Published online 2022 February 20 **Original Article**

Evaluation of the Factors Related to Strangulation and Mortality in Patients with Incarcerated Abdominal Wall Hernias

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Received 2021 December 28; **Revised** 2022 January 22; **Accepted** 2022 January 28.

Abstract

Background: Patients with incarcerated abdominal wall hernias (AWHs) are often encountered in emergency care units. Despite advances in anesthesia, antisepsis, antibiotic therapy, and fluid therapy, the morbidity and mortality rates for these patients remain high.
Objectives: In this five-year study, the authors aimed at investigating the factors related to strangulation and mortality in patients who underwent urgent surgery for incarcerated abdominal wall hernias.
Methods: Participants of this study included patients referring to the emergency department with an incarcerated abdominal wall hernia (incisional, umbilical, femoral, or inguinal) between October 2015 and October 2019. The presence of intraoperative ischemia and necrosis was defined as "strangulation". Based on the presence or absence of strangulation in the incarcerated segment, patients were divided into two groups: Group 1 (non-strangulated) and Group 2 (strangulated). The following factors were determined with univariate and multivariate analyses between the two groups: length of time between incarceration and hospital admission, demographic characteristics and clinical data, physical examination findings, and risk factors for strangulation and mortality.
Results: A total of 161 patients were selected for this study. Group 1 consisted of 119 patients and Group 2 consisted of 42 patients. In multivariate analysis, the prominent risk factors for strangulation were: high American Society of Anesthesiologists score (P=0.008), acute abdomen findings with distension and elevated body temperature (P<0.001), delayed hospital admission (P<0.001), procalcitonin level of >0.5 ng/mL (P<0.001), D-Dimer level of >500 µg/L (P<0.001), lactate level of >2 mmol/L (P<0.001), and creatinine level of >2 mg/dl (P<0.001). The leading risk factors for mortality were the presence of strangulation (P<0.001), lactate level of >2 mg/dL (P=0.004), and ASA scores of >3 (P=0.035).
Conclusion: The most significant risk factors for strangulation were delay of more than 48 h in hospital admission, as well as high levels of procalcitonin, creatinine, lactate, and D-Dimer. On the other hand, significant risk factors for mortality were strangulation, as well as high lactate levels and ASA scores. Mortality rates may be lowered with an earlier diagnosis, more specifically, one made before the development of metabolic and radiologic impairment.

Keywords: Hernia, Incarceration, Morbidity, Mortality, Strangulation

1. Background

Surgery on abdominal wall hernias is one of the most frequently-performed general surgical operations worldwide. Incarceration and strangulation are the most serious complications since patients with these conditions constitute a significant proportion of patients operated in emergencies (1). In the literature, 5% to 13% of patients with abdominal wall hernias needed urgent surgery and 10% to 15% of the same type of patients needed intestinal resection due to necrosis (2).

Outcomes of the surgical repair of abdominal wall hernias have improved considerably in recent years due to the great advancements in anesthesiologic and surgical practices. However, despite the improvements in surgical techniques and the advancements in patient selection and perioperative care, urgent hernia surgery was still reported to be associated with high rates of morbidity and mortality. The rate of mortality was reported to be approximately 5% (3-5).

Treatment and prognosis of incarcerated hernias are closely related to the presence of bowel necrosis. Therefore, determination of the risk factors associated with strangulation is of paramount importance to preoperatively predict the outcomes in patients with an incarcerated hernia (6-7). Many parameters have been previously investigated in the literature to anticipate the risk of strangulation, including procalcitonin level, D-Dimer level, neutrophile/lymphocyte ratio, platelet-to-lymphocyte ratio, white blood cell (WBC) count, mean platelet volume, platelet distribution width, ischemia modified albumin measurements, and hyponatremia (8-14). Moreover, it is particularly essential to recognize factors that are related to mortality in incarcerated hernias to take precautions for preventing such factors.

