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# Recognizing Predictors of Ischemic Bowel in Patients with Mechanical Acute Small Bowel Obstruction - A Retrospective Study

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## ABSTRACT

Early and precise diagnosis of bowel strangulation is the main focus of clinicians treating bowel obstructions due to the high morbidity and mortality rate associated with this disease. The objective of this study was to improve the therapeutic prognosis of

Small bowel obstruction (SBO) by identifying and assessing predictive factors independently associated with the presence of ischemia. A retrospective study was conducted in two hospitals in TAIF, Saudi Arabia, from January 2015 to January 2020.A total of 151 patients had retrieved from records. Study findings suggest that intestinal ischemia was considerably associated with tachycardia (>100 bpm), signs of peritoneal irritation, White blood cells (WBC) (×10^9/L) > 10.0, CRP (≥75 mg/l) and CT finding of thickened walled small bowel ≥3mm, Seroperitoneum> 500 ml, and Closed-loop obstruction. The study concluded that the presence of predictors clinically and by investigations in patients with mechanical SBO should alert the clinicians of underlying bowel ischemia and early diagnosis of patients who need surgical intervention, which ensures better therapeutic prognosis and patient outcomes.

**Key words:** Predictors, Bowel, Intestinal, Ischemia, Strangulation, Obstruction.

## 1. INTRODUCTION

Early and precise diagnosis of bowel strangulation is the main objective of clinician treating bowel obstructions, as it causes high morbidity and mortality rates in patients due to very difficult diagnosis (Takeuchi et al., 2004).

The main reason of strangulation is compromised blood supply to the affected area which is either reversible (i.e., the viability of the bowel is maintained if blood supply is regained after relief of obstruction) or irreversible (when bowel ischemia leads to trans-mural necrosis either obstruction relieved or not (Bazaz et al., 2017).

Strangulated obstruction characterized by intestinal necrosis is 9-38% among the cases of the intestinal obstruction (Paladino et al., 2014). SBO was responsible for about 15% of surgical admissions for acute non-traumatic abdominal pain, and so remains as major cause of morbidity (Mir et al., 2019). Different contributing factors of high mortality rate are late and challenging diagnosing and non-availability of accurate diagnostic instruments for evaluating bowel gangrene (Manjunath et al., 2019). Regardless of better understanding of the pathophysiology of the small bowel, it is still misdiagnosed most of the times (Dítě et al., 2003).

Initially, pain tends to be periodic and crampyin character. However, with bowel ischemia incidence, pain becomes constant. Other symptoms of strangulated obstruction include increased body temperature, tachycardia, localized abdominal tenderness, acidosis, and marked leukocytosis (Cappell & Batke, 2008). Simple intestinal obstruction can be differentiated from strangulated obstruction through lab and radiologic findings (especially CT scans; Cha et al., 2016).

The appropriate therapeutic management for SBO remains a key surgical issue. Most patients of SBO are treated successfully with conservative therapeutic regimen. However, some cases require appropriate surgical interventions to be taken in order to treat patients. Inability to perform surgical interventions will leads to increases mortality and morbidity (Diaz et al., 2008). Management plan typically includes initial resuscitation, confirmation of diagnosis through radiology testing, and either conservative or surgical management (Maung et al., 2012).

Surgery is difficult decision to take for patients who previously recovered with conservative therapy or who do not have clear indicative symptoms for surgery (Hajibandeh et al., 2017). However, the analysis of specific clinical factors for delayed operation is lacking. DeLay in removal of the necrotic tissues of the intestine may leads to severe outcomes. Besides, conservative treatment still considered as a discretionary treatment approach for a few patients with incomplete intestinal obstruction without necrosis (Manjunath et al., 2019).

Due to lack of diagnostic tools, there is a considerable risk of progression to irreversible ischemia especially in patients with suspected complete obstruction (Hayanga, 2005). Proper management of SBO requires a methodology to prevent unnecessary laparotomy, at the same time minimizing the chance of ignoring the obstructed strangulation which can cause intestinal ischemia.

### The aim of the study

The purpose of this study was to improve the therapeutic prognosis of SBO by identifying and assessing predictive factors independently associated with the presence of ischemia for the early detection of patients to establish appropriate early operative management.

