Int Surg 2015;**100:**96–100
DOI: 10.9738/INTSURG-D-14-00186.1

A Novel Bowel Necrosis Classification System and Examination of Patient Outcomes in Incarcerated Groin Hernia Patients

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The objective of this study was to determine a classification system for BN in incarcerated groin hernia patients and to explore the possible relationship between BN staging and patient outcomes. Incarcerated groin hernia patients treated with emergency bowel resection from January 2008 to December 2013 were screened for inclusion in a prospective study. A novel three-stage classification system was proposed for BN (BN stages I–III) and correlations between adverse events (AEs) and mortality with BN stage were determined. A total of 108 patients were included, with 71, 26, and 11 patients in BN stages I, II, and III, respectively. AEs, which included wound and intra-abdominal infections and other systemic complications, increased with higher BN stage (all $P < 0.05$). Mortality increased with BN stage, with 2.8%, 7.7%, and 27.3% at BN stages I, II, and III, respectively ($P < 0.05$). The proposed BN staging system can objectively reflect the degree of bowel damage and its corresponding adverse outcomes.

Key words: Groin hernia – Incarceration – Intestinal necrosis – Prognosis

Incarcerated hernia is a common emergency, with a risk of increasing bowel necrosis (BN) and necessitating emergency interventions. In fact, for irreversible BN, the BN degree changes with increasing necrosis time. The bowel wall can transform from having a normal morphology to being cracked and perforated. The surgical field can transform from contamination to infection. The patient can present with bowel obstruction, peritonitis, systemic shock, and even death. Therefore, the prognosis is different with increasing BN degree, and its corresponding management is different as well. There is no standardized system for grading BN severity or guiding appropriate interventions. Thus, there is a critical need in clinical practice for a grading system designed to assess BN degrees, such as those in groin hernia patients, and to ultimately

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Table 1 A novel three-stage BN classification system

Stage	Incarceration time (h)[a]	Bowel function	Description of bowel wall	Description of hernia sac	Peritonitis	Mechanical obstruction	Systemic shock
I	4–12	Intact	Purplish black bowel color with intact morphology	Complete without congestion/ inflammation, yellow/ dark red extrudates	No	No	No
II	≥12–36	Mild impairment	Loss of normal bowel form, with collapse or cracking	Complete with congested and swollen walls, mixed intestinal juice/ necrotic tissues	Yes	Yes	No
III	≥36	Severe impairment	Bowel cracked and without form	Incomplete, festering/ cracking/perforation, with purulent liquid	Yes	Yes	Yes

[a]Incarceration time (symptom onset to surgery) is considered the primary determinant of BN stage, with confirmation by clinical and morphologic parameters.

offer clinical guidance for the selection of appropriate management and estimating prognosis.

We hypothesize that the grade of BN might reflect the degree of necrosis. Thus, the current study was designed to establish a preliminary classification system for BN in incarcerated groin hernia patients based on the severity of groin hernias, and to analyze the relationship between patient outcomes and BN staging. Ultimately, this study aimed to expand and facilitate the organization of the body of work pertaining to prognosis of patients surgically treated for incarcerated hernia and bowel resection.

Materials and Methods

Study design

A prospective study was conducted with consecutive adult patients with incarcerated groin hernias who underwent emergency surgery at the Department of General Surgery, Qilu Hospital of Shandong University (PR China), from January 2008 to December 2013. The study protocol was approved by the Institutional Review Board.

Patients

Patients were included who (1) were of adult age (>18 years); (2) were admitted for emergency care because of unilateral groin hernia; (3) were diagnosed with incarcerated groin hernia; (4) had irreversible BN; and (5) were treated with simultaneous hernia repair and bowel resection. Patients were excluded who (1) had a previous history of groin infection or severe dysfunction; (2) exhibited no infarction or other contents (*e.g.*, omentum) during surgical exploration; (3) exhibited any other significant comorbidity, malignancy, or suspected malignancy that could have an impact on patient outcomes. All of the included patients underwent repair by using an open approach with primary sutures under epidural anesthesia.

Bowel condition assessments

Patient bowel viability was assessed visually at the time of surgery. We used the following four criteria to assess irreversible BN: (1) the intestinal wall was purplish black and/or had collapsed; (2) the intestinal wall lost tension and peristalsis ability or had paralytic expansion without shrinkage following stimulus; (3) the disappearance of pulsation of the corresponding terminal mesenteric artery; and (4) the application of hot compress with isotonic saline gauze or 5% procaine for vascular closure at mesenteric root (10–30 minutes) failed to produce improvement. If the bowel wall had cracked without form or the hernia sac filled with purulent liquid or fragments, it could be definitely defined as BN.