2. Objectives

The present study, therefore, aimed to investigate the factors associated with strangulation and mortality in patients who underwent emergency surgery due to an incarcerated hernia over five years.

3. Methods

Participants of this study included patients operated on an incarcerated abdominal wall hernia (incisional, umbilical, femoral, or inguinal) between October 2015 and October 2019. They were selected for the study after obtaining the approval of the Ethical Committee for this research (2020/248). Patients under the age of 18, who had an epigastric, parastomal, or Spigelian hernia, as well as those with an unclear medical history, were excluded from the study. A database was created based on the hospital automation system, pathology and surgical operation reports, emergency follow-up cards, as well as observation charts from nurses. Postoperative mortality is defined as death within 30 days after a surgical operation.

Irreduction of external hernias was defined as "incarceration", and an non-irreducible hernia accompanied by objective symptoms of intraoperative ischemia and necrosis was defined as "strangulation." According to the presence or absence of strangulation in the incarcerated segment, patients were divided into two groups: Group 1 (non-strangulated) and Group 2 (strangulated).

In both groups, the following items were evaluated: demographic data, hernia types, length of time between incarceration and hospital admission (within 24 h, 24 to 48 h, 48 to72 h, 72 to 96 h, and 96 to 120 h), types of operation (primary repair, primary repair and mesh, resection and anastomosis, resection and stoma, resection, anastomosis and primary repair, resection, or stoma and primary repair), and American Society of Anesthesiologists (ASA) score. Single-dose, second-generation cephalosporin was used for antibacterial prophylaxis. Antibiotic use was extended to 5-7 days both when intestinal resection was performed due to confirmed necrosis and perforation, and in patients with severe surgical site contamination.

The WBC count, as well as the levels of C-reactive protein (CRP), procalcitonin, lactate, D-Dimer, and creatinine, were measured as laboratory markers. The vital parameters, as well as the findings of clinical and radiological examinations, were also included in statistical analyses.

3.1. Statistical Evaluation

The collected data was analyzed using SPSS (version 23.0, IBM Corp., Armonk, N.Y., USA). The data were summarized as mean±SD, median (min.–max.), the *n* number (sample size), and percentage (%). An independent Student's t-test was employed to compare continuous variables. Additionally, a Pearson's chi-squared test was used to compare categorical variables, and a logistic regression analysis was performed to identify the independent variables that affected the dependent variable. Moreover, a P-value of <0.05 was considered significant.

4. Results

A total of 161 patients were included in this study. Group 1 consisted of 119 patients and Group 2 consisted of 42 patients. Gender distribution was similar in both groups but the average age was higher in Group 2. Additionally, the inguinal hernia was the most commonly found hernia in both groups, and the number of patients who had an ASA score of 3 was higher in Group 2 (Table 1).

The length of time between incarceration and hospital admission was longer and tenderness, as well as distention during the abdominal examination, were more frequent in Group 2. Moreover, WBC counts, the levels of CRP, procalcitonin, lactate, D-Dimer, and creatinine, as well as body temperature, were significantly higher in Group 2. The presence of peritonitis was similar in both groups (Table 2). In the computed tomography (CT) examination, small bowel obstruction was higher in Group 2. However, the presence of bowel wall thickening (P=0.349), free air (P=0.414), free liquid (P=0.347), and pneumatosis intestinalis was similar in both groups (P=0.455) (Table 3).