## 2. MATERIALS AND METHODS

### Type of study and duration

A retrospective study was conducted in two hospitals in TAIF, Saudi Arabia, from January 2015 to January 2020.

**Study population**

Inclusion criteria; all patients aged more than 18 years old and presenting with acute SBO in the emergency departments were included in the study. Exclusion criteria; patients with a history of as cites, trauma, malignancy, suspected perforation, and a dynamic obstruction were excluded from the study.

We reviewed the baseline demographic data and the clinical features of all admitted patients (duration of symptoms, abdominal pain characteristics, presence of signs of peritoneal irritation, initial vital signs, and history of smoking, diabetes mellitus, and cardiovascular comorbidities) were noted down. Other data includes laboratory findings; C-reactive protein (CRP) and white blood cell count, radiological results based on radiologist reports, intraoperative findings, histopathology findings of removed necrotic samples, and the lengths of hospital stay were also collected and analyzed.

**Data collection**

A detailed data has been collected through retrospectively reviewing the medical records through a prepared performa. Patients in this study were grouped according to whether they managed non-operatively or needed operative intervention (which further classified into ischemic or non-ischemic groups), (Figure 1).

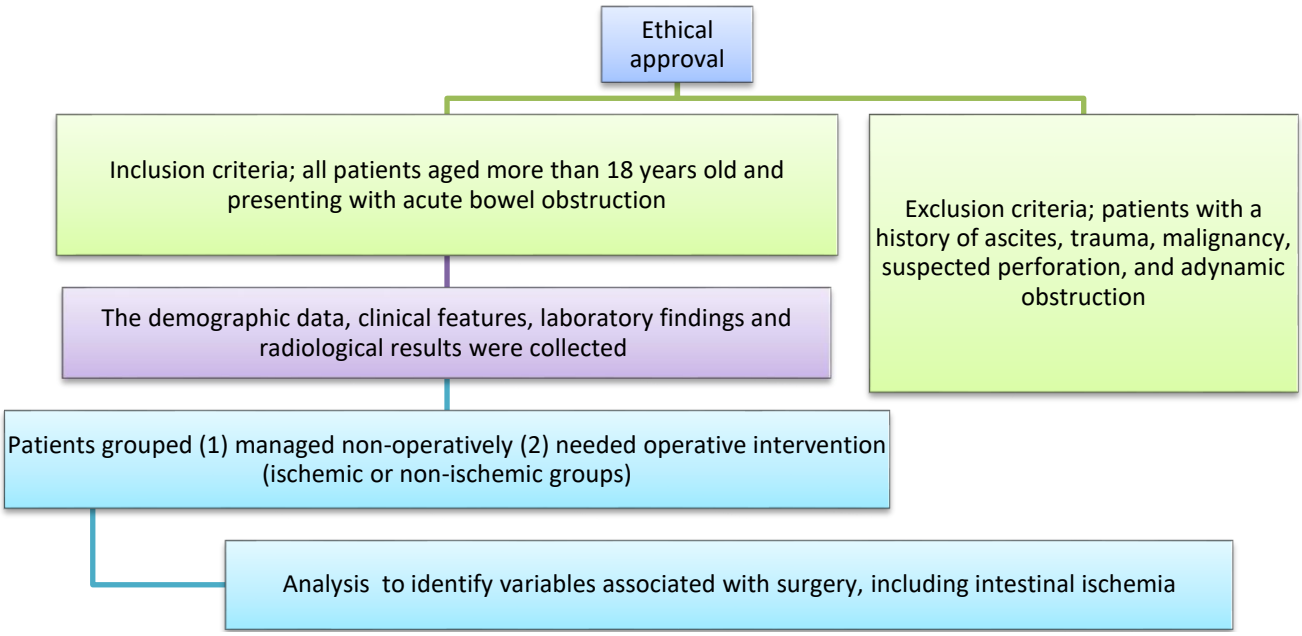


**Figure 1:** Flow chat for methodology of the study

**Statistical analyses**

Continuous variables were presented as mean ± SD and compared using a one-way analysis of various tests (ANOVA). Categorical variables were presented as number and percentage and compared using the X2 test. Logistic regression has been used to identify variables associated with surgery, including intestinal ischemia. All data were considered measurably significant at p-value <0.05. Statistical analysis was performed utilizing SPSS adaptation 24.0 programs for Windows (SPSS, Chicago, IL, USA).