Novel classification of BN stage

The BN degree was exacerbated with elapsed time, and its corresponding local and systemic signs changed. Based on our clinical observations and the consensus reached by collaborating experienced surgeons at our facility, a novel classification system for BN (BN stage) was the development with grades from least to most severe, as I, II, or III (Table 1). Staging was determined based on incarceration time (4–12, ≥12–36, or ≥36 hours), bowel function, qualitative assessment of bowel morphology (*i.e.*, color and anatomic structure) and hernia sac (*i.e.*,

Table 2 Patient outcomes by BN stage

Outcome parameter	Total no. of patients (n = 108)	Stage I, no. (%) (n = 71)	Stage II, no. (%) (n = 26)	Stage III, no. (%) (n = 11)	*P* value
Adverse events	55				
Wound infection	12	4 (5.6)	4 (15.4)	4 (36.3)	0.008
Seroma or hematoma	5	2 (2.8)	2 (7.7)	1 (9.1)	0.455
Intra-abdominal infection	8	3 (4.2)	2 (7.7)	3 (27.3)	0.025
Anastomotic leak and bleeding	9	4 (5.6)	3 (11.5)	2 (18.2)	0.298
Other systemic complications	21	10 (14.1)	6 (23.1)	5 (45.5)	0.043
Mortality	7	2 (2.8)	2 (7.7)	3 (27.3)	0.009

completeness and extrudate character), peritonitis, mechanical obstruction, and systemic shock.

Outcomes

Adverse events (AEs) were recorded, including postoperative wound and abdominal complications [*i.e.*, wound infection, seroma or hematoma, intra-abdominal infection (or abscess), anastomotic leak, and bleeding] and other systemic complications (*i.e.*, pneumonia, upper gastrointestinal bleeding, disseminated intravascular coagulation, sepsis, organ failure, etc). Mortality was determined by the number of deaths within 30 days of surgery, and no exclusions were made for cause of death (all deaths were assumed to be treatment related).

Statistical analysis

Categoric variables were compared by Pearson χ^2 test. All analyses were performed with SPSS v.17.0. (SPSS, Inc, Chicago, Illinois). *P* values less than 0.05 were considered statistically significant ($P < 0.05$).

Results

Observations in BN stage classification of included patients

A total of 108 patients ranging in age from 19 to 86 years (n = 108; male-female, 87:21; mean age, 51.4 ± 14.6 years) met all criteria for inclusion, with varying lengths of necrosis time. With increasing time (higher BN stage), intestinal morphology was observed to become progressively more obscured. Furthermore, with increasing BN stage, the contents of the hernia sac progressively became darkly colored and purulent liquid and, in some advanced cases, solid fragments of liquid and necrotic tissues (pus within the sac). And the patients progressively experienced mechanical obstruction, obvious peritonitis, and systemic shock. For necrosis within 4 to 12 hours of incarceration (BN stage I), exudates were yellow or dark red, the hernia sac was complete, the bowel was purplish black but with complete morphology, and there were no signs of peritonitis. This necrotic area increased progressively with BN stage. Progressively larger resection areas were required for patients with higher BN stage. Notably, no significant differences were observed in BN stage III patients, indicating that progression of the necrotic area reaches a maximum rate near 36 hours and slows thereafter.

BN stage of included patients and outcomes by BN stage

These 108 patients were grouped as BN stage I (n = 71), BN stage II (n = 26), or BN stage III (n = 11). A total of 55 AEs (50.9%) and 7 deaths (6.5%) were registered in the included patients. AEs included 12 cases of wound infection (11.1%), 5 cases of seroma or hematoma (4.6%), 8 cases of intra-abdominal infection (or abscess; 7.4%), 9 cases of anastomotic leak and bleeding (8.3%), and 21 cases of other systemic complications (19.4%), with AE occurrence varying by BN stage (Table 2). Wound and intra-abdominal infections and other systemic complications were the most common AEs. Wound infection occurred at significantly different rates of 5.6%, 15.4%, and 36.3% for BN stages I, II, and III, respectively, with severity of infection increasing with increasing BN stage ($\chi^2 = 9.740$; $P = 0.008$). Intra-abdominal infection increased significantly with BN stage, from 4.2% at BN stage I to 7.7% at BN stage II and 27.3% at BN stage III ($\chi^2 = 7.380$; $P = 0.025$). Other systemic complications occurred at significantly different rates of 14.1%, 23.1%, and 45.5% for BN stages I, II, and III, respectively ($\chi^2 = 6.272$; $P = 0.043$). Overall, mortality increased significantly with BN stage, from 2.8% at BN stage I to 7.7% at BN stage II and 27.3% at BN stage III ($\chi^2 = 9.481$; $P = 0.009$).

Discussion

By applying the proposed novel three-classification BN staging system (I–III) in adult incarcerated groin hernia patients, the current study was able to demonstrate that higher BN stage was linked to greater mortality (2.8%, 7.7%, and 27.3% mortality at BN stages I, II, and III, respectively) and increased most AE occurrences, including higher infection rates. Because the primary determinant of the proposed BN staging system was incarceration time, these results also have implications for the importance of early intervention before irreversible BN occurs. Using BN stage, clinicians may be able to more effectively make prognostic determinations prior to surgery based on incarceration time, and additionally use perioperative morphologic and clinical assessments to indicate prognosis and survival during the acute 30-day period following surgery. This study links more extensive BN with poor prognosis, highlighting the importance of BN prevention.