Table 1. Demographic and clinical features

		Non-strangulated (n=119) n (%)	Strangulated (n=42) n (%)	P
Sex	Male	61 (51.3)	18 (42.9)	0.225
	Female	58 (48.7)	24 (57.1)	
Age		60.11±12.88 (21-83)	64.57±9.31 (45-80)	0.041
Hernia type	Femoral	16 (13.4)	10 (23.8)	0.424
	Inguinal	43 (36.1)	13 (31.0)	
	Incisional	27 (22.7)	10 (23.8)	
	Umbilical	33 (27.7)	9 (21.4)	
ASA score	1	11 (9.2)	0 (0.0)	0.029
	2	43 (36.1)	9 (21.4)	
	3	53 (44.5)	26 (61.9)	
	4	12 (10.1)	7 (16.7)	

ASA: American Society of Anesthesiologists

Table 2. Physical examination and laboratory features

	Non-strangulated (n=119) n (%)	Strangulated (n=42) n (%)	P
Length of time between incarceration and hospital admission (h)	37.11±16.45 (24-96)	65.71±21.89 (24-120)	<0.001
Temperature	36.87±0.59 (35.9-39.1)	37.78±0.60 (36.7-39.1)	<0.001
Abdominal Tenderness	64 (53.8)	36 (85.7)	<0.001
Distension	39 (32.8)	30 (71.4)	<0.001
Peritonitis Findings	4 (3.4)	1 (2.4)	0.610
WBC count (4.8-10.7/mm³)	10.62±2.27 (4.5-16.7)	14.48±2.86 (10.2-23)	<0.001
C-Reactive Protein (CRP) (0-5 mg/L)	18.13±14.28 (4-56)	45.62±28.61 (5-128)	<0.001
Procalcitonin (0-0.5 ng/mL)	0.52±0.25 (0.13-1.46)	1.05±0.38 (0.45-2.14)	<0.001
Lactate (0.4-2.2 mmol/L)	1.20±0.63 (0.2-2.9)	1.93±0.59 (0.6-3.0)	<0.001
D-Dimer (0-500 µg/L)	513.77±325.39 (200-2363)	867.74±382.35 (320-2054)	<0.001
Creatinine (0.5-1.2 mg/dL)	1.22±0.3 (0.4-1.9)	1.53±0.29 (0.9-2.1)	<0.001

Table 3. Radiologic findings

	Non-strangulated (n=119)	Strangulated (n=42)	P
Small Bowel Obstruction	86 (72.3)	37 (88.1)	0.027
Bowel Wall Thickening	10 (8.4)	2 (4.8)	0.349
Free Air	6 (5.0)	1 (2.4)	0.414
Free liquid	85 (71.4)	28 (66.7)	0.347
Pneumatosis intestinalis	1 (0.8)	1 (2.4)	0.455

The majority of patients with strangulated hernias underwent resection anastomosis and primary hernia repair. Postoperative complications were more frequent in Group 2 (P=0.01). The most common complication in both groups was wound infection. In addition, the postoperative mortality rate was higher in Group 2, and patients died most often due to septic causes and pulmonary embolism (Table 4).

In the univariate and multivariate analyses carried out for strangulation, significant risk factors were determined to be: delay in hospital admission, ASA score of ≥3, bicarbonate level of >22, CRP value of >5, increased procalcitonin level of >0.5, lactate level of >2, D-Dimer level of >500, body temperature of over 37.3˚C, and the presence of small bowel obstruction in the CT (Table 5). In the univariate and multivariate analyses carried out for mortality, significant risk factors were determined as delay in hospital admission, ASA score of ≥3, WBC count of >10,000, lactate level of >2, body temperature of over 37.3˚C, the presence of strangulation and small bowel obstruction in the CT (Table 6).

Table 4. Details of the operation and mortality rates

		Non-strangulated (n=119)	Strangulated (n=42)	P
Operation	Primary repair	49 (41.2%)	0 (0.0)	<0.001
	Primary repair+Mesh	70 (58.8%)	0 (0.0)	
	Resection+Anastomosis	0 (0.0)	10 (23.8%)	
	Resection+Anastomosis and primary repair	0 (0.0)	24 (57.1%)	
	Resection+Stoma	0 (0.0)	3 (7.1%)	
	Resection+Stoma and primary repair	0 (0.0)	5 (11.9%)	
Postoperative complications	No complications	90 (75.6%)	21 (50.0%)	<0.01
	Wound infection	10 (8.4%)	8 (19.0%)	
	Stoma complications	0 (0.0)	1 (2.4%)	
	Anastomotic leaks	0 (0.0)	2 (4.8%)	
	Pulmonary complications	8 (6.7%)	4 (9.5%)	
	Cardiac complications	7 (5.9%)	3 (7.1%)	
	Sepsis	4 (3.4%)	5 (11.9%)	
Mortality		1 (0.8%)	9 (21.4%)	<0.001
Cause of mortality	Sepsis	0 (0.0)	4 (44.4%)	0.300
	Myocardial infarction	1 (100.0%)	1 (11.1%)	
	Pulmonary embolism	0 (0.0)	3 (33.4%)	
	Decompensated heart failure	0 (0.0)	1 (11.1%)	

Table 5. Univariate and multivariate analysis of factors associated with strangulation

Measurements		Univariate	Multivariate	
		P	HR (95%-Cl)	P
Age	<65 ≥65	0.349	1.000 1.402 (0.960-2.849)	0.350
Sex	Female Male	0.359	1.000 1.308 (0.790-2.617)	0.353
Hernia type	Femoral Inguinal Incisional Umbilical	0.448	1.000 0.484 (0.177-1.321) 0.593 (0.203-1.732) 0.436 (0.148-1.286)	0.436 0.156 0.339 0.133
Length of time between incarceration and hospital admission (h)	<48 ≥48	<0.001	1.000 24.074 (5.562-104.209)	<0.001
ASA score	1-2 ≥3	0.006	1.000 3.046 (1.341-6.921)	0.008
WBC count	4<WBC<10 ≥10	0.862	1.000 2.773 (1.978-4.756)	0.997
CRP level	<5 ≥ 5	0.003	1.000 9.299 (1.213-71.300)	0.032
Procalcitonin level	<0.5 ≥ 0.5	<0.001	1.000 43.121 (5.743-323.768)	<0.001
Lactate level	<2 ≥2	<0.001	1.000 6.371 (2.918-13.911)	<0.001
D-dimer level	<500 ≥500	<0.001	1.000 11.000 (4.286-28.230)	<0.001
Creatinine Level	<1.2 ≥1.2	<0.001	1.000 6.148 (2.259-16.731)	<0.001
Temperature	<37.3 ≥37.3	<0.001	1.000 13.527 (5.841-31.327)	<0.001
Abdominal tenderness		<0.001	5.156 (2.021-13.152)	<0.001
Distension		<0.001	5.128 (2.372-11.089)	<0.001
Peritonitis		0.746	0.701 (0.076-6.457)	0.754
Small bowel obstruction		0.029	2.840 (1.028-7.847)	0.044
Bowel wall thickening		0.420	0.545 (0.114-2.596)	0.446
Free air		0,440	0.459 (0.054-3.931)	0.478
Free liquid		0,565	0.800 (0.376-1.702)	0.562
Pneumatosis intestinalis		0,468	2.878 (0.176-47.068)	0.458

ASA: American Society of Anesthesiologists, WBC: White Blood Cell, CRP: C-Reactive Protein

Table 6. Univariate and multivariate analysis of factors associated with mortality

Measurements		Univariate	Multivariate	
		P	HR (95%-Cl)	P
Age	<65 ≥65	0.226	1.000 0.378 (0.160-1.249)	0.317
Sex	Female Male	0.552	1.000 1.480 (0.402-5.457)	0.556
Hernia type	Femoral Inguinal Incisional Umbilical	0.450	1.000 0.679 (0.106-4.333) 1.455 (0.246-8.599) 0.293 (0.025-3.401)	0.513 0.682 0.679 0.326
Length of time between incarceration and hospital admission (h)	<48 ≥48	0.022	1.000 6.988 (0.864-56.548)	0.038
ASA score	1-2 ≥3	0.033	1.000 6.270 (0.774-50.754)	0.035
WBC count	4<WBC<10 ≥10	0.010	1.000 0.159 (0.120-1.124)	0.012
CRP level	<5 ≥5	0.074	1.000 1.212 (0.788-1.844)	0.102
Procalcitonin level	<0.5 ≥0.5	0.036	1.000 6.100 (0.753-49.387)	0.090
Lactate level	<2 ≥2	0.003	1.000 7.733 (1.899-31.496)	0.004
D-dimer level	<500 ≥500	0.155	1.000 2.629 (0.655-10.553)	0.173
Creatinine level	<1.2 ≥1.2	0.048	1.000 5.613 (0.693-45.464)	0.106
Temperature	<37.3 ≥37.3	0.011	1.000 5.515 (1.363-22.313)	0.017
Strangulation	No Yes	0.000	1.000 32.182 (3.934-263.256)	0.001
Abdominal tenderness		0.208	2.565 (0.526-12.499)	0.244
Distension		0.074	3.349 (0.834-13.459)	0.088

Table 6. Continued

Peritonitis	0.419	0.250 (0.080-1.317)	0.488
Small bowel obstruction	0.632	0.704 (0.173-2.867)	0.624
Bowel wall thickening	0.206	0.142 (0.075-0.456)	0.378
Free air	0.338	0.125 (0.058-0.752)	0.452
Free liquid	0.989	0.991 (0.245-4.004)	0.989
Pneumatosis intestinalis	0.083	16.667 (0.962-288.780)	0.053

ASA: American Society of Anesthesiologists, WBC: White Blood Cell, CRP: C-Reactive Protein

5. Discussion

Surgery for an incarcerated abdominal wall hernia encompasses a large proportion of operations with a high morbidity and mortality rate, which is generally performed under emergency conditions. Strangulation might develop upon disruption of blood flow in the intestines in incarcerated hernias, which leads to intestinal ischemia or necrosis. Intestinal ischemia and necrosis might be life-threatening; therefore, early detection of this situation is prominently important for planning surgery and a favorable outcome. Despite the advancements in anesthesia, antibiotic treatment, fluid replacement, and intensive care management, morbidity and mortality rates following a strangulated abdominal wall hernia surgery continue to be high (3-5).

It might be difficult to recognize strangulation in incarcerated hernia preoperatively. Previous studies showed that risk factors for strangulation include: femoral type hernias, peritonitis findings, high ASA scores, high D-Dimer levels, the presence of leukocytosis, high creatinine levels, skin changes, intestinal obstruction, and old age (9, 15). However, none of these parameters are sufficient to diagnose strangulation by itself. Therefore, it may be necessary to swiftly evaluate many parameters along with the physical and radiological findings of the patient. This study aimed to find a handful of parameters and findings that may be useful for an early and accurate diagnosis.

Delayed arrival at the hospital continues to be an important risk factor for strangulation. Kulah et al. (15) reported that the development of strangulation and necrosis was higher in patients who arrived at the hospital later than 48 h, compared to those who were hospitalized within the first 24 h of their symptoms. Patients who were hospitalized after more than 24 h following incarceration constituted 81.8% of death cases. Koizumi et al. (16) determined that the length of time before admission into the hospital was longer in patients who developed strangulation. The findings of the present study are in line with the results of previous literature in that the findings showed the length of time between the onset of symptoms and hospital admission was longer in patients with strangulated hernias, 65 and 37 h, respectively (P=0.00). A delay of more than 48 h increased the risk of strangulation and mortality by 24 and 7 times, respectively. Delayed arrival at the hospital might also lead to the appearance of physical examination findings in patients and abnormalities in laboratory values. The results of this study revealed high levels of lactate (P=0.00), D-dimer (P=0.00), procalcitonin (P=0.00), creatinine (P=0.00), and CRP (P=0.00), as well as elevated WBC counts (P=0.00), were associated with strangulation.