## 3. RESULT

A total of 151 patients had retrieved from records, 11 of them had incomplete data required for the study are excluded. Fifty-three patients have successfully treated through conservative therapy. A total of 87 patients have undergone exploratory laparotomies. Out of them, 28 patients have confirmed intestinal ischemia with an incidence of 32.18%. There was no case of mortality in our series of collected data.

In this study, the most common cause of SBO in patients undergoing surgery included volvulus (11patients, 39.3%) in the ischemic group and adhesions (24 patients, 40.7%) in the non-ischemic group (Figure 2).

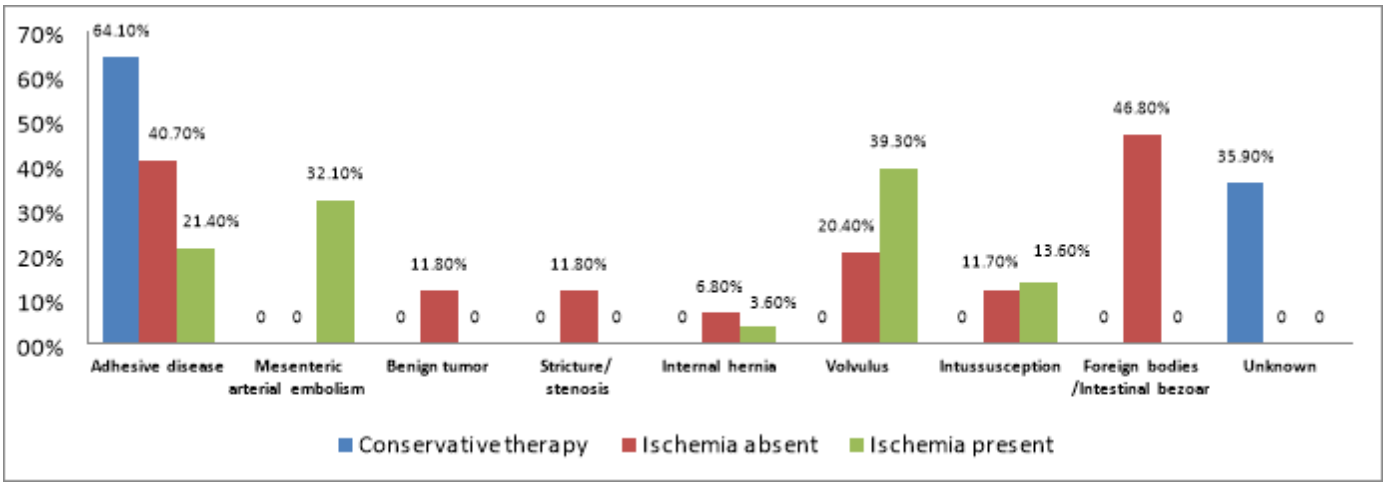


**Figure 2:** Etiologies of small intestinal obstruction in patients subjected to operation

**Table 1** Incidence of SBO according to gender

| Parameter | Conservative therapy (n = 53) | Ischemia absent (n = 59) | Ischemia present (n = 28) | P value |
|---|---|---|---|---|
| **Male** | 33 (62.3%) | 38 (64.4%) | 20 (71.4%) | 0.7 |
| **Female** | 20 (37.7%) | 21 (35.6%) | 8 (28.6%) | |
| **Age (mean** ± SD) | 45.3 ± 18.4 | 46.5 ± 13.6 | 59.8 ± 14.3 | 0.0001* |

Values are number (%).* Significant (p ≤0.05)

(Table 1) shows that the mean age in the conservative therapy groups was 45.3 ± 18.4 years, and the non-ischemic group was 46.5 ± 13.6 years while in the ischemic group was 59.8 ± 14.3 years, and the difference is statistically significant. According to gender, there was no statistically significant difference between the three study groups.

**Table 2** Various comorbidities and risk factors associated with disease

| Parameter | | Conservative (n = 53) | Ischemia absent (n = 59) | Ischemia present (n = 28) | P value |
|---|---|---|---|---|---|
| **Hypertension** | Yes | 16 (30.2%) | 24 (40.7%) | 15 (53.6%) | 0.1 |
| | No | 37 (69.8%) | 35 (59.3%) | 13 (46.4%) | |
| **Diabetes** | Yes | 13 (24.5%) | 11 (18.6%) | 10 (35.7%) | 0.2 |
| | No | 40 (75.5%) | 48 (81.4%) | 18 (64.3%) | |
| **Smoking** | Yes | 33 (62.3%) | 30 (50.9%) | 17 (60.7%) | 0.4 |
| | No | 20 (37.7%) | 29 (49.1%) | 11 (39.3%) | |
| **Previous Surgeries** | Yes | 38 (71.7%) | 30 (50.8%) | 8 (28.6%) | 0.001* |
| | No | 15 (28.3%) | 29 (49.2%) | 20 (71.4%) | |

Values are number (%).* Significant (p ≤0.05)

Common co-morbid conditions identified in this study were hypertension (55 patients) and diabetes mellitus (34 patients), but had no association with the incidence of the small intestinal ischemia. Seventeen patients out of 28 were smokers in the ischemia group, and 30 patients out of 59 were smokers in the non-ischemia group, and 33 patients out of 53 patents in the conservative therapy group were smokers with no significant difference between them. About 71.4 % of the ischemia group had no history of previous abdominal surgery (Table 2).

Regarding the clinical examination at admission, temperature ≥38 ˚C was reported in only four patients in the ischemic group and showed no association with ischemia (P = 0.9), while tachycardia was observed in 23 patients (82.2%) in that group which showed a strong association with ischemia (P = < 0.0001). In our study, continuous pain was present in 26 patients (92.9%) of the

ischemic group, ten patients (16.9%) of the non-ischemic group, and five patients (9.4%) of the conservative therapy group as compared to other patients who had colicky pain which proved a strong association with ischemia. While in our study, the duration of pain until admission was not statistically significant.

**Table 3** Association of ischemia with preoperative clinical variables

| Parameter | | Conservative therapy (n = 53) | Ischemia absent (n = 59) | Ischemia present (n = 28) | P value |
|---|---|---|---|---|---|
| **Fever (°C)** | ≥38 | 8 (15.1%) | 9 (15.3%) | 4 (14.3%) | 0.9 |
| | <38 | 45 (84.9%) | 50 (84.7%) | 24 (85.7%) | |
| **Tachycardia (>100 bpm)** | Present | 5(9.4%) | 9 (15.3%) | 23 (82.2%) | < 0.0001* |
| | Absent | 48(90.6%) | 50 (84.7%) | 5 (17.8%) | |
| **Type of pain** | Colicky | 48 (90.6%) | 49 (83.1%) | 2 (7.1%) | < 0.0001* |
| | Continuous | 5 (9.4%) | 10 (16.9%) | 26 (92.9%) | |
| **Pain duration (days)** | 1 | 21 (39.6%) | 21 (35.6%) | 13 (46.6%) | 0.6 |
| | 2-3 | 26 (49.1%) | 30 (50.8%) | 14 (50%) | |
| | 4-8 | 6 (11.3%) | 8 (13.6%) | 1 (3.5%) | |
| **Peritonism** | Present | 10 (18.9%) | 32 (54.2%) | 19 (67.9%) | 0.0001* |
| | Absent | 43 (81.1%) | 27 (45.8%) | 9 (32.1%) | |
| **Bowel sounds** | Sluggish | 26 (49.1%) | 14 (23.7%) | 22 (78.6%) | < 0.0001* |
| | Exaggerated | 27 (50.9%) | 45 (76.3%) | 6 (21.4%) | |

Values are number (%).* Significant (p ≤0.05)

The findings of suggested peritonism (guarding and rebound tenderness) were present in 19 patients (67.9%) in the ischemic group, while present in 32 (54.2%) and 10 (18.9%) of the non-ischemic group and the conservative therapy group respectively, showing a strong association of these finding with ischemia.

Bowel sounds in the present study were sluggish in 22 patients (78.6%) of the ischemic group, while present in 14 (23.7%) and 26 (49.1%) of the non-ischemic group and the conservative therapy group respectively. These findings showed a high association of sluggish bowel sounds with ischemia (Table 3).

