ferritin-albumin ratio as a predictive biomarker for morbidity among obstetric patients admitted to a tertiary care center in Bundelkhand region

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ABSTRACT

Background: Maternal morbidity and mortality remain significant public health challenges, particularly in resource-constrained regions. Early identification of at-risk obstetric patients is crucial to prevent severe complications. The ferritin-albumin ratio (FAR) is a composite biomarker reflecting inflammatory burden and nutritional status.
Methods: This prospective cohort study included 100 obstetric patients admitted to ICU over a 12-month period. Serum ferritin and albumin were measured at admission, and FAR was calculated. Clinical outcomes including organ dysfunction, shock, ARDS, DIC, AKI, and mortality were recorded. ROC curves and multivariable logistic regression were used to assess FAR's predictive value.
Results: FAR was significantly higher in patients with severe morbidity (median 11.0 versus 8.5; $p<0.001$). ROC analysis showed FAR had modest predictive accuracy (AUC 0.61). Multivariable analysis confirmed FAR as an independent predictor of morbidity (adjusted OR 2.09; $p<0.001$), along with SOFA score, maternal age, and sepsis.
Conclusions: FAR is a simple, cost-effective biomarker that independently predicts severe maternal morbidity in critically ill obstetric patients. Integration into early risk stratification may improve maternal outcomes in low-resource settings.

Keywords: Biomarker, Ferritin-albumin ratio, Maternal morbidity, Obstetric ICU, Postpartum hemorrhage Sepsis, SOFA score

INTRODUCTION

Background of the study

Maternal mortality and morbidity remain significant global health challenges, particularly in low- and middle-income countries where access to quality obstetric care is limited. Despite considerable progress in reducing maternal deaths over the past two decades, approximately 287,000 maternal deaths occurred globally in 2010, with the vast majority concentrated in resource-poor settings.[1] The World Health Organization attributes roughly 50% of maternal deaths globally to three major causes: obstetric hemorrhage, hypertensive disorders, and sepsis.[2]

India, as a lower-middle-income country with a large population, bears a substantial burden of maternal morbidity and mortality. The situation is particularly concerning in resource-limited regions such as the Bundelkhand area, which includes districts like Jhansi in Uttar Pradesh. Recent data from district Jhansi highlight persistent maternal health disparities and the need for improved early identification and management of high-risk obstetric patients.[3] A study from central India reported

that hypertensive disorders, hemorrhage, and sepsis remain the leading causes of maternal death in tertiary centers.[4]

Severe maternal morbidity (SMM), defined as unexpected outcomes of labor and delivery resulting in significant short- or long-term consequences to a woman's health, has emerged as an important indicator of maternal health system performance.[5] The concept of "maternal near miss" (MNM)- women who nearly died but survived a complication during pregnancy, childbirth, or within 42 days of termination- provides valuable insights into the quality of obstetric care and opportunities for intervention.[6] In high-risk obstetric populations admitted to tertiary centers, severe adverse maternal outcomes have been documented in 31.6% of cases, with intensive care unit (ICU) admissions required in 6.6% and maternal deaths occurring in 4.6% of cases.[7] Various biomarkers have been studied in obstetric populations, including inflammatory markers such as c-reactive protein (CRP), procalcitonin, and ferritin; markers of organ dysfunction such as serum lactate and creatinine; and markers of endothelial dysfunction and oxidative stress.[8,9]

Ferritin, an intracellular iron-storage protein, also functions as an acute-phase reactant and has been implicated in various pregnancy complications. Elevated serum ferritin levels have been associated with increased risk of gestational diabetes mellitus and preterm labor, suggesting a role for inflammation in adverse pregnancy outcomes.[10,11] Serum albumin, the most abundant plasma protein, serves multiple physiological functions including maintenance of oncotic pressure, antioxidant activity, and binding of various substances. Hypoalbuminemia is a marker of critical illness and has been associated with adverse outcomes in various patient populations. In obstetric patients, low serum protein levels have been linked to increased risk of postpartum hemorrhage, particularly in multifetal pregnancies.[12]

The ferritin-to-albumin ratio (FAR) represents a novel composite biomarker that combines information about systemic inflammation (ferritin) and nutritional/synthetic liver function status (albumin). This ratio has shown promise in other clinical contexts, particularly in predicting outcomes in COVID-19 patients and other critical illnesses, but has not been systematically evaluated in obstetric populations.[13] Given that pregnancy complications often involve both inflammatory processes and alterations in protein metabolism, the FAR may provide enhanced predictive value compared to individual biomarkers alone.

Need of study

High maternal morbidity and mortality

The Bundelkhand region reports persistently high maternal mortality rates (358 per 100,000 live births), despite national progress.

Delayed recognition

Many maternal complications are diagnosed too late due to subtle or nonspecific clinical signs, especially in low-resource settings.

Lack of early biomarkers

There is a critical need for inexpensive, reliable, and early-warning biomarkers to identify high-risk obstetric patients before clinical deterioration.

Limitations of current monitoring

Vital signs alone often fail to reflect underlying inflammation or organ dysfunction until advanced stages.

Promise of FAR (ferritin–albumin ratio)

Combines two routinely available parameters- ferritin (inflammatory marker) and albumin (nutritional/metabolic marker)- into one composite index.

Clinical utility in critical illness

Emerging evidence suggests FAR correlates well with severity and outcomes in ICU and obstetric patients, supporting its evaluation as a prognostic tool.

Aim and objectives

Aim

To evaluate the utility of the ferritin-albumin ratio (FAR) as a predictive biomarker for severe maternal morbidity and adverse outcomes among obstetric patients admitted to the department of obstetrics and gynecology at a tertiary care center in the Bundelkhand region.

Objectives

To assess the levels of ferritin-albumin ratio (FAR) among obstetric patients admitted to severe maternal complications. To compare the diagnostic utility of FAR with conventional biomarkers (ferritin, albumin, CRP, lactate) for predicting severe maternal morbidity. To determine whether FAR is an independent predictor of severe maternal morbidity in critically ill obstetric patients. To correlate admission FAR values with clinical outcomes such as shock, ARDS, DIC, and mortality.

METHODS

Study/research design

This hospital-based, prospective cohort study was conducted in the department of obstetrics and gynecology, Maharani Laxmi Bai Medical College, Jhansi. The study included a total of 100 obstetric patients admitted to the

department due to various obstetric complications. Data collection was carried out over a period of 12 months, from April 2025 to March 2026.

Inclusion criteria

Pregnant women or women within 48 hours postpartum. Patients who are admitted to the ICU due to obstetric-related complications such as severe preeclampsia, eclampsia, postpartum hemorrhage, sepsis, acute renal failure, and acute respiratory distress syndrome (ARDS). Patients who consent to participate in the study.

Exclusion criteria

Non-obstetric ICU admissions (patients admitted for non-obstetric reasons). Patients with pre-existing chronic diseases (e.g., chronic kidney disease, cirrhosis, malignancy) that might affect the results independently of obstetric conditions. Women who do not give informed consent to participate.

Sampling including sample size calculation

For comparing two means (e.g., FAR levels in patients with vs. without morbidity):

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 (s_1^2 + s_2^2)}{(\mu_1 - \mu_2)^2}$$

Where: $Z_{\alpha/2}$: Z value for desired confidence level (1.96 for 95%), Z_{β}: Z value for desired power (0.84 for 80%), s_1^2, s_2^2: estimated variances in each group, $\mu_1 - \mu_2$: expected mean difference in FAR.

Or for comparing proportions (e.g., morbidity incidence in high vs. low FAR):

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 [P_1(1 - P_1) + P_2(1 - P_2)]}{(P_1 - P_2)^2}$$

Where: P_1, P_2: expected proportions (e.g., from previous studies), P: pooled proportion = $(P_1+P_2)/2$

If we were referencing the Taskin et al study in COVID ICU patients with: FAR cut-off =128, Sensitivity =88.4%, Specificity =88.4%, Expected mortality ~30% in high FAR versus ~10% in low FAR.

Using: $Z_{\alpha/2}$=1.96 (for 95% CI), Z_{β}=0.84 (for 80% power), P_1=0.30, P_2=0.10

Plug values into the proportion formula, you get approximately:

n≈49 per group = Total n=98

Study method/ tools

Blood samples were collected from each participant at the time of ICU admission for laboratory analysis. Serum ferritin and albumin were measured using standard automated assays (ferritin by a chemiluminescent immunoassay and albumin by a bromocresol green dye-binding colorimetric method) in the hospital's central laboratory. C-reactive protein (CRP) and lactate were also measured at admission (CRP via an immunoturbidimetric assay, and lactate from an arterial blood sample on a blood gas analyzer). Because these tests are routinely available, the ferritin-albumin ratio (FAR) could be readily calculated for each patient by dividing the ferritin value (ng/ml) by the albumin value (gm/dl).

In addition to these laboratory measurements, each patient's clinical status was assessed using the sequential organ failure assessment (SOFA) score at ICU admission. The SOFA score is a standardized tool that assigns 0-4 points for dysfunction in each of six organ systems (respiratory, cardiovascular, renal, hepatic, coagulation, and neurological), yielding a total score reflecting overall illness severity. This scoring was performed upon admission for all participants to provide a uniform baseline measure of organ dysfunction, complementing the biomarker data in risk assessment.

Data collection procedure

This hospital-based prospective study was conducted over a 12-month period from April 2025 to March 2026. During this time, all obstetric patients meeting the inclusion criteria were recruited consecutively upon admission. Eligible participants comprised pregnant women (antenatal) or women within 48 hours postpartum who were admitted to critical care for severe obstetric complications such as severe pre-eclampsia/eclampsia, postpartum hemorrhage (PPH), sepsis, or other life-threatening conditions. Patients fulfilling these criteria and providing informed consent were enrolled in the study, yielding a total sample size of 100 cases over the study period.

For each enrolled patient, data collection began at the point of admission. Baseline information- including demographics (age, parity), relevant obstetric history, and the clinical diagnosis prompting admission- was recorded on the case record form. A blood sample was obtained immediately upon admission for the measurement of ferritin, albumin, CRP, and lactate, and the laboratory results were documented in the data form as soon as they became available. Concurrently, the admission SOFA score was calculated to quantify the degree of organ dysfunction at presentation.

Plan for data analysis

Data was analyzed using SPSS. Continuous variables were summarized as mean±SD and compared using t-tests or

Mann-Whitney U tests. Categorical variables were analyzed with chi-square or Fisher's exact tests. ROC curves assessed the predictive value of FAR and other biomarkers. Multivariable logistic regression was used to identify independent predictors of severe maternal morbidity. A p value <0.05 was considered statistically significant.

RESULTS

The age distribution in this study shows that the majority of patients were in the 31-35 years age group (38%), followed by 25-30 years (34%), with 72% of cases concentrated in the 25-35 years range, which represents the peak reproductive age. Patients aged ≤25 years accounted for 17%, while only 11% were >36 years.

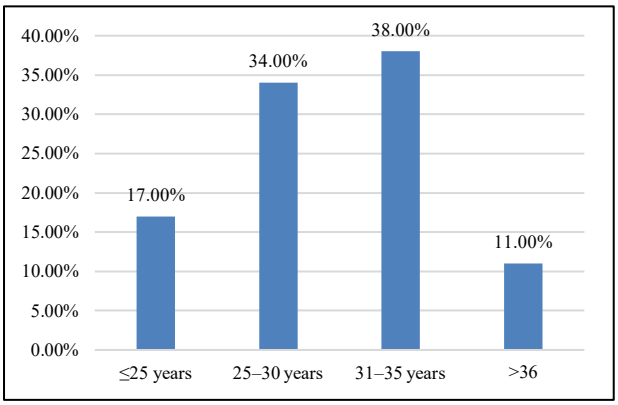

Figure 1: Age wise distribution.

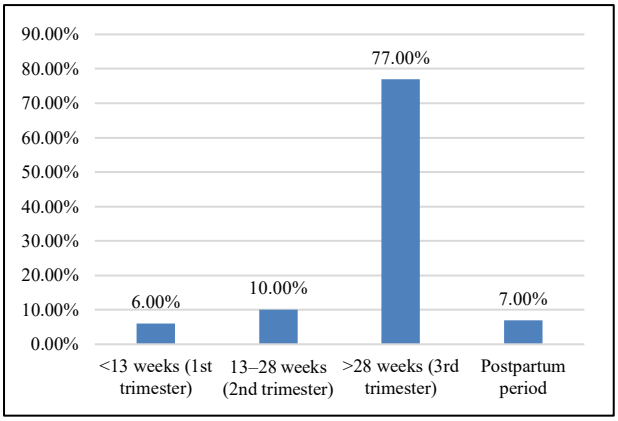

Figure 2: Gestational age at ICU admission (n=100).

The distribution of patients according to gestational age shows that the majority were admitted during the third trimester (>28 weeks), accounting for 77% of cases, followed by 10% in the second trimester and 6% in the first trimester, while 7% were in the postpartum period.

The distribution of primary obstetric diagnoses shows that hypertensive disorders (pre-eclampsia/eclampsia) were the most common cause of ICU admission, accounting for 35% of cases, followed by postpartum hemorrhage (18%) and placenta accreta/percreta (14%). Other causes included placental abruption and placenta previa (8% each), while sepsis, ruptured ectopic pregnancy, and other conditions contributed smaller proportions.

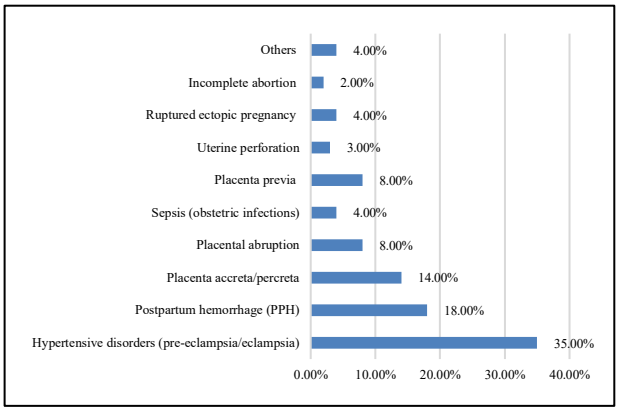

Figure 3: Primary obstetric diagnoses (n=100).

Table 1: Admission SOFA score.

Statistic	SOFA score on ICU admission
Median (IQR)	3 (1-5)
Mean±SD	4.2±3.0
Range	0-15

The SOFA score at ICU admission showed a median value of 3 (IQR: 1-5) with a mean of 4.2±3.0 and a wide range from 0 to 15 (Table 1).

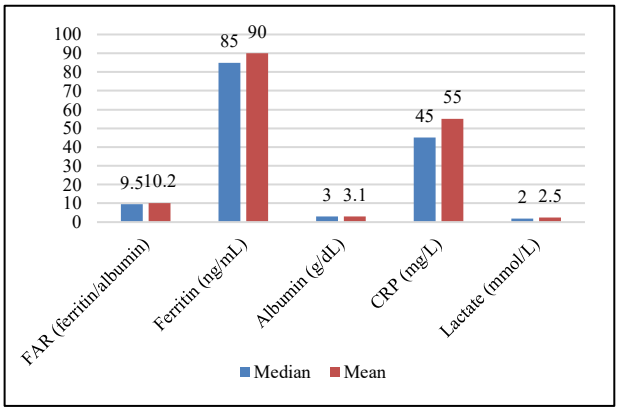

Figure 4: Biomarkers at admission.

The biomarker profile at admission showed a median FAR of 9.5 (IQR: 7.0-12.0), with a mean of 10.2±5.8, indicating moderate elevation in the study population. Serum ferritin levels were also elevated (median 85 ng/ml), while albumin levels were relatively low (mean 3.1±0.6 gm/dl), reflecting an inflammatory and stressed physiological state.

