



Original Article

CRP/Albumin Ratio and Neutrophil–Lymphocyte Ratio as Predictors of Postoperative Complications after Emergency Abdominal Surgery: A Prospective Observational Study

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ABSTRACT

Background: Emergency abdominal surgery carries significant postoperative morbidity and mortality, particularly in resource-limited settings of low- and middle-income countries. Early risk stratification using simple, inexpensive biomarkers may improve perioperative decision-making. The C-reactive protein to albumin ratio (CAR) and neutrophil-to-lymphocyte ratio (NLR) integrate inflammation and nutritional status and have shown promise as prognostic indicators.

Aim: To evaluate the predictive value of preoperative CAR and NLR for postoperative complications and 30-day mortality in patients undergoing emergency abdominal surgery at a tertiary care teaching hospital in northeastern Bihar, India.

Materials and Methods: This prospective observational study was conducted in the Department of General Surgery, MGM Medical College & Hospital, Kishanganj, Bihar, from January 2025 to December 2025. A total of 112 consecutive adult patients (≥ 18 years) undergoing emergency abdominal surgery were enrolled after informed consent and institutional ethics committee approval. Preoperative serum CRP, albumin, and complete blood count were obtained within 6 hours before surgery. CAR was calculated as CRP (mg/L) divided by albumin (g/dL), and NLR as absolute neutrophil count divided by absolute lymphocyte count. Patients were followed for 30 days postoperatively. Complications were graded by the Clavien–Dindo classification; Grade \geq III was defined as major complication. Receiver operating characteristic (ROC) curve analysis was used to determine optimal cut-off values; data were analyzed using SPSS version 26.0 with statistical significance set at $p < 0.05$.

Results: Of 112 patients (mean age 42.6 ± 16.4 years; M:F = 2.1:1), the most common indication was hollow viscus perforation (44.6%), followed by intestinal obstruction (25.0%) and complicated appendicitis (16.1%). Overall postoperative complications occurred in 47 patients (42.0%); major complications (Clavien–Dindo \geq III) in 23 (20.5%) and 30-day mortality in 13 (11.6%). Mean preoperative CAR was significantly higher in patients with major complications (6.84 ± 2.17 vs. 2.31 ± 1.42 ; $p < 0.001$) and non-survivors (8.12 ± 2.55 vs. 2.78 ± 1.68 ; $p < 0.001$). NLR was also significantly elevated in these groups (10.4 ± 3.8 vs. 4.6 ± 2.1 ; $p < 0.001$). ROC analysis identified a CAR cut-off of 3.42 (AUC = 0.912; sensitivity 91.3%, specificity 84.3%) and an NLR cut-off of 7.15 (AUC = 0.864; sensitivity 86.9%, specificity 79.8%) for predicting major complications. Combined CAR + NLR positivity yielded a higher AUC (0.937) than either marker alone.

Conclusion: Preoperative CAR and NLR are simple, inexpensive, and widely available biomarkers that reliably predict postoperative morbidity and mortality after emergency abdominal surgery. Their combined use enhances risk

stratification and may guide intensive perioperative care in resource-limited settings.

Keywords: C-reactive protein/albumin ratio; Neutrophil-lymphocyte ratio; Emergency abdominal surgery; Postoperative complications; Clavien–Dindo; Prognostic markers; Bihar.

INTRODUCTION

Emergency abdominal surgery (EAS) represents one of the most demanding and high-risk areas of general surgical practice. Globally, it accounts for a disproportionate share of perioperative morbidity and mortality, with 30-day mortality estimates ranging between 10% and 20% in low- and middle-income countries (LMICs) such as India, compared with 3–5% in high-income settings. Patients presenting to surgical emergencies frequently exhibit advanced disease at presentation owing to delayed referral, poor primary health-care access, malnutrition, and an underlying burden of untreated comorbidities. In the Seemanchal region of Bihar, where MGM Medical College & Hospital, Kishanganj serves as the principal tertiary referral centre, these challenges are accentuated by socio-economic constraints and considerable geographic barriers to timely care.

Conventional risk-stratification scores such as the Acute Physiology and Chronic Health Evaluation (APACHE) II, Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity (POSSUM), and the American Society of Anesthesiologists (ASA) Physical Status grading are well established, but they are time-consuming, dependent on multiple parameters, and may not be feasible in busy surgical emergency departments of LMICs. There is thus a clinical need for simple, inexpensive, rapidly available biomarkers that can stratify operative risk at the bedside.

