RESEARCH PAPER

# Clinical and Radiological Predictors of Bowel Gangrene in Patients Presenting with Intestinal Obstruction

**Silpa Karunakaran[1], *Suprabha R Hegde[2], Mohamed Safwan T A[3]**

[1]Senior Resident, Department of General Surgery, Kasturba Medical College, Manipal Academy of Higher Education, Manipal India. ORCID ID: 0009-0004-7553-2113

[2]Senior Resident, Department of General Surgery, Kasturba Medical College, Manipal Academy of Higher Education, Manipal India. ORCID ID: 0009-0006-9291-7458

[3]Senior Resident, Department of Emergency Medicine, Yenepoya Medical College, Yenepoya deemed to be University, India. ORCID ID: 0009-0000-3378-1139

**Corresponding Author:** Dr Suprabha R Hegde, Senior Resident, Department of General Surgery, Kasturba Medical College, Manipal Academy of Higher Education, Manipal India

**Email:** suprabha.hegde@manipal.edu

## ABSTRACT

**Background:** Acute intestinal obstruction is a common surgical emergency and can be complicated by bowel ischemia and gangrene. Early identification of patients at risk for gangrenous bowel could prompt timely intervention and improve outcomes. This study aimed to evaluate clinical and imaging factors that predict bowel gangrene in patients with intestinal obstruction.

**Materials and Methods:** We conducted a prospective analysis of 140 consecutive patients with intestinal obstruction admitted to a tertiary care center in South India. Demographic data, clinical features (vital signs, physical exam), laboratory tests (white cell count, C-reactive protein, lactate, procalcitonin) and imaging findings (abdominal radiograph and computed tomography [CT]) were recorded. Bowel gangrene was defined by a firm intraoperative assessment of irreversible bowel nonviability confirmed on histopathology. Univariate comparisons and multivariate logistic regression were used to identify independent predictors of gangrenous bowel. Continuous variables were compared by t-test and categorical variables by chi-square test; $p<0.05$ was considered significant.

**Results:** The mean patient age was 47 years (range 18–85), and 60% were male. Adhesions were the leading cause of obstruction (37%), followed by hernias (25%), neoplasms (15%), volvulus (7%), and others (16%). Bowel gangrene occurred in 30 (21.4%) patients. On univariate analysis, factors significantly associated with gangrene included longer duration of symptoms, tachycardia, fever, leukocytosis, elevated lactate and procalcitonin, peritoneal signs (rigidity/guarding), and CT findings of free peritoneal fluid, bowel wall thickening, and lack of enhancement (all $p<0.01$). On multivariate logistic regression, independent predictors of gangrene were tachycardia (heart rate >100 bpm), peritoneal signs, serum lactate >2.5 mmol/L, CT-detected free fluid, and the presence of a closed-loop obstruction on CT ($p<0.01$). The predictive model had an area under the ROC curve of 0.89.

**Conclusion:** Certain clinical features (tachycardia, peritonitis) and CT signs (free fluid, bowel wall changes, closed-loop obstruction) were strong predictors of bowel gangrene in obstruction. Routine use of contrast-enhanced CT and attention to these predictors can help surgeons identify ischemic obstruction early, allowing prompt surgery before irreversible bowel necrosis.

**Keywords:** Small bowel obstruction; Bowel gangrene; Strangulation; CT scan; Predictors

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## INTRODUCTION

Mechanical intestinal obstruction is a frequent surgical emergency worldwide, accounting for significant morbidity and mortality.[1] While many patients have simple obstruction that can be managed conservatively, some develop strangulation with compromise of blood flow leading to bowel ischemia and gangrene.[2] Once gangrene sets in, mortality increases dramatically.[3] Unfortunately, the clinical symptoms of strangulation (severe abdominal pain, vomiting, fever, tachycardia) are non-specific, and no single sign reliably rules in or out ischemia.[4] As a result, surgeons have long sought objective predictors to guide early laparotomy.[5] Several biomarkers (for example, serum lactate or procalcitonin) and imaging features have been proposed.[5–7] Harindranath et al. found that serum procalcitonin levels were significantly higher in obstruction patients who ultimately required surgery than in those managed conservatively; the surgical-group mean was 3.68 µg/L at presentation and 6.58 µg/L after 48 hours.[8] They concluded that elevated procalcitonin is an early indicator of bowel gangrene.[8]