The maternal outcome distribution showed that the majority of patients survived (95%), while 5% resulted in maternal mortality (Figure 5).

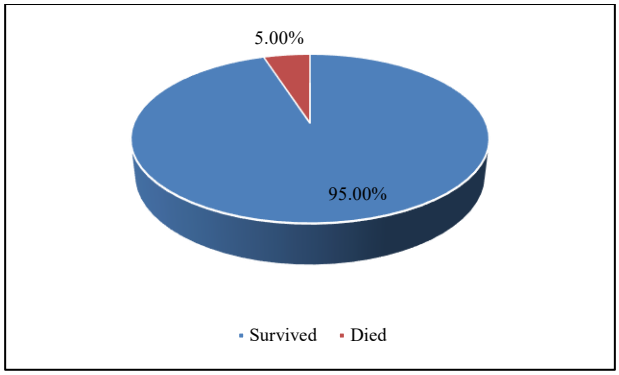

Figure 5: Maternal outcomes.

Table 2: Maternal complications.

Complication	No. of patients	Percentage
ARDS (acute respiratory distress)	12	12.00
AKI (requiring dialysis)	15	15.00
DIC (disseminated intravascular coagulation)	03	03.00
Shock (vasopressor use)	28	28.00

The distribution of maternal complications revealed that shock was the most common complication, occurring in 28% of patients, followed by acute kidney injury (15%) and acute respiratory distress syndrome (12%), while disseminated intravascular coagulation was observed in 3% of cases.

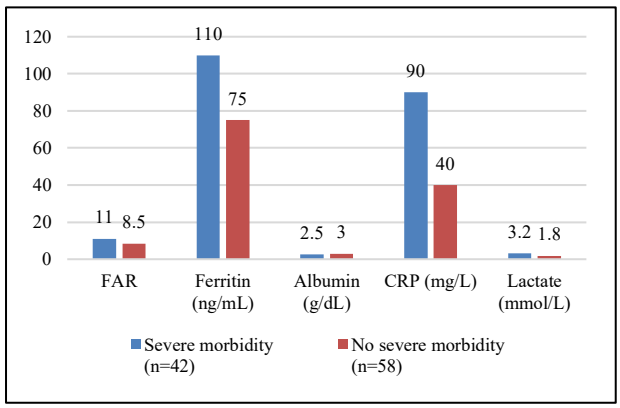

Figure 6: Biomarkers in patients with severe morbidity versus without.

Comparison of biomarkers between patients with and without severe morbidity showed that FAR, ferritin, CRP, and lactate levels were significantly higher in the severe morbidity group, while albumin levels were significantly lower. The median FAR was notably elevated in patients with severe morbidity (11.0 versus 8.5, p<0.001).

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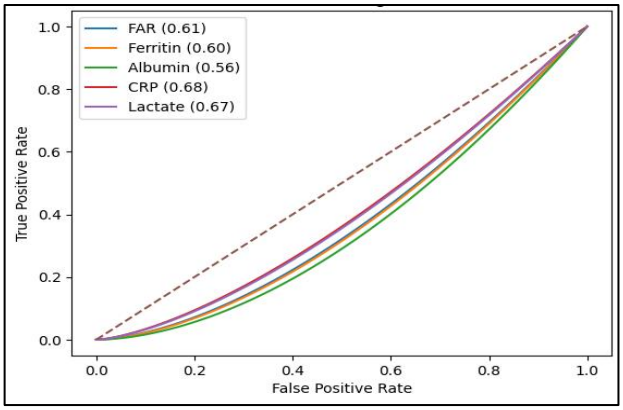

Figure 7: ROC AUC for severe maternal morbidity prediction.