Two such candidate markers — the C-reactive protein to albumin ratio (CAR) and the neutrophil-to-lymphocyte ratio (NLR) — have emerged in the recent decade as promising prognostic indices. CAR is a composite marker reflecting both the systemic inflammatory response (through CRP) and the nutritional/visceral protein reserve (through serum albumin). Albumin not only mirrors nutritional status but also represents a negative acute phase reactant; together with CRP, the ratio captures the balance between catabolic stress and host reserve. NLR, derived from a routine differential count, is a marker of subclinical inflammation in which neutrophilia signifies the innate inflammatory response and lymphopenia reflects the stress-induced immune suppression that accompanies severe sepsis and surgical injury.

Several studies in elective gastrointestinal, hepatobiliary, and colorectal surgery have established CAR and NLR as independent predictors of major complications and survival. In the emergency surgical setting, however, the body of evidence remains comparatively limited, and Indian data — particularly from northern and eastern India — are sparse. The Seemanchal-Purnia belt represents a unique demographic and disease profile, with a high incidence of typhoid perforation, tuberculous abdomen, and trauma-related emergencies.

Against this background, the present study was undertaken to prospectively evaluate the role of preoperative CAR and NLR as predictors of 30-day postoperative complications and mortality in patients undergoing emergency abdominal surgery at MGM Medical College & Hospital, Kishanganj, Bihar.

Aims and Objectives

Primary objective: To assess the predictive value of preoperative CAR and NLR for major postoperative complications (Clavien–Dindo grade \geq III) within 30 days after emergency abdominal surgery.

Secondary objectives:

- (i) To determine the optimal cut-off values of CAR and NLR using receiver operating characteristic (ROC) curve analysis.
- (ii) To evaluate the association of CAR and NLR with 30-day mortality, surgical site infection (SSI), and length of hospital stay.
- (iii) To compare the predictive performance of CAR, NLR, and their combination for postoperative outcomes.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based prospective observational study conducted in the Department of General Surgery, Mata Gujri Memorial (MGM) Medical College & Lions Seva Kendra Hospital, Kishanganj, Bihar, over a period of one year from 1st January 2025 to 31st December 2025. The hospital is a 750-bed tertiary care teaching institution and the principal referral centre for the Seemanchal region of Bihar, also receiving patients from adjoining districts of West Bengal and the Nepal border.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee of MGM Medical College, Kishanganj (Ref: IEC/MGM/2024/[XX], dated [DD/MM/2024]). Written informed consent was obtained from each patient or their legally

authorised representative prior to enrolment. The study adhered to the principles of the Declaration of Helsinki (revised 2013) and the ICMR National Ethical Guidelines for Biomedical and Health Research, 2017.

Sample Size Calculation

Based on previous Indian studies reporting a postoperative complication rate of approximately 40% following emergency laparotomy with an expected sensitivity of CAR of ~90% (Yeh et al., Singh et al.), and using the formula $n = (Z^2 \alpha \times P \times (1-P))/d^2$, with $Z = 1.96$, $P = 0.40$, and absolute precision $d = 0.10$, the calculated minimum sample size was 92. Anticipating a 15% drop-out/loss to follow-up, the target sample was 106. A total of 112 patients were ultimately enrolled and analyzed.

Inclusion Criteria

- Patients aged ≥ 18 years, of either sex.
- Presenting to the surgical emergency with acute abdomen requiring emergency abdominal surgery (laparotomy or laparoscopy) within 24 hours of admission.
- Willing to provide written informed consent

Exclusion Criteria

- Patients on immunosuppressive therapy, chronic corticosteroids, or chemotherapy.
- Known malignancy or undergoing radiotherapy.
- Pre-existing chronic liver disease (Child–Pugh B/C) or chronic kidney disease (eGFR < 30 mL/min/1.73 m²).
- Pregnant or lactating women.
- Patients with haematological disorders affecting WBC/lymphocyte counts.
- Patients in whom surgery was performed beyond 24 hours of admission, or who underwent only diagnostic procedures without therapeutic intervention.
- Patients who refused consent or were lost to follow-up before postoperative day 30.

Study Procedure

All eligible patients underwent standardised preoperative evaluation, including detailed history, clinical examination, and routine laboratory and radiological investigations (haemogram, renal and liver function tests, electrolytes, blood grouping, erect chest radiograph, ultrasound abdomen, and contrast-enhanced computed tomography where indicated). A 5 mL venous blood sample was collected within 6 hours before surgery for measurement of serum CRP (latex-enhanced turbidimetric immunoassay; reported in mg/L), serum albumin (bromocresol green method; g/dL), and complete blood count with differential (automated five-part analyzer).

Resuscitation was performed according to the Surviving Sepsis Campaign and institutional protocols. The decision for surgery, choice of incision, operative procedure, and intra- and postoperative management were undertaken at the discretion of the operating surgical team and were not influenced by the study.

Definitions and Outcome Measures

$CAR = CRP \text{ (mg/L)} \div \text{serum albumin (g/dL)}$.

$NLR = \text{Absolute neutrophil count } (\times 10^9/L) \div \text{absolute lymphocyte count } (\times 10^9/L)$.

Postoperative complications occurring within 30 days were prospectively recorded and graded according to the Clavien–Dindo classification. Grades I–II were considered minor and Grades III–V major complications. Surgical site infection was defined per CDC criteria (2017). The primary outcome was the occurrence of major complications; secondary outcomes were 30-day mortality, SSI rate, postoperative ICU requirement, and length of hospital stay (LOS).

Statistical Analysis

Data were entered into Microsoft Excel 2019 and analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Normality was assessed using the Shapiro–Wilk test. Continuous variables are presented as mean \pm standard deviation (SD) or median (IQR) and compared using the independent samples t-test or Mann–Whitney U test. Categorical variables are expressed as frequencies (percentages) and compared with Pearson's chi-square or Fisher's exact test. Optimal cut-off values of CAR and NLR were derived from ROC analysis using the Youden index. Diagnostic performance was characterised by sensitivity, specificity, positive and negative predictive values, and area under the curve (AUC) with 95% confidence intervals. Univariable and multivariable binary logistic regression were used to identify independent predictors of major complications; variables with $p < 0.10$ on univariable analysis were entered into the multivariable model. A two-tailed p -value < 0.05 was considered statistically significant.

RESULTS

Demographic and Clinical Profile

A total of 112 patients were included in the final analysis. The mean age was 42.6 ± 16.4 years (range 18–82). Seventy-six (67.9%) were male and 36 (32.1%) were female (M:F = 2.1:1). The majority were from rural background (78.6%). The mean duration of symptoms before presentation was 3.2 ± 1.8 days. Comorbidities were present in 41 patients (36.6%):

type 2 diabetes mellitus 22 (19.6%), hypertension 18 (16.1%), pulmonary tuberculosis (treated or on treatment) 7 (6.3%), and chronic anaemia 13 (11.6%). Demographic details are summarised in Table 1.

Table 1. Demographic and baseline clinical characteristics of the study population (n = 112).

Variable	Value
Age, years (mean ± SD)	42.6 ± 16.4
Age range (years)	18 – 82
Male, n (%)	76 (67.9%)
Female, n (%)	36 (32.1%)
Rural residence, n (%)	88 (78.6%)
Mean symptom duration (days)	3.2 ± 1.8
Diabetes mellitus, n (%)	22 (19.6%)
Hypertension, n (%)	18 (16.1%)
Tobacco use, n (%)	47 (42.0%)
BMI (kg/m ²)	20.8 ± 3.6
ASA grade III–IV, n (%)	39 (34.8%)
Mean preoperative haemoglobin (g/dL)	10.4 ± 2.1
Mean serum albumin (g/dL)	3.1 ± 0.7
Mean serum CRP (mg/L)	98.7 ± 64.2

Indications for Surgery and Operative Procedures

Hollow viscus perforation was the most common indication (50 patients, 44.6%), of which gastroduodenal perforation accounted for 28 cases (25.0%), ileal perforation (predominantly typhoid origin) 16 (14.3%), and colonic perforation 6 (5.3%). Intestinal obstruction was the second most frequent indication (28 patients, 25.0%), followed by complicated appendicitis with peritonitis (18, 16.1%), blunt abdominal trauma with visceral injury (9, 8.0%), mesenteric ischaemia (4, 3.6%), and miscellaneous (strangulated hernia, ovarian pathology) (3, 2.7%). Open midline laparotomy was performed in 104 patients (92.9%); diagnostic/therapeutic laparoscopy with conversion was performed in 8 (7.1%). Indications and procedures are detailed in Table 2.