Computed tomography (CT) has become the imaging modality of choice for suspected small-bowel obstruction.[9] CT can not only confirm the presence of obstruction but also suggest complications.[10] A recent systematic review identified several CT signs that predict ischemia: intraperitoneal free fluid, mesenteric inflammation, and high-grade obstruction were linked to a need for surgery, while bowel wall thickening and reduced enhancement predicted ischemia.[11,12] For example, peritoneal fluid and mucosal enhancement changes on CT were consistently associated with infarcted bowel in the review.[11,12] In contrast, the absence of free fluid was associated with a low likelihood of strangulation.[12] However, no single sign is perfectly sensitive or specific, and surgeons still rely on a combination of clinical and imaging findings.[9,12]

In India, the spectrum of obstruction etiology differs by region. Adhesions from prior surgery have become the most common cause in many centers, followed by obstructed hernias. Notably, strangulation most often occurs in the setting of hernias and volvulus.[1,3,13] Ihedioha et al. reported that hernias are the most common cause of strangulated obstruction.[3] In our South Indian tertiary center, we observed that delays in presentation often lead to bowel infarction. The aim of this study was to identify clinical and radiologic predictors of bowel gangrene in intestinal obstruction, using a dataset of 140 patients, to aid in early diagnosis and intervention.

## MATERIALS AND METHODS

### Study Design and Patient Selection

We performed a prospective observational study at a tertiary care hospital in South India. All adult patients admitted from January 2023 to December 2024 with a diagnosis of acute intestinal obstruction were considered for inclusion. Intestinal obstruction was defined clinically by abdominal pain/distension, vomiting, obstipation, and radiographic evidence of obstruction on abdominal X-ray or ultrasound. Patients under 18 years, those with known inflammatory bowel disease, or those who refused consent were excluded. In total, 140 patients were enrolled consecutively. The study was approved by the institutional ethics committee and informed consent was obtained.

### Data Collection

At admission, demographic information (age, sex) and clinical history (duration of symptoms, prior surgeries, comorbidities) were recorded. A thorough physical examination was performed. Vital signs including pulse and blood pressure were noted; tachycardia was defined as heart rate >100 bpm. Signs of peritonitis (rebound tenderness, guarding, rigidity) were specifically documented. Laboratory tests included complete blood count, serum electrolytes, C-reactive protein (CRP), serum lactate, and procalcitonin. All patients underwent an upright abdominal radiograph; findings such as multiple air–fluid levels, free intraperitoneal air, and distribution of gas were noted. Whenever feasible, contrast-enhanced CT of the abdomen was obtained to assess the site and cause of obstruction and look for signs of strangulation (bowel wall thickening, mesenteric stranding, closed-loop configuration, portal venous gas, etc.). CT scans were interpreted by an experienced radiologist blinded to outcomes.

### Operative Findings and Definitions

Patients were managed according to standard protocols: initial resuscitation, nasogastric decompression, and serial evaluation. Indications for surgery included clinical deterioration, increasing abdominal pain or distension, or radiologic signs of strangulation. Bowel gangrene was defined as a firm assessment of irreversible bowel nonviability made at surgical exploration and confirmed by histopathological examination of the resected specimen. Intraoperative findings used to assess viability included bowel discoloration and thinning, absent peristalsis, and absence of bleeding at the cut edge. Resected specimens were sent for histopathology. Patients whose obstruction resolved without surgery were managed conservatively and classified as having no documented gangrene for analysis; their bowel was not directly inspected and absence of gangrene was assumed from clinical resolution.