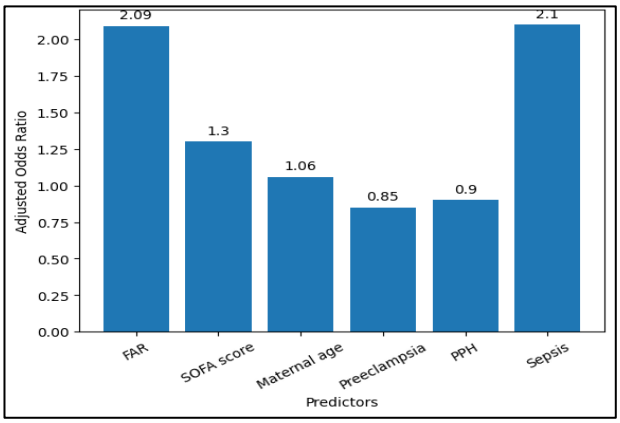

Figure 8: Independent predictors of severe maternal morbidity (multivariable logistic regression).

Comparison of biomarkers between patients with and without severe morbidity showed that FAR, ferritin, CRP, and lactate levels were significantly higher in the severe morbidity group, while albumin levels were significantly lower. The median FAR was notably elevated in patients with severe morbidity (11.0 versus 8.5, p<0.001).

DISCUSSION

The present prospective cohort study was undertaken to evaluate the prognostic utility of the ferritin-albumin ratio (FAR) as a biomarker for severe maternal morbidity among obstetric patients admitted to a tertiary care center in the Bundelkhand region. The findings of this study demonstrate a significant association between elevated FAR and adverse maternal outcomes, suggesting its potential role in early risk stratification in critically ill obstetric populations.

In the present study, the majority of patients belonged to the age group of 25-35 years (72%), representing the peak

reproductive age. A similar demographic distribution has been reported in tertiary care studies evaluating obstetric ICU admissions, where complications are more prevalent in this age group. Furthermore, most patients (77%) were admitted during the third trimester, which is consistent with the increased hemodynamic burden and higher incidence of complications such as hypertensive disorders and obstetric hemorrhage in late gestation.

Hypertensive disorders of pregnancy constituted the most common indication for ICU admission (35%), followed by postpartum hemorrhage (18%) and placenta accreta spectrum (14%). These findings are in concordance with earlier studies such as Naagar et al and Rani et al which identified hypertensive disorders and hemorrhage as leading causes of severe maternal morbidity in tertiary care settings.[4,7] Although sepsis accounted for only 4% of cases in the present study, it emerged as a significant independent predictor of severe morbidity (OR 2.10, p=0.022), highlighting its disproportionately high clinical severity.

The overall maternal mortality rate in this study was 5%, which is comparable to findings from similar high-risk obstetric cohorts. However, a substantial proportion of patients developed life-threatening complications such as shock (28%), acute kidney injury (15%), and acute respiratory distress syndrome (12%), indicating a high severity of illness at presentation. This observation is consistent with reports from resource-limited settings, where delayed referrals and inadequate primary care contribute to advanced disease at admission.

A key observation in this study was that FAR was significantly elevated in patients with severe maternal morbidity compared to those without (median 11.0 versus 8.5, p<0.001). This finding suggests that FAR is a reliable surrogate marker of systemic inflammation and physiological stress.[17] Patients with severe morbidity also exhibited significantly higher ferritin, CRP, and lactate levels, along with lower albumin levels, reflecting a state of heightened inflammatory response and metabolic derangement.

Ferritin, an acute-phase reactant, increases in response to inflammatory cytokine activation, oxidative stress, and cellular injury, whereas albumin levels decline due to increased capillary permeability, redistribution, and decreased hepatic synthesis during systemic inflammation. As described by Soeters et al, hypoalbuminemia is not merely a nutritional marker but a reflection of the severity of systemic inflammatory response.[21] Therefore, FAR integrates these opposing biological processes, providing a composite indicator of both inflammatory burden and physiological reserve.

In terms of diagnostic performance, FAR demonstrated moderate predictive accuracy with an AUC of 0.61. Although this was lower than CRP (AUC 0.68) and lactate (AUC 0.67), FAR outperformed ferritin (0.60) and albumin (0.56) when used individually. This suggests that the combined assessment of inflammatory and nutritional parameters enhances predictive capability compared to isolated biomarkers.