**Table 4** Association of ischemia with investigation

| Parameter | | Conservative (n = 53) | Ischemia absent (n = 59) | Ischemia present (n = 28) | P value |
|---|---|---|---|---|---|
| **Leukocytosis (×109/l)** | <10 | 29 (54.7%) | 28 (47.45%) | 7 (25%) | 0.01 |
| | 10–15 | 17 (32.1%) | 21 (28.8%) | 9 (32.1%) | |
| | >15 | 7 (13.2%) | 10 (13.6%) | 12 (42.9%) | |
| **CRP (mg/l)** | 0–9 | 29 (54.7%) | 23 (39%) | 11 (39.3%) | 0.04 |
| | 10–74 | 19 (35.9%) | 25 (42.4%) | 8 (28.6%) | |
| | 75–470 | 5 (9.4%) | 11 (18.6%) | 9 (32.1%) | |

Values are number (%).

Table 4 showed that higher level of leukocytosis and CRP were present in patients of the ischemic group with a statistically significant difference with the other groups (P 0.01) and (P 0.04), respectively.

CT scans performed as part of the preoperative evaluation and the results of dilated bowel loops ≥ 40mm present in the three groups nearly with the same incidence percentage. In comparison, the results of thick-walled small bowel ≥ 3mm, seroperitoneum≥500, and closed-loop obstruction were found high in the ischemic groups than in the non-ischemic and conservative group (Table 5). Figure 3 showed a post contrast multidetector computed tomography (MDCT); axial, coronal, and sagittal images of a female patients presented in emergency department with symptoms and sign of acute intestinal obstruction, picture suggestive of small bowel loops obstruction (adhesive type).

**Table 5** Association of ischemia with investigation and CT findings

| CT parameter | | Conservative therapy (n = 53) | Ischemia absent (n = 59) | Ischemia present (n = 28) | P value |
|---|---|---|---|---|---|
| **Small bowel dilatation** | ≥ 40mm | 11 (20.7%) | 14 (23.7%) | 5(17.9%) | 0.8 |
| | < 40mm | 42 (79.3%) | 45 (76.3%) | 23 (82.1%) | |
| **Thick-walled small bowel** | ≥ 3mm | 4 (7.5%) | 17 (28.8%) | 9 (32.1%) | 0.007* |
| | < 3mm | 49 (92.5%) | 42 (71.2%) | 19 (67.9%) | |
| **Seroperitoneum** | ≥500 | 8 (15.1%) | 25 (42.4%) | 15(53.6%) | 0.001* |
| | <500 | 45 (84.9%) | 34 (57.6%) | 13(46.4%) | |
| **Closed loop obstruction** | Yes | 0 | 12 (20.3%) | 11 (39.3%) | 0.0001* |
| | No | 53(100%) | 47(79.7%) | 17 (60.7%) | |

Values are number (%).* Significant (p ≤0.05)

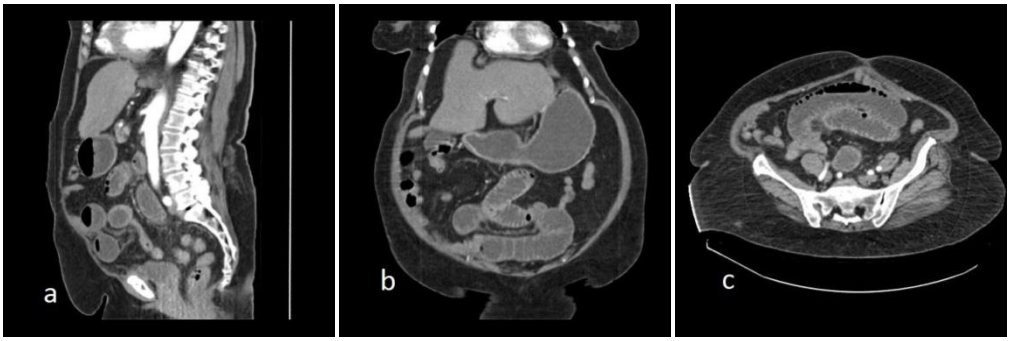


**Figure 3:** Post contrast MDCT images (a) sagittal, (b) coronal, and (c) axial, showed an area of abrupt changes of caliber of distal small intestine at lower abdomen with distention of proximal small bowel loops with average caliber of small intestine reaching about 3.5 cm.