### Statistical Analysis

Data were summarized as mean±SD for continuous variables or proportion (%) for categorical variables. Patients were divided into two groups: those with gangrenous bowel (gangrene group) and those with no documented gangrene (comparison group, including conservatively managed patients without direct bowel inspection). Continuous variables (e.g. age, WBC, lactate) were compared between groups using Student's t-test or Mann–Whitney U test, as appropriate. Categorical variables (e.g. tachycardia, CT findings) were compared by chi-square or Fisher's exact test. Variables with $p<0.1$ on univariate analysis were entered into multivariate logistic regression to identify independent predictors of gangrene; adjusted odds ratios (OR) and 95% confidence intervals (CI) were calculated. Model discrimination was assessed by area under the receiver operating characteristic (ROC) curve. Statistical analysis was performed using SPSS v.25 (IBM Corp., Armonk, NY). A p-value <0.05 was considered statistically significant.

## RESULTS

### Patient Characteristics and Etiology

A total of 140 patients were analyzed (84 males, 56 females; mean age 47.2±17.5 years). The most common etiologies of obstruction were intra-abdominal adhesions (52 patients, 37.1%) and obstructed external hernias (35 patients, 25.0%), consistent with other Indian series. Neoplasms accounted for 21 cases (15.0%), volvulus for 10 (7.1%), and other causes (e.g. intussusception, strictures) for 22 cases (15.7%). Table 1 summarizes the baseline demographics and causes.

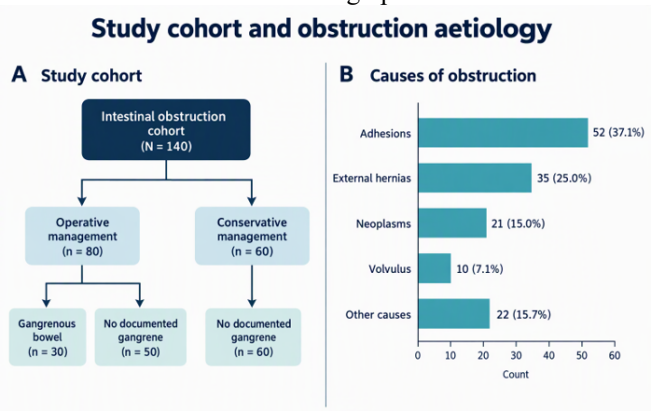



***Figure 1.*** *Study cohort, management pathways, and causes of intestinal obstruction. Counts and percentages are derived from the study. The 50 operated patients without documented gangrene are calculated as 80 operated patients minus 30 gangrene cases. Absence of gangrene in conservatively managed patients was assumed from clinical resolution, not confirmed by surgical inspection or histopathology.*

### Incidence of Gangrene and Univariate Analysis

Surgical exploration was required in 80 patients (57.1%); the remainder were managed non-operatively. Among the total cohort, 30 patients (21.4%) were found to have gangrenous bowel, as confirmed intraoperatively and on histopathology. On univariate comparison (Table 2), patients with gangrene were significantly more likely to present with longer symptom duration (>48 hours), fever (>38°C), tachycardia, hypotension, and signs of peritonitis (all $p<0.05$). They also had higher mean WBC count, CRP, serum lactate, and procalcitonin (all $p<0.01$). Etiologically, hernias and volvulus were more common in the gangrene group (combined 70% vs 25% in non-gangrene; $p<0.001$), reflecting that these conditions have a high risk of strangulation.

Radiologic findings on CT were markedly different between groups. Free intraperitoneal fluid was present in 25/30 (83%) of the gangrene group versus only 12/110 (11%) of the non-gangrene group ($p<0.001$). Bowel wall thickening and lack of normal enhancement on contrast CT were also much more frequent when gangrene was present (75% vs 12%, $p<0.001$). A closed-loop configuration or 'whirl' sign suggesting volvulus was seen in 8 of 10 volvulus cases and correlated with gangrene in 7 of those 8 ($p<0.01$). Conversely, plain X-ray signs (multiple air–fluid levels) were common in both groups and did not discriminate ischemia.