It has been reported that up to 15% of patients with incarcerated inguinal hernia develop BN requiring surgical resection.[1,2] Incarceration time has been consistently reported as a central determinant of BN risk, with Kurt *et al*[1] reporting that hospital admission >6 hours after symptom onset was associated with larger necrotic areas requiring much more extensive resection. Similarly, Atila *et al*[3] reported that symptoms lasting for >6 hours often resulted in large resection areas and more severe complications. Although no formal study has been completed previously, it has been our experience that even within this 6-hour window, many patients still required extensive resection. Thus, the current BN staging system was designed with incarceration time as a primary determinant, verified by perioperative morphology and clinical signs. Furthermore, a larger window of 4 to 12 hours was used as BN stage I because of the potentially high risk for BN even before 6 hours.

A useful indicator of BN is peritonitis, which has also been reported to indicate the extent of bowel resection and may be linked to the response to infection in herniated tissues.[3] For patients exhibiting BN stages II and III, infection in the surgical field is a central issue, as infection can potentially spread if care is not taken in resecting infected tissues. Furthermore, much larger resection areas are generally required as the extent of infection increases, and autogenous flaps may sometimes be required in severe cases.[4] In general, later hospital admission time increased the extent of infection and BN in groin hernia patients, increasing the rate of AEs and mortality, consistent with previous studies.[1,2,5]

As expected, BN stage also corresponded with increased bowel obstruction and anatomic abnormality, which may further complicate surgery when the bowel is cracked and clear bacterial activity is observed in the wound. Wound infection was a common complication of incarcerated hernia with BN, and often led to repair failure and recurrence.[6–8] However, with the aggravation of BN, the wound and abdominal infections increased. There is no consensus yet with regard to the use of prosthesis in the emergency management of incarcerated hernia with a bowel resection.[9,10] In fact, all of the current reports of successful mesh repair lack the analysis of local pollution. Therefore, further study should be made to select appropriate repair methods according to different BN stages.

Furthermore, staging for other bowel conditions, particularly malignancies,[11] has resulted in a great wealth of documentation on disease-related change in bowel function and habits. Thus, it may be possible to gain more detailed prognostic information using detailed bowel function information, although this hypothesis has yet to be explored. In addition, some attempts have been made to develop staging systems for necrotizing enterocolitis in infants, including a symptom-based three-stage system that includes stage I characterized by apnea, bradycardia, abdominal distension, vomiting, and lethargy; stage II characterized by increasing symptom severity and radiologic pneumatosis intestinalis; and stage III characterized by low blood pressure, bradycardia, acidosis, disseminated intravascular coagulation, and anuria [12]. The benefits and limitations of these classification systems may be useful in improving the proposed BN staging system for adults with BN due to incarcerated groin hernia.

In adult patients with incarcerated groin hernias, a novel BN staging system was applied to successfully group patients by BN extent, and morbidity and mortality risk, demonstrating that BN stage I patients had a much lower mortality risk and lower wound and abdominal infection rates, as well as a lower occurrence of systemic complications occurrence than BN stage II or III patients. These findings stress the critical importance of early diagnosis and surgical treatment in patients with suspected BN, which may rapidly progress over only 36 hours. Extensive BN was a significant predictor of poor prognosis. Thus, the proposed BN staging system may serve the dual purpose of raising clinician and

patient awareness of the need for prevention and early treatment of suspected BN in groin hernia patients and providing a useful, if preliminary, tool for prognostic prediction and evaluation.

References

1. Kurt N, Oncel M, Ozkan Z, Bingul S. Risk and outcome of bowel resection in patients with incarcerated groin hernias: retrospective study. *World J Surg* 2003;**27**(6):741–743
2. Oishi SN, Page CP, Schwesinger WH. Complicated presentations of groin hernias. *Am J Surg* 1991;**162**(6):568–570; discussion 571
3. Atila K, Guler S, Inal A, Sokmen S, Karademir S, Bora S. Prosthetic repair of acutely incarcerated groin hernias: a prospective clinical observational cohort study. *Langenbecks Arch Surg* 2010;**395**(5):563–568
4. Szczerba SR, Dumanian GA. Definitive surgical treatment of infected or exposed ventral hernia mesh. *Ann Surg* 2003;**237**(3): 437–441
5. Bendavid R, Abrahamson J, Arregui ME, Flament JB. *Abdominal Wall Hernias: Principles and Management*. New York, NY: Springer-Verlag, 2001
6. Kulah B, Duzgun AP, Moran M, Kulacoglu IH, Ozmen MM, Coskun F. Emergency hernia repairs in elderly patients. *Am J Surg* 2001;**182**(5):455–459
7. Iannitti DA, Hope WW, Norton HJ, Lincourt AE, Millikan K, Fenoglio ME. Technique and outcomes of abdominal incisional hernia repair using a synthetic composite mesh: a report of 455 cases. *J Am Coll Surg* 2008;**206**(1):83–88
8. Cassar K, