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Role of Serum Sodium Levels, Intra-Operative Blood Pressure, and Non-Surgical Risk Factors in Predicting Anastomotic Leaks Following Emergency Bowel Resections

Dr Girish T U[1] ,Dr Nithin K B[2] ,Dr Harikishore K S[*3],Dr Shriguru[4] ,Dr Ramakrishna[5]

[1]Professor and Unit chief, Dept of general surgery, Jss hospital Mysore
[2]Associate professor Dept of general surgery, Jss hospital Mysore
[3]Post graduate Dept of general surgery, Jss hospital Mysore
[4]Senior resident Dept of general surgery, Jss hospital Mysore
[5]Senior resident Dept of general surgery, Jss hospital Mysore

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Abstract

Background and Objectives - Anastomotic leak is a serious complication following emergency bowel resections, leading to increased morbidity and mortality. The objective of this study is to assess the role of serum sodium levels and intra-operative blood pressure values in predicting anastomotic leaks. Additionally, the study aims to evaluate other non-surgical risk factors influencing the occurrence of post-operative anastomotic leaks in emergency bowel surgeries.

Method - This is a longitudinal observational study conducted at JSS Hospital, Mysuru, over 18 months. A total of 100 patients undergoing emergency laparotomy with bowel resection and primary anastomosis were included. Serum sodium levels were measured preoperatively, and intra-operative blood pressure values (Mean Arterial Pressure <65 mmHg) were recorded. Other non-surgical factors such as age, serum albumin, hemoglobin, creatinine, and total leukocyte count were also analysed. Statistical analysis was performed to determine the relationship between these variables and the incidence of anastomotic leaks. SPSS (Version 26.0) was used for analysis.

Results - Significant predictors of anastomotic leaks included low intra-operative MAP (<65 mmHg) ($p < 0.001$), hyponatremia (Na < 130 mEq/L) ($p = 0.013$), low serum albumin (<2.7 g/dl) ($p = 0.002$), elevated total leukocyte count (TLC >11000) ($p = 0.008$), high serum creatinine (>1.4 mg/dl) ($p = 0.039$). Intra-operative MAP had a sensitivity of 90% and specificity of 48%, while hyponatremia had a sensitivity of 38% and specificity of 84%.

Conclusion -Serum sodium levels and intra-operative MAP are significant predictors of anastomotic leak following emergency bowel resections. Other factors such as hypoalbuminemia, elevated TLC, and anemia also contribute to the risk of leaks. Early identification of these factors may improve outcomes by guiding perioperative management and optimising patient care. A risk-scoring system incorporating these variables can assist in identifying high-risk patients and potentially reduce the occurrence of anastomotic leaks.

Keywords- Anastomotic leak, Emergency bowel resection, Serum sodium, Hyponatremia, Intra-operative blood pressure, Mean arterial pressure (MAP)

Introduction-

Anastomotic leak, a complication arising primarily from surgical procedures involving the gastrointestinal tract, represents a significant challenge in modern medicine. This condition occurs when the connection (anastomosis) between two sections of the intestine or other hollow organs fails to heal properly post-surgery, leading to leakage of contents into the abdominal cavity or surrounding areas. The consequences can range from mild discomfort to life-threatening sepsis, depending on the severity and promptness of intervention (1)

Understanding the complexities and risks associated with anastomotic leaks is crucial for both healthcare providers and patients alike. (2) Surgical advancements have reduced the incidence of leaks, yet they remain a persistent concern in abdominal surgeries, including those for cancer, inflammatory bowel disease, and trauma cases. Factors contributing to these leaks include poor blood supply to the site, technical errors during surgery, underlying diseases like diabetes or malnutrition, and the overall health status of the patient (3)

Effective management of anastomotic leaks requires early recognition, often presenting with symptoms such as fever, abdominal pain, increased heart rate, and sometimes drainage from surgical wounds or drains. Diagnosis typically involves imaging studies such as CT scans or contrast studies to assess the integrity of the anastomosis and identify any leakage (4)

Prevention strategies continue to evolve, encompassing meticulous surgical technique, patient optimization preoperatively, and adherence to evidence-based protocols for postoperative care. Research efforts focus on innovative approaches such as enhanced recovery after surgery (ERAS)[5] protocols and the use of biological adhesives or sealants to reinforce anastomotic sites. Historically, studies of the incidence and etiology of anastomotic leak have been hindered by a lack of a consensus definition of anastomotic leak. There are a broad array of clinical scenarios that could reasonably be described as representing or caused by an overt or occult disruption/imperfection in the anastomotic site (e.g., postoperative abscess). This has often made comparative analyses between institutions and among surgeons a largely arbitrary and unreliable exercise (5,6)

Anastomotic leak remains a significant complication following emergency bowel surgeries, contributing to morbidity, mortality, and prolonged hospital stays. Predicting and preventing these leaks is crucial for improving patient outcomes and reducing healthcare costs. Serum sodium levels and intra-operative blood pressure have emerged as potential predictors due to their influence on tissue perfusion, healing, and overall surgical recovery.

Materials and Methods-

It was a Longitudinal Observational study conducted at Department of General Surgery, JSS Hospital, Mysuru from **August 2022 – February 2024 (18 months).** The study was done on patients who underwent Emergency Laparotomy with Primary resection and anastomosis irregardless of the indication for the procedure (As per the inclusion criteria) over 18 months in the Department of General Surgery at JSS Hospital Mysore**.** Purposive sampling techniques was used for sample collection. Serum sodium levels were measured at presentation during initial assessment of the patient.
Intra-operative blood pressure (MAP) readings were measured after laparotomy incision was made, and recorded till the resection of the diseased segment was done.

Inclusion Criteria:

- Patients Aged 17-80 years
- Patients undergoing emergency Bowel resection and anastomosis
- Small intestine /Large intestine.
- Anastomosis by either Staples or Sutures.
- Anastomosis by End to End /End to Side Technique.

Exclusion Criteria:

- Patients less than 17 years of age.
- Anastomosis after Abdominal Trauma.
- Patients with anastomosis involving the stomach esophagus or biliary tract and feeding jejunostomies.
- Primary Stoma Procedures
- Patients who died in the first 48 hours postoperatively.

Other non-surgical factors which were included in this study were- Age of the patient, Total leucocyte count, Serum creatinine, Serum albumin.

Sample Size:

Total of 100 cases were included.
Sample size estimated considering prevalence of anastomotic leak in Bowel resection and anastomosis as 15% (hospital data) and anticipated odds ratio for the Hyponatremia as predictor for leak as 3.9 and alpha error as 5% and power of 80%, as 100.

$$N_1 = \left[Z_\alpha + \exp\left((-\theta^{*2})/4\right)Z_\beta\right]^2 (1+2P\delta)/(P\theta^{*2})$$

Where,

$$\delta = \left[1+(1+\theta^{*2})\exp(5\theta^{*2}/4)\right]\left[1+\exp((-\theta^{*2})/4)\right]^{-1}$$

θ : Log_e Odds Ratio

P : Overall Proportion (Proportion of Disease)

α : Significance level

1-β : Power

Understanding the role of Intra Operative Blood pressure and Serum sodium levels in predicting Anastomotic Leak following a bowel resection and anastomosis in an Emergent set-up.

Ethical clearance was obtained from the Institutional Ethics Committee (IEC) of medical college. Patient confidentiality and data protection were strictly maintained in compliance with ethical and regulatory standards, with each specimen and record anonymized for analysis.

Statistical Analysis-

Data for this study were entered into Excel 2019 and analyzed using SPSS version 26, licensed to the institution. Descriptive statistics were computed to summarize the demographic and clinical characteristics of the study participants. Continuous variables were compared using paired t-tests, while categorical variables were analyzed using chi-square tests. A p-value <0.05 was considered statistically significant. The Area under the Curve (AUC) was calculated to assess the overall diagnostic ability of these variables, with confidence intervals and p-values used to determine statistical significance.

Results-

Table 1: Comparison of Age between Patients with and Without Anastomotic Leak

Age	Mean	Std. Deviation	Mean Difference	p-value
Group 1	49.60	15.46	0.760	0.803
Group 2	48.84	14.87		

The mean age of participants in Group 1 (patients with an anastomotic leak) was 49.60 years, with a standard deviation of 15.46 years. The mean age in Group 2 (patients without an anastomotic leak) was 48.84 years, with a standard deviation of 14.87 years. The mean difference in age between the two groups was 0.760 years, with a p-value of 0.803. Since the p-value is greater than 0.05, the difference in age between the two groups is not statistically significant.

Table 2: Intergroup Comparison of Low Intra-Operative MAP (<65 mmHg)

Low intra-op MAP (<65mmhg)	Group				chi-square value	p-value
	Group 1		Group 2			
	N	%	N	%		
Yes	45	90.0%	26	52.0%	17.533	<0.001
No	5	10.0%	24	48.0%		

Among patients in Group 1 (those with an anastomotic leak), 45 participants (90.0%) experienced low intra-operative mean arterial pressure (MAP) below 65 mmHg, while only 5 participants (10.0%) did not. In contrast, in Group 2 (patients without an anastomotic leak), 26 participants (52.0%) had low intra-operative MAP, and 24 participants (48.0%) maintained a MAP above 65 mmHg. The chi-square test resulted in a value of 17.533, with a p-value of less than 0.001, indicating a statistically significant difference in the incidence of low intra-operative MAP between the two groups.

Table 3: Intergroup Comparison of Hyponatremia (Na<130 mEq/L)

Hyponatremia (Na<130mEq/L)	Group				chi-square value	p-value
	Group 1		Group 2			
	N	%	N	%		
Yes	19	38.0%	8	16.0%	6.14	.013*
No	31	62.0%	42	84.0%		

In this study, 38.0% of patients in Group 1 (those with an anastomotic leak) had hyponatremia compared to 16.0% in Group 2 (those without an anastomotic leak). The chi-square test indicates a statistically significant association between hyponatremia and the occurrence of an anastomotic leak, with a p-value of 0.013. This suggests that patients with hyponatremia are more likely to develop an anastomotic leak after emergency bowel surgeries.

Table 4: Intergroup Comparison of Serum Albumin Levels (<2.7 g/dl)

Sr Albumin (<2.7 g/dl)	Group				chi-square value	p-value
	Group 1		Group 2			
	N	%	N	%		
Yes	37	74.0%	22	44.0%	9.301	.002*

A total of 37 participants (74.0%) in Group 1 (patients with an anastomotic leak) had serum albumin levels below 2.7 g/dl, compared to 22 participants (44.0%) in Group 2 (patients without an anastomotic leak). In contrast, 13 participants (26.0%) in Group 1 and 28 (56.0%) in Group 2 had 2.7 g/dl or higher serum albumin levels. The chi-square test yielded a value of 9.301 with a p-value of 0.002, indicating a statistically significant difference in serum albumin levels between the two groups.

Table 5: Intergroup Comparison of Total Leukocyte Count (TLC >11,000)

TLC (>11,000)	Group					p-value
	Group 1		Group 2			
	N	%	N	%	chi-square value	
Yes	27	54.0%	14	28.0%	6.986	.008*
No	23	46.0%	36	72.0%		

Elevated total leukocyte count (TLC >11,000) was observed in 27 participants (54.0%) from Group 1 (patients with an anastomotic leak) compared to 14 participants (28.0%) from Group 2 (patients without an anastomotic leak). On the

other hand, 23 participants (46.0%) in Group 1 and 36 participants (72.0%) in Group 2 had TLC values of 11,000 or lower. The chi-square test resulted in a value of 6.986 with a p-value of 0.008, reflecting a statistically significant difference in TLC between the two groups.

Table 6: Intergroup Comparison of Serum Creatinine Levels (>1.4)

	Group					p-value
S. Creatinine (>1.4)	Group 1		Group 2		chi-square value	
	N	%	N	%		
Yes	24	48.0%	14	28.0%	4.244	.039*
No	26	52.0%	36	72.0%		

Elevated serum creatinine levels (>1.4) were found in 24 participants (48.0%) in Group 1 (patients with an anastomotic leak), while 14 participants (28.0%) in Group 2 (patients without an anastomotic leak) had elevated levels. Conversely, 26 participants (52.0%) in Group 1 and 36 participants (72.0%) in Group 2 had serum creatinine levels of 1.4 or lower. The chi-square test resulted in a value of 4.244 with a p-value of 0.039, indicating a statistically significant difference in serum creatinine levels between the two groups.

Table 7: Sensitivity and Specificity of Low Intra-Operative MAP (<65 mmHg) for Predicting Anastomotic Leak

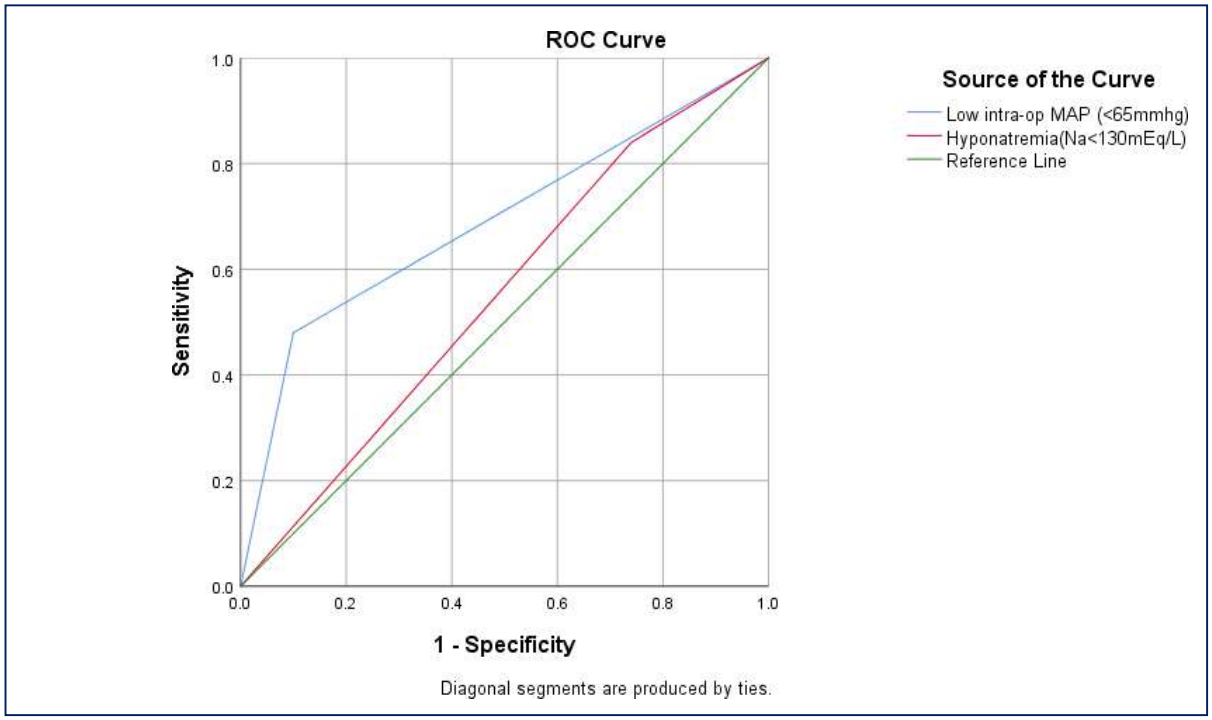
			Group		Total
			Group 1	Group 2	
Low intra-op MAP (<65mmhg)	Yes	Count	45	26	71
		%	90.0%	52.0%	71.0%
	No	Count	5	24	29
		%	10.0%	48.0%	29.0%
Total		Count	50	50	100
		%	100.0%	100.0%	100.0%

Results showed that while low intra-operative MAP has a high sensitivity of 90.0%, indicating it is effective at identifying patients with an anastomotic leak, its specificity is lower at 48.0%, suggesting it is less effective at identifying patients without an anastomotic leak.

Table 8: Sensitivity and Specificity of Hyponatremia (Na <130 mEq/L) for Predicting Anastomotic Leak

			Group		Total
			Group 1	Group 2	
Hyponatremia (Na<130mEq/L)	Yes	Count	19	8	27
		%	38.0%	16.0%	27.0%
	No	Count	31	42	73
		%	62.0%	84.0%	73.0%
Total		Count	50	50	100
		%	100.0%	100.0%	100.0%

Table 9: ROC Curve Analysis for Predictive Variables



Low Intra-Operative MAP (<65 mmHg): The Area Under the Curve (AUC) for low intra-operative MAP is 0.690 with a standard error of 0.054 and a p-value of 0.001. The 95% confidence interval for the AUC ranges from 0.585 to 0.795. This indicates that low intra-operative MAP can predict an anastomotic leak with statistical significance.

Hyponatremia (Na <130 mEq/L): The AUC for hyponatremia is 0.610 with a standard error of 0.058 and a p-value of 0.389. The 95% confidence interval for the AUC ranges from 0.437 to 0.663. This suggests that hyponatremia has a poor predictive ability for an anastomotic leak, with no statistical significance.

Discussion-

This study evaluated the influence of serum sodium levels and intra-operative blood pressure when anticipating anastomotic leaks following emergency bowel resection and primary anastomosis surgeries.

Our analysis revealed no statistically significant disparity in age between patients who experienced anastomotic leaks (Group 1) and those who did not (Group 2) (mean age: 49.60 years vs 48.84 years, p=0.803). This observation is consistent with the results obtained by Frasson et al. (2015), who concluded that age did not serve as a standalone risk factor for anastomotic leakage in their comprehensive study of 3,193 patients who had colon cancer surgery. (1) However, our findings contradict those of many other studies. Rencuzogullari et al. (2017) conducted a study on 12,798 senior patients who had a colectomy. (2) Their findings revealed that older age consistently predicted the occurrence of anastomotic leaks. In their study of 1,391 colorectal surgery patients, Parthasarathy et al. (2017) found that age beyond 60 was classified as an independent risk factor for anastomotic leakage.

Concerning gender, while we did see a more significant percentage of males in the leak group (80% compared to 64%), this disparity did not reach statistical significance (p=0.075). This
result aligns with the findings of other studies, such as Frasson et al. (2015), which identified male gender as a risk factor in their nomogram. (3) Parthasarathy et al. (2017) established that male gender is a distinct risk factor for anastomotic leakage. Although the trend towards increased risk in males was not statistically significant in our analysis, it justifies additional research in bigger cohorts. (4) A meta-analysis by Qu et al. (2015) on 11 studies with 13,655 patients revealed no statistically significant correlation between gender and anastomotic leakage. (5)

Our investigation revealed a notable correlation between low intraoperative mean arterial pressure (<65 mmHg) and anastomotic leakage (90% in Group 1 compared to 52% in Group 2, p<0.001). This observation is consistent with the results reported by Sieda et al. (2019), who established intraoperative hypotension as a distinct risk factor for anastomotic leakage in emergency laparoscopic procedures. (6) Our study's findings align with those of van Rooijen et al. (2017), who observed a threefold rise in the incidence of anastomotic leaks in their analysis of 521 colorectal resections when intraoperative hypotension was present. (7) The high sensitivity (90%) but lower specificity (48%) of low mean arterial pressure (MAP) in our investigation indicates that although it successfully detects patients who are at risk of leaks, it may tend to overstate the danger in certain instances. Chernyshov et al. (2018) highlighted the need to maintain sufficient perfusion during surgery, identifying intraoperative blood loss and perioperative blood transfusion as significant risk factors for leakage. (8)

The results of our investigation revealed a statistically significant correlation between hyponatremia (Na <130 mEq/L) and anastomotic leaks (38% in Group 1 compared to 16% in Group 2, p=0.013). The results of Käser et al. (2014) support

the notion that hyponatremia can indicate anastomotic leakage following colorectal surgery, and their study included 196 patients. (9) Their findings indicated hyponatremia (<136 mmol/L) has a 92% specificity in predicting leakage. Our findings are consistent with those of Umemoto et al. (2020), who, in their study of 1,530 colorectal cancer procedures, identified preoperative hyponatremia as an independent risk factor for anastomotic leakage. ROC curve study revealed a relatively poor ability to detect hyponatremia (AUC 0.610, p=0.389), contradicting the results reported by Zhang et al. (2020). (10) By redefining hyponatremia with a higher sodium cutoff (139.5 mmol/L) in their study of 265 patients, they aimed to enhance its negative predictive value for leak identification.
A higher prevalence of elevated TLC levels (>11,000) was seen in individuals who experienced leaks (54% vs 28%, p=0.008). The results of Sieda et al. (2019) support the notion that an increased white blood cell count is a strong indicator of inflammation and can predict the occurrence of anastomotic leaks. (6) The findings of our study align with those of Cikot et al. (2019), who identified preoperative leukocytosis as a distinct risk factor for anastomotic leaks in their analysis of 1,090 colorectal cancer procedures. (11) The correlation between leukocytosis and leaks underscores the possible involvement of systemic inflammation in the failure of anastomosis.

A strong correlation was seen between elevated blood creatinine levels (>1.4) and anastomotic leaks in our study (48% vs 28%, p=0.039). The present discovery aligns with previous research that has shown renal impairment as a predisposing factor for postoperative complications, such as anastomotic leakage. Frasson et al. (2015) incorporated increased creatinine levels into their nomogram to predict the probability of anastomotic leakage. (3) In their analysis of 1,857 colorectal resections, Marinello et al. (2016) showed that preoperative renal insufficiency was a distinct risk factor for anastomotic leakage. The correlation could indicate, in general, patient weakness or reduced tissue blood flow, underscoring the need to optimize renal function before surgery, wherever feasible. (12)

Our results suggest a scoring system that includes specific criteria: low intraoperative mean arterial pressure (MAP) below 65 mmHg, hyponatremia with sodium levels below 130 mEq/L, low serum albumin levels below 2.7 g/dl, high total lipid content (TLC) above 11,000, high serum creatinine levels above 1.4, and low haemoglobin levels below 10.5 g/dl. This suggested system is consistent with other scoring systems established in the literature, such as the DULK score verified by Martín et al. (2015), which incorporates clinical and laboratory indicators. (13) The emphasis of our method on preoperative and intraoperative variables has the potential to enable earlier risk classification and therapeutic action. The incorporation of both inflammatory (TLC) and non-inflammatory (haemoglobin) indicators in our approach is substantiated by recent scholarly works, such as Ṛezáč et al. (2023), which underscored the need to integrate these categories of predicted variables. (14).

This study adopts a methodology akin to that of Arezzo et al. (2019), who created the REAL
(REctal Anastomotic Leak) score by conducting a meta-analysis of preoperative variables. (15)

The present study offers significant insights, yet it is essential to acknowledge certain limitations:
1. Our findings may not be generalizable to all groups or contexts. Multi-centre studies are required to further validate these findings across various patient populations and healthcare systems.
2. Although our study comprised 100 patients, more significant cohorts would provide more statistical power to construct and verify predicting models.
3. Although this emphasis yields meaningful data on a high-risk group, it restricts direct comparisons with research on elective procedures. A comparative analysis of risk factors in emergency and elective situations would benefit future studies.
4. Our study did not evaluate the long-term consequences of anastomotic leakage.

Conclusion-

The findings of our study have significant clinical significance. The authors advocate creating a risk categorization system for anastomotic leaks in emergency intestinal procedures. This system would guide surgical decision-making, enable informed choices for temporary diversion, and customize postoperative care approaches.

Therefore, our work enhances our comprehension of the danger of anastomotic leakage in emergencies and establishes a basis for creating guidelines based on empirical facts to reduce this risk. Through ongoing refinement of our approach to emergency bowel surgery, the knowledge acquired from this research provides a means to increase patient care and achieve better surgical results.

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Source of Funding- None

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