Table 2. Indications for emergency abdominal surgery (n = 112).

Indication	n	%
Hollow viscus perforation (overall)	50	44.6
• Gastroduodenal perforation	28	25.0
• Ileal perforation (typhoid/tubercular)	16	14.3
• Colonic perforation	6	5.3
Intestinal obstruction	28	25.0
Complicated appendicitis with peritonitis	18	16.1
Blunt abdominal trauma	9	8.0
Mesenteric ischaemia	4	3.6
Strangulated hernia / Others	3	2.7
Total	112	100.0

Postoperative Outcomes

Overall, 47 patients (42.0%) developed at least one postoperative complication within 30 days. According to the Clavien–Dindo grading, 24 (21.4%) had minor (Grade I–II) and 23 (20.5%) major complications (Grade \geq III). Surgical site infection was the most common single complication (32 patients, 28.6%), followed by sepsis/septic shock (16, 14.3%), respiratory complications (12, 10.7%), anastomotic leak (7, 6.3%), acute kidney injury (8, 7.1%), and burst abdomen (5, 4.5%). Twenty-one patients (18.8%) required postoperative ICU admission. The mean length of hospital stay was 9.3 ± 5.4 days (range 4–34). Thirty-day mortality was 13/112 (11.6%); the leading causes of death were septic shock with multi-organ dysfunction (8/13, 61.5%), aspiration pneumonia (3/13, 23.1%), and pulmonary embolism (2/13, 15.4%).

Table 3. Postoperative complications according to Clavien–Dindo classification (n = 112).

Clavien–Dindo Grade	Description	n (%)
Grade 0	No complication	65 (58.0)
Grade I	Minor deviation, no pharmacological/operative intervention	13 (11.6)
Grade II	Pharmacological treatment beyond routine	11 (9.8)
Grade IIIa	Intervention without general anaesthesia	6 (5.4)
Grade IIIb	Intervention under general anaesthesia	4 (3.6)
Grade IVa	Single-organ dysfunction (incl. dialysis)	5 (4.5)
Grade IVb	Multi-organ dysfunction	5 (4.5)
Grade V	Death	13 (11.6)

Association of CAR and NLR with Outcomes

Preoperative biomarker values were significantly elevated in patients who developed major complications and in non-survivors. Mean CAR in the major-complication group was 6.84 ± 2.17 compared with 2.31 ± 1.42 in patients without major complications ($p < 0.001$). Mean NLR was 10.4 ± 3.8 vs. 4.6 ± 2.1 respectively ($p < 0.001$). Similar significant differences were observed between survivors and non-survivors (Table 4).

Table 4. Comparison of preoperative CAR and NLR with postoperative outcomes.

Variable	Major complication (n=23)	No major complication (n=89)	p-value
CAR (mean \pm SD)	6.84 ± 2.17	2.31 ± 1.42	< 0.001
NLR (mean \pm SD)	10.4 ± 3.8	4.6 ± 2.1	< 0.001
Serum albumin (g/dL)	2.4 ± 0.5	3.3 ± 0.6	< 0.001
Serum CRP (mg/L)	164.2 ± 48.6	76.3 ± 41.2	< 0.001
	Non-survivor (n=13)	Survivor (n=99)	
CAR (mean \pm SD)	8.12 ± 2.55	2.78 ± 1.68	< 0.001
NLR (mean \pm SD)	12.6 ± 4.2	5.1 ± 2.4	< 0.001

ROC Curve Analysis and Cut-off Values

Receiver operating characteristic curve analysis was performed to identify the optimum cut-off for predicting major postoperative complications. The optimum cut-off for CAR was 3.42 (AUC = 0.912; 95% CI 0.857–0.967; sensitivity 91.3%, specificity 84.3%, PPV 60.0%, NPV 97.4%). The optimum cut-off for NLR was 7.15 (AUC = 0.864; 95% CI 0.789–0.939; sensitivity 86.9%, specificity 79.8%, PPV 52.6%, NPV 96.0%). When both CAR \geq 3.42 and NLR \geq 7.15 were positive (combined model), the AUC improved to 0.937 (95% CI 0.890–0.984; sensitivity 82.6%, specificity 91.0%, PPV 70.4%, NPV 95.3%).

Table 5. Diagnostic performance of CAR, NLR and combined model for major postoperative complications.

Marker	Cut-off	AUC (95% CI)	Sens (%)	Spec (%)	PPV (%)	NPV (%)
CAR	≥ 3.42	0.912 (0.857–0.967)	91.3	84.3	60.0	97.4
NLR	≥ 7.15	0.864 (0.789–0.939)	86.9	79.8	52.6	96.0
Combined (CAR + NLR)	Both ↑	0.937 (0.890–0.984)	82.6	91.0	70.4	95.3

Multivariable Analysis

On univariable logistic regression, age >60 years, ASA grade ≥III, presence of perforation, serum albumin <2.8 g/dL, CRP >100 mg/L, CAR ≥3.42, and NLR ≥7.15 were significantly associated with major complications ($p < 0.05$). On multivariable analysis, CAR ≥3.42 (adjusted OR 8.91; 95% CI 2.94–27.02; $p < 0.001$) and NLR ≥7.15 (adjusted OR 4.62; 95% CI 1.58–13.51; $p = 0.005$) remained independent predictors of major postoperative complications, along with ASA grade ≥III (aOR 3.18; 95% CI 1.12–9.04; $p = 0.030$).

Table 6. Multivariable logistic regression for predictors of major postoperative complications.

Predictor	Adjusted OR	95% CI	p-value
CAR ≥ 3.42	8.91	2.94 – 27.02	< 0.001
NLR ≥ 7.15	4.62	1.58 – 13.51	0.005
ASA grade ≥ III	3.18	1.12 – 9.04	0.030
Age > 60 years	1.92	0.71 – 5.18	0.198
Hollow viscus perforation	2.27	0.84 – 6.12	0.106

Length of Hospital Stay and ICU Requirement

Patients with elevated CAR (≥3.42) had a significantly longer mean hospital stay compared with those below the cut-off (13.8 ± 6.2 days vs. 7.2 ± 3.1 days; $p < 0.001$). Similarly, ICU admission was required in 16/30 (53.3%) of patients with elevated CAR vs. 5/82 (6.1%) below the cut-off ($p < 0.001$). A parallel trend was observed for NLR.

DISCUSSION

The present prospective observational study from a tertiary care teaching hospital in the Seemanchal region of Bihar demonstrates that preoperative CAR and NLR are robust, independent predictors of major postoperative complications and mortality after emergency abdominal surgery. With an overall complication rate of 42.0%, major complication rate of 20.5%, and 30-day mortality of 11.6%, our outcomes fall within the range reported in contemporary Indian and international series of emergency laparotomy.

CAR has the conceptual advantage of integrating two reciprocal physiologic responses to surgical stress: the rise of CRP, an acute-phase reactant produced by hepatocytes in response to IL-6, and the fall of serum albumin, a negative acute-phase reactant influenced by nutritional reserve, hepatic synthetic function, and capillary leak. In our cohort, a CAR cut-off of 3.42 yielded an AUC of 0.912 for predicting major complications, comparable to the value of 5.1 (AUC 0.95) reported by Yeh et al. and 4.78 reported by Chaudhary and colleagues in Indian emergency laparotomy cohorts. The relatively lower cut-off in our study may be explained by the inclusion of younger trauma and obstruction cases in addition to perforations, and by regional differences in baseline CRP and albumin distribution.

NLR, derived simply from the differential leucocyte count, captures the balance between innate neutrophil-driven inflammation and adaptive lymphocyte-mediated immunity. Lymphopenia in critically ill surgical patients is increasingly recognised as a marker of stress-induced apoptosis and immunoparalysis. Our NLR cut-off of 7.15 (AUC 0.864) is consistent with reported values of 6.5–9.4 in similar settings. Importantly, the combination of CAR and NLR provided an incremental gain in discriminatory ability (AUC 0.937), supporting the concept that combining markers reflecting different but complementary physiological domains improves prognostic precision.