Old age was reported to be another factor that affects morbidity and mortality in incarcerated abdominal hernia operations (1). Martínez-Serrano et al. (3) stated that old age affects morbidity and mortality in incarcerated abdominal wall hernia cases. Similarly, Ozkan et al. (1) reported that old age affects morbidity (P<0.001) and mortality (P<0.005). In their study, 85.2% of patients with morbidity were ≥65 years old, and all patients with mortality were ≥65 years old. Additionally, a high ASA score (3-4) and coexisting diseases were observed to be other factors affecting mortality and morbidity (1). Their findings also showed morbidity (P<0.001) and mortality (P=0.029) rates of patients with an ASA score of 3-4 were higher. In the present study, the majority of patients with strangulation had an ASA score of 3-4, which was an independent risk factor for strangulation and mortality. Based on the findings of the present study, age was a risk factor for strangulation; however, contrary to the findings of previous literature, being over the age of 65 was not determined as a risk factor for strangulation and mortality in this study. This nonsignificant relationship between age and mortality may be related to the low number of patients aged >65 years and to the relatively high number of elderly patients without any comorbidity in the present study.

The connection between hernia type and strangulation has been examined in many studies in the literature. Strangulation has been more frequently encountered in hernias, which are difficult to diagnose, the necks of which are narrow. Kurt et al. (17) reported that strangulation that requires bowel resection was more common in epigastric and femoral hernias than in incisional, umbilical, and inguinal hernias (P=0.008 and P=0.038, respectively). Ozkan et al. (1) found the rate of intestinal resection associated with strangulation and necrosis to be higher in femoral hernias than in other types of hernia (P<0.005 and P<0.001, respectively). However, a significant effect of hernia type on mortality and morbidity has not been shown; there are some studies which show that there is not a significant relationship between strangulation and

the hernia type (18). In the present study, cases of strangulation were distributed evenly among hernia types, and in line with previous findings, hernia type was not found as a risk factor for strangulation.

Although many laboratory parameters may be used to predict the risk of strangulation and mortality, physical examination and radiological investigations are still the mainstay of the diagnosis; even skin changes such as erythema and induration may be signs of intestinal ischemia (9). Physical examination findings should raise doubts about underlying necrosis. In the present study, the presence of abdominal tenderness and distension, accompanied by high body temperature, elevated pulse rate, and the presence of small bowel obstruction on plain X-ray were closely related to strangulation. When these clinical and laboratory parameters are present, strangulation with necrosis is more likely and the surgeon must be aware of the possibility of the contaminated abdomen and the necessity of bowel resection.

One of the most important drawbacks of this study is its retrospective nature. However, this study has several advantages, including a high number of patients, heterogeneous design, statistical evaluation of many parameters, as well as the selection of participants from almost every emergency unit with regards to their relations to strangulation and mortality.

6. Conclusion

The predictors for strangulation and mortality are almost identical in incarcerated hernia patients. While the length of time between incarceration and hospital admission, high ASA score, and lactate levels may lead to strangulation and eventually death. Therefore, prehospital preventive strategies and a high index of suspicion need to be developed by caregivers to prevent strangulation for these patients since strangulation is the main factor for death.

Acknowledgments

None.

Footnotes

Conflicts of Interest: The authors declare no conflict of interests.

Authors' contributions: Ugur Topal wrote the paper and reviewed the literature. Fatih Dal collected data and drafted tables. Tutkun Talih collected and interpreted the data. Erdogan Sozuer, Hizir Akyildiz, and Muhammet Akyuz made final revisions and gave the final style to the paper. Hizir Akyildiz conceived and designed the study. All authors have approved the final version of the manuscript.

Ethical Approval: This study was approved by the Ethics Committee of Faculty of Medicine, Erciyes University, Melikgazi, Kayseri, Turkey on 20.05.2020, numbered as 2020/248.

Funding/Support: The authors declared that this case has received no financial support.

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