Multivariable logistic regression analysis further established FAR as an independent predictor of severe maternal morbidity (adjusted OR 2.09, p<0.001), along with SOFA score and maternal age. This is consistent with findings from critical care studies such as Liu et al demonstrated that FAR independently predicts mortality in septic patients.[18] These results reinforce the concept that FAR retains prognostic significance even after adjusting for established clinical severity indices.

Comparison with the study by Taşkın et al conducted among critically ill COVID-19 patients, reveals that FAR had markedly higher predictive accuracy in their cohort (AUC 0.958).[23] The superior performance observed in that study may be attributed to the homogeneous disease pathology and the presence of extreme hyperinflammatory states associated with COVID-19, leading to markedly elevated ferritin levels and profound hypoalbuminemia. In contrast, the present study included a heterogeneous group of obstetric conditions, each with varying degrees of inflammation, which may have attenuated the predictive performance of FAR.

Additionally, the range of FAR values in the present study was relatively narrow (2-28) compared to the significantly higher values reported by Taşkın et al which may have limited its discriminative ability.[23] Similar findings were reported by Liu et al in septic ICU patients, where FAR demonstrated moderate predictive accuracy (AUC ~0.61), closely aligning with the results of the present study.[18-23]

From a pathophysiological standpoint, elevated FAR reflects a complex interplay of systemic inflammation, endothelial dysfunction, and metabolic stress. Increased ferritin levels indicate activation of inflammatory pathways and iron-mediated oxidative injury, while decreased albumin levels signify impaired oncotic balance, capillary leakage, and reduced physiological resilience.[24] These mechanisms collectively contribute to organ dysfunction, as evidenced by the higher incidence of complications such as ARDS, AKI, and shock in patients with elevated FAR.

The clinical implications of these findings are particularly relevant in low-resource settings. FAR is a simple, cost-effective, and readily available biomarker that can be calculated using routine laboratory investigations. Its use at the time of admission may facilitate early identification of high-risk patients, enabling timely intervention and optimized resource allocation. Furthermore, integration of FAR with established scoring systems such as SOFA may enhance prognostic accuracy and clinical decision-making.

Despite these strengths, the present study has certain limitations. The relatively small sample size and single-center design may limit the generalizability of the findings. Additionally, the moderate predictive accuracy of FAR suggests that it should be used as part of a multimodal assessment rather than as a standalone predictor. The absence of standardized cut-off values for FAR in obstetric populations also limits its immediate clinical applicability.

CONCLUSION

Based on the findings of this prospective cohort study conducted among critically ill obstetric patients, the ferritin-albumin ratio (FAR) demonstrates significant potential as a predictive biomarker for severe maternal morbidity. Patients who developed severe complications exhibited markedly higher FAR values compared to those without morbidity, indicating that FAR effectively reflects the combined impact of systemic inflammation and physiological stress.

Although FAR showed moderate predictive accuracy (AUC 0.61), it performed better than individual parameters such as ferritin and albumin alone and remained an independent predictor of adverse maternal outcomes on multivariable analysis (OR 2.09, $p<0.001$). This highlights its robustness even after adjusting for confounding clinical variables such as SOFA score and maternal age.

Importantly, FAR is derived from routinely available, cost-effective laboratory tests, making it particularly suitable for resource-limited settings like the Bundelkhand region. Its integration into early assessment protocols can aid in timely risk stratification, prioritization of care, and improved clinical decision-making in obstetric emergencies.

However, given its moderate discriminative ability, FAR should be used as part of a multimodal assessment rather than a standalone predictor. Further large-scale, multicentric studies are recommended to validate its clinical utility and establish standardized cut-off values for broader application.

Recommendations

Incorporate FAR into routine assessment of obstetric patients admitted to ICU for early identification of high-risk cases. Use FAR in combination with clinical scoring systems (e.g., SOFA score) to improve overall prognostic accuracy and decision-making. Conduct larger multicentric studies to validate findings and enhance generalizability across diverse obstetric populations. Establish standardized FAR cut-off values specific to obstetric patients for better clinical applicability. Promote awareness and training among healthcare providers regarding the utility of FAR as a simple, cost-effective biomarker in resource-limited settings.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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