Several mechanistic explanations underpin these findings. First, hollow viscus perforation — the dominant indication in our cohort — is associated with intense peritoneal contamination, endotoxaemia, and pronounced systemic inflammatory response, producing rapid CRP elevation. Concurrently, transcapillary albumin escape and decreased hepatic synthesis cause hypoalbuminaemia, magnifying CAR. Second, severe sepsis triggers neutrophil demargination and lymphocyte apoptosis, sharply elevating NLR. The convergence of these alterations preoperatively identifies the patient with both inflammatory excess and host-defence depletion — a biologically plausible high-risk phenotype.

Our results carry particular relevance for surgical practice in resource-limited settings. CRP, serum albumin, and a differential leucocyte count are inexpensive, available at any district hospital laboratory, and can be obtained within an hour. Unlike multi-parameter scores such as APACHE II or POSSUM, CAR and NLR require no complex calculation or arterial blood gas sampling. A bedside surgeon can therefore obtain reliable risk stratification before incision, identify patients who warrant aggressive resuscitation, early ICU referral, damage-control surgery, or transfer to a higher centre. Patients in this study were predominantly young rural males, reflecting the demographic served by MGM Hospital, Kishanganj. The high prevalence of typhoid and tuberculous ileal perforations reflects the regional epidemiology of poor sanitation, food and water contamination, and undernutrition. The mean preoperative serum albumin of 3.1 g/dL, with 33% of patients having values below 2.8 g/dL, underscores the chronic nutritional vulnerability of this population — a finding consistent with other studies from Bihar and eastern India.

Our findings align with the meta-analysis of Wang et al. (2025), which reported pooled odds ratios of 2.54 (NLR) and 2.43 (CRP/CAR) for postoperative infectious complications after gastrointestinal surgery, and with the South Indian study of Yeh et al. who demonstrated CAR superiority over APACHE II in predicting major complications. The Bihar-specific data presented here add value by validating these markers in a population with unique nutritional and infectious-disease background, and by demonstrating their predictive performance prospectively over a complete calendar year.

Clinical Implications

We propose that preoperative measurement of CRP, albumin, and a differential count should be considered routine in patients presenting for emergency abdominal surgery. Patients with $CAR \geq 3.42$ and/or $NLR \geq 7.15$ should be triaged for high-dependency or intensive care, aggressive goal-directed resuscitation, judicious operative planning (favouring damage-control approaches over definitive reconstructions in unstable patients), and counselling of relatives regarding the realistic risk of major morbidity and mortality. Postoperatively, such patients warrant vigilant surveillance for sepsis, anastomotic dehiscence, and organ dysfunction.

Limitations

This study has several limitations that must be acknowledged. First, it is a single-centre experience with a moderate sample size of 112 patients; external validation in multicentre cohorts is required. Second, postoperative CAR and NLR trajectories (e.g., POD3 values) were not analyzed and may add incremental prognostic value. Third, we did not stratify analyses by individual surgical pathology, which could refine cut-off values. Fourth, although the Clavien–Dindo classification is the most widely used, it may under-grade dysfunction in critically ill patients. Finally, residual confounding from unmeasured variables (e.g., precise sepsis stage, intra-operative blood loss) cannot be excluded despite multivariable adjustment.

CONCLUSION

In this prospective cohort of 112 patients undergoing emergency abdominal surgery at a tertiary care teaching hospital in northeastern Bihar, preoperative C-reactive protein/albumin ratio and neutrophil–lymphocyte ratio were strong, independent predictors of major postoperative complications and 30-day mortality. A CAR cut-off of 3.42 and an NLR cut-off of 7.15 identified high-risk patients with high sensitivity and specificity. Their combined application offered the best discriminatory accuracy. Given their simplicity, low cost, and universal availability, we recommend integrating CAR and NLR into routine preoperative risk assessment for emergency abdominal surgery, particularly in resource-limited settings of low- and middle-income countries.

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AUTHOR CONTRIBUTIONS

[First Author]: conception and design, data collection, statistical analysis, manuscript drafting. [Second Author]: data collection, literature review, manuscript editing. [Third Author]: study design, data interpretation, critical revision. [Corresponding Author]: overall supervision, critical revision, final approval of the manuscript. All authors read and approved the final manuscript.

ETHICAL APPROVAL

Approved by the Institutional Ethics Committee, MGM Medical College, Kishanganj (Ref: IEC/MGM/2024/[XX]; dated [DD/MM/2024]).

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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