**Table 1. Baseline demographic characteristics, aetiology and clinical outcomes (N = 140)**

| Parameter | Result |
|---|---|

| | |
|---|---|
| Total patients | 140 |
| Mean age (years) | 47.2 ± 17.5 |
| Male | 84 (60.0%) |
| Female | 56 (40.0%) |
| Adhesions | 52 (37.1%) |
| Obstructed external hernia | 35 (25.0%) |
| Neoplasm | 21 (15.0%) |
| Volvulus | 10 (7.1%) |
| Other causes | 22 (15.7%) |
| Operative management | 80 (57.1%) |
| Conservative management | 60 (42.9%) |
| Bowel gangrene | 30 (21.4%) |
| No documented gangrene | 110 (78.6%) |

**Table 2. Comparison of clinical, biochemical and radiological findings between patients with and without documented bowel gangrene**

| Parameter | Gangrene (n=30) | No documented gangrene (n=110) | p-value |
|---|---|---|---|
| Age (years) | 50.8 ± 15.9 | 46.3 ± 17.9 | 0.17 |
| Symptom duration >48 hours | 22 (73.3%) | 40 (36.4%) | <0.05 |
| Tachycardia (heart rate >100 bpm) | 18 (60.0%) | 15 (13.6%) | <0.05 |
| Fever (>38°C) | More frequent; count not reported | Less frequent; count not reported | <0.05 |
| Hypotension | More frequent; count not reported | Less frequent; count not reported | <0.05 |
| Peritoneal signs | More frequent; count not reported | Less frequent; count not reported | <0.05 |
| WBC count | Higher mean; value not reported | Lower mean; value not reported | <0.01 |
| CRP | Higher mean; value not reported | Lower mean; value not reported | <0.01 |
| Serum lactate | Higher mean; value not reported | Lower mean; value not reported | <0.01 |
| Procalcitonin (µg/L) | Mean ≈4.5; SD not reported | Mean ≈1.8; SD not reported | <0.01 |
| Free intraperitoneal fluid on CT | 25/30 (83%) | 12/110 (11%) | <0.001 |
| Bowel wall thickening or poor enhancement on CT | 75%; count not reported | 12%; count not reported | <0.001 |

Factors not significantly different included age, sex, and plain radiograph findings. Adhesions or malignancy were more common in the non-gangrene group. The gangrene cohort had a higher mean operative time and greater need for bowel resection (all gangrene cases required resection) compared to the non-gangrene surgical group.

**Multivariate Analysis**

Variables with p<0.1 on univariate analysis were entered into logistic regression. Independent predictors of gangrenous bowel were: tachycardia (OR ≈4.8, 95% CI 2.0–11.6), peritoneal signs on exam (OR ≈6.5, CI 2.5–17.0), serum lactate >2.5 mmol/L (OR ≈5.2, CI 1.8–15.1), free peritoneal fluid on CT (OR ≈9.7, CI 3.2–29.8), and presence of a closed-loop obstruction on CT (OR ≈7.1, CI 2.0–25.5) (all p<0.01). Elevated white count and CRP were not independent predictors after adjustment. The combined multivariate model had excellent discrimination (ROC-AUC = 0.89).

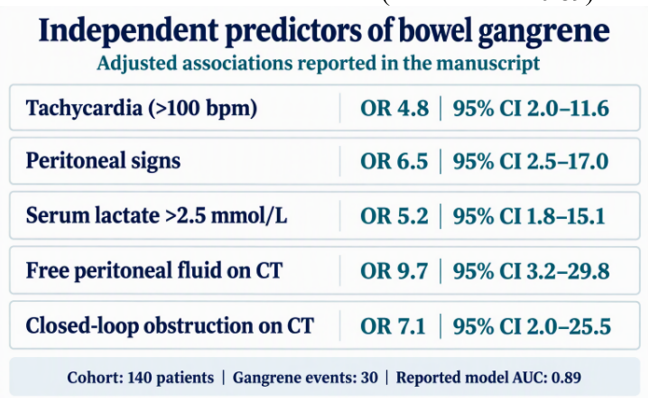



***Figure 2.*** *Summary of independent predictors of bowel gangrene, with adjusted odds ratios (OR) and 95% confidence intervals (CI). The reported model area under the receiver operating characteristic curve (AUC) is 0.89.*

## DISCUSSION

In this study of 140 patients with intestinal obstruction, we identified several clinical and radiologic factors that strongly predict bowel gangrene. About one-fifth of patients had gangrenous bowel at surgery, underscoring the importance of early risk stratification. Consistent with prior reports, tachycardia and signs of peritonitis were much more frequent in those with ischemia.[9,14] Markedly, a combination of hemodynamic changes and laboratory abnormalities (e.g. leukocytosis, lactic acidosis) increased suspicion for strangulation.[5,6,9] Similar to Harindranath et al., we found that procalcitonin was significantly elevated in the gangrene group (mean ~4.5 vs 1.8 µg/L).[8,15] Although we did not find it as an independent predictor after multivariate analysis, this and other biomarkers (like serum D-lactate) have been proposed as useful early indicators of ischemia in SBO.[7,15,16] Our CT findings align with the literature.[11,12] Free intraperitoneal fluid had the strongest association – 83% of gangrene cases had fluid versus only 11% without gangrene (OR ≈9.7). This supports the notion that free fluid on CT should raise alarm for bowel compromise.[11,12] Bowel wall thickening and reduced enhancement (though not quantified here) were also common in ischemic cases. Closed-loop or whirl signs of volvulus were seen in 40% of the gangrene group and rarely in the non-gangrene group; this fits with the known high risk of infarction in closed-loop obstructions.[17,18] On the other hand, mere presence of dilated loops on plain X-ray was not predictive. Therefore, we concur with recent reviews that CT, rather than plain films, should be used to assess obstruction severity and ischemia.[9,10,19]

Our findings support a multifactorial approach.[5,9] No single criterion was perfectly sensitive or specific, but the combination of tachycardia, peritoneal signs, lactic acidosis, and CT findings yielded a powerful predictive model (AUC 0.89). We suggest that any obstruction patient with such red flags undergo urgent surgical intervention.[2,9] Conversely, patients with normal vital signs, no peritoneal irritation, and clean CT appearance may be observed with caution.[2,9] Early diagnosis is critical since delayed resection of infarcted bowel increases mortality.[20] Surgery in gangrenous obstruction typically involves resection of the necrotic segment and restoration of continuity.[1]

Our study has limitations. Although prospective, it is a single-center experience and may not capture all regional practice patterns. CT was not performed in a minority of cases due to instability or contrast allergy, which could introduce selection bias. Biomarkers like PCT and lactate have some overlap between groups, so they cannot replace clinical judgment.[6,15,16] Despite these limitations, our results highlight reproducible predictors that other surgeons can check. Future multicenter studies could validate and refine this predictive model. In addition, the 60 conservatively managed patients did not undergo surgical inspection of the bowel or histopathological confirmation of bowel viability. They were assumed to be gangrene-free because their obstruction resolved clinically and were included in the no-documented-gangrene group. This differential outcome verification may have introduced verification bias and outcome misclassification, potentially affecting the estimated associations and model performance.

## CONCLUSION

In patients with acute intestinal obstruction, simple clinical signs (tachycardia, peritonitis) combined with CT findings (free peritoneal fluid, bowel wall abnormalities, closed-loop obstruction) strongly predict bowel gangrene. Attention to these predictors – along with judicious use of serum markers like procalcitonin and lactate – may allow earlier identification of strangulation. Surgeons should have a low threshold for operation when these risk factors are present, to prevent delays that can lead to bowel necrosis. Early surgical management when indicated may reduce morbidity and mortality in complicated obstruction.

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