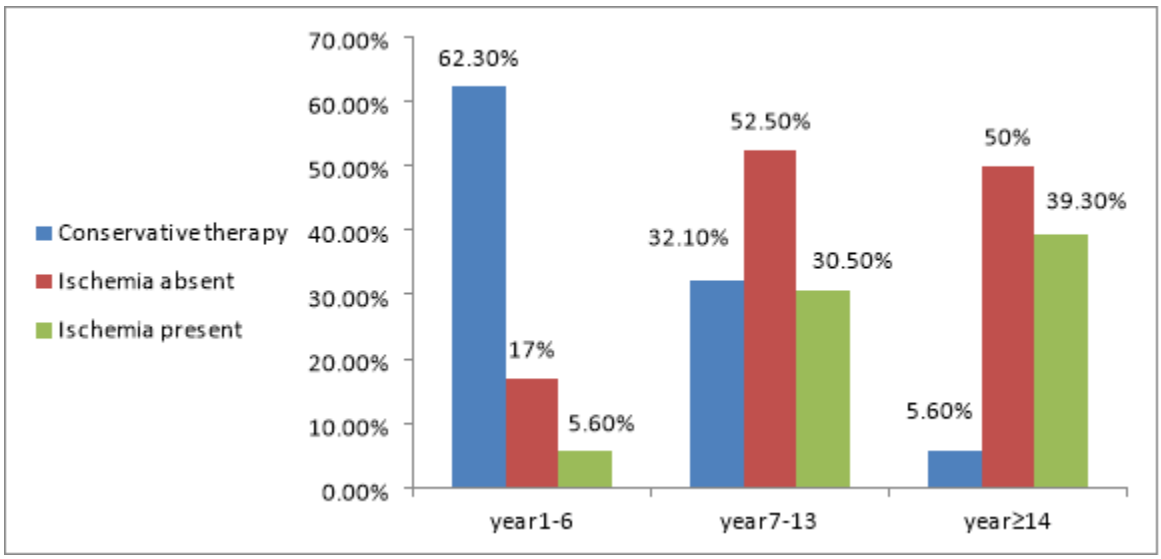


**Figure 4** Duration of hospital stay

There were statistically significant differences where the surgical patients were staying in the hospital for a longer duration than those treated conservatively (P < 0.0001) with the most extended hospital stay was in the ischemic group (83 days) (Figure 4).

**Table 6** Comparison of patients who underwent conservative treatment who had small bowel resection

| Variable | Odds ratio (95% CI) | P value |
|---|---|---|
| **Tachycardia (>100 bpm)** | 3.43 (1.5-8.9) | 0.002* |
| **Fever (>38°C)** | 3.1 (0.66-12.5) | 0.14 |
| **Guarding** | 20.8 (12.0-30.2) | 0.001* |
| **WBC (≥10 × 109/l)** | 4.15(2.4-7.6) | 0.001* |
| **CRP (≥75 mg/l)** | 7.08 (2.7-22.6) | 0.001* |
| **CT: Small bowel dilatation** | 2.7 (0.9-16.8) | 0.08 |
| **CT: Thick-walled small bowel** | 12.6 (7.7-38.6) | 0.001* |
| **CT: Seroperitoneum** | 15.05 (6.9-22.4) | 0.006* |
| **C.T: Closed loop obstruction** | 3.1 (1.7-15.1) | 0.02 |

Values are number (%).* Significant (p ≤0.05)

Comparison between conservative and surgical resection groups were used in the analysis of predictive factors of intestinal ischemia. Univariable logistic regression analysis confirmed that several clinical variables were significantly related with ischemia, which are increasing heart rate (>100 bpm), abdominal guarding, leukocyte count at least ten × 109/l, CRP level 75 mg/l or higher. CT scan findings were significantly more frequent in patients with intestinal ischemia, including thick-walled small bowel ≥3mm, sero-peritoneum at least 500 ml, and closed-loop obstruction (Table 6).

## 4. DISCUSSION

Intestinal strangulation has a clear association with intestinal necrosis and severe intra-peritoneal infection; therefore, timely diagnosis of intestinal strangulation is important for surgical decision making in patients presented with acute abdomen (DiSaverio et al., 2013; Strik et al., 2016).

The intestinal ischemia represents an urgent, life-threatening issue. Even the most intelligent clinicians are often unable to differentiate between strangulation and simple obstruction (Schwenter et al., 2010).

The precise diagnosis of intestinal necrosis is key factor. Clinical findings, such as continuous abdominal pain, fever, tachycardia, peritoneal irritation, increased WBC count, isolated abdominal mass, the sluggish bowel sounds, or hematochezia, may confirm the diagnosis of bowel necrosis. However, the results from a typical clinical examination usually lack detailed and precise information related to intestinal strangulation (Yang et al., 2015).

However, if the diagnosis obtained from clinical signs mentioned is late then it indicates severe and progressive disease. So, major issue for surgeons is to make interventions at the early stage of strangulated bowel obstruction to avoid the occurrence of intestinal necrosis or identify and treat bowel necrosis early when it happens unavoidably. Unfortunately, diagnostic tools are lacking that can predict or diagnose intestinal necrosis accurately (Boguševičius et al., 2007).

It has been reported that CT imaging is animportant modality for evaluating the cause of intestinal obstruction and for assessing whether an intestinal hemodynamic disorder is present or not. To precisely anticipate intestinal strangulation in acute SBO patients, specialists ought to combine and compare clinical data (symptoms and signs), laboratory and imaging investigations results(Millet et al., 2017).

Several studies have been carried out to find out predictive factor that can help in the proper management of SBO, but these studies focus mainly on clinical scenario. On the other hand, we tried in this study to identify the relevant clinical characteristics, including laboratory parameters, physical examination, and CT scans. Contributing factors including age, previous surgeries, smoking, tachycardia, type of pain, peritonism, bowel sounds, clinical variables, leukocytosis, CRP, thick-walled small bowel, seroperitoneum, closed-loop obstruction, duration of hospital stay had an additive effect and close monitoring of these factors could help to determine whether surgery is needed or not.

In contrast to our study, several previous studies found a significant correlation between intestinal ischemia and pain duration before admission (Schwenter et al.2010; Huang et al., 2018), and body temperature (Lo et al., 1966; Nandyala et al., 2016).This study

showed that heart rate >100 bpm is significantly associated with the occurrence of intestinal strangulation in cases of intestinal obstruction; these findings are in line with previous findings (DiSaverio et al., 2013; Strik et al., 2016).

Type of pain sometimes gives an indication to the diagnosis of intestinal ischemia. In this study, continuous pain as compared to colicky pain is strongly associated with intestinal ischemia. On examination, the findings of peritonism (guarding and rebound tenderness) and sluggish bowel sounds showed a strong association with intestinal ischemia. These finding were in line with results ofBazaz et al. (Bazaz et al., 2017). On laboratory evaluation, WBC> 10 × 109/l was a significant finding documented among patients presenting with strangulated small intestinal obstruction. Nandyala et al. reported the presence of leukocytosis in the conservative, surgical non-ischemic and ischemic groups, but it was significantly higher among patients with intestinal ischemia (Nandyala et al., 2016).

Dhoon et al. studied the mean WBC and there was significant difference in both conservative and ischemic groups. Also, Ajay K pal et al. found that the values of WBC were also higher in the strangulated bowel obstruction (Dhoon et al., 2019; Pal, et al., 2016).

A previous study by Ten Broek et al. emphasized the value of inflammatory markers such as CRP as predictors of intestinal ischemia in acute SBO (Ten et al., 2018).

In this study, the levels of CRP 75 mg/l or higher were markedly associated with intestinal ischemia, this finding was supported by the previous study by Demir et al. which was done to identify factors predicting the need for surgery identified that elevated CRP was markedly associated with bowel gangrene and signifying the need of surgery (Demir et al., 2012). Another study by Lin et al. for the evaluation of risk factors for intestinal gangrene identified that elevated serum CRP was associated with bowel gangrene (Lin et al., 2011).

Dhoon et al. and Ajay K pal et al. observed that serum values of CRP were markedly higher in patients with strangulated bowel obstruction as compared to simple bowel obstruction (Dhoon et al., 2019; Pal et al., 2016).

With the presence of MDCT there is a significant improvement in the determination of intestinal obstruction etiology. High specificity and sensitivity of CT scan in determination of strangulated small bowel obstruction (SSBO) were reported in various researches. One study reported some limitations of CT scans to diagnose strangulated smack bowel obstruction when conducted independently. It was also proposed that combining clinical and CT criteria could overcome majority of CT's inherent limitations (Kim et al., 2004).

In this study, we were evaluating the CT imaging importance in the diagnosis of intestinal ischemia in patients with SBO as we found bowel wall thickening ≥3mm, sero-peritoneum at least 500 ml, and closed-loop obstruction to be independently predictive of bowel ischemia. Similar to our study O'Leary et al. and Geffroy et al. noted that bowel wall thickening ≥3mm was related with intestinal ischemia(O'Leary, et al., 2016; Geffroy, et al., 2014). Also, a recent meta-analysis identified small bowel wall thickening ≥3mm as useful and highly associated with ischemic bowel (Millet et al., 2015).

Results by Matsushima et al. showed that presence of seroperitoneum as a CT finding significantly associated with intestinal strangulation (Matsushima et al., 2016),which are consistent with our study results, were at least 500 ml of seroperitoneum was essentially related with intestinal ischemia.

Our study also supported previous work done by Zielinski et al. and another study by O'Leary et al. where they found closed-loop obstruction to be markedly related with ischemic bowel (O'Leary et al., 2016; Zielinski et al., 2010).

In this study, we investigated the univariate analysis risk factors of bowel necrosis in patients with acute intestinal obstruction by analysis of the clinical symptoms, laboratory parameters, physical examination, and CT findings.

Intestinal ischemia was impressively related with tachycardia (>100 bpm), signs of peritoneal irritation, WBC (×10^9/L) > 10.0, CRP (≥75 mg/l) and CT finding of thickened walled small bowel ≥3mm, Seroperitoneum> 500 ml, and Closed-loop obstruction.

We detected that tachycardia (>100 bpm) has 3.4-fold increased risk of ischemic intestinal obstruction. Positive peritoneal irritation sign has 20.8 -fold increased risk of ischemic intestinal obstruction. WBC count > 10.0 × 10^9/L has 4.15-fold increased risk of ischemic intestinal obstruction. CRP (≥75 mg/l) has a 7.08 fold increased risk of ischemic intestinal obstruction.

Thickens of the small bowel wall ≥3mm in the CT finding was associated with more than 12.6 fold increased risk of ischemic intestinal obstruction. Also the presence of Seroperitoneum>500 ml on CT was associated with more than 15.05 -fold increased risk of ischemic intestinal obstruction. While the presence of volvulus on CT was associated with more than 3.1 -fold increased risk of ischemic intestinal obstruction.

This study has some limitations, such as being a retrospective study based mostly on data obtained from chart review, which may be limited or biased. We did not look for bowel wall enhancement, which may have been an important finding as CT scans with intravenous contrast not done for all patients. In any case, our consideration can give a conceivable approach to the issue of intestinal ischemia with acute intestinal obstruction.

## 5. CONCLUSION

In our study, we concluded that the presence of predictors clinically and by investigations in patients with mechanical SBO should alert the clinicians of underlying bowel ischemia and early diagnosis of patients who need surgical intervention, which ensures better therapeutic prognosis and patient outcomes.

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**Authors' Contributions**

Tamer M. Abdelrahman and Alaa E. Younes were responsible of conception and design of the study and approval of the final version of the manuscript.

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**Conflicts of Interest:** The author declares no conflicts of interests regarding the publication of this paper.

**Ethical approval**

The study was approved by the Medical Research Ethics Committee of Research and Studies Department-Directorate of Health Affairs Taif (ethical approval code: HAP-02-T-067).

**List of abbreviations**

SBO: Small bowel obstruction
SSBO: strangulated small bowel obstruction
CRP: C-reactive protein
WBC: White blood cells
MDCT: Multi-detector computed tomography

**Data and materials availability:** All data associated with this study are present in the paper.

**Peer-review:** External peer-review was done through double-blind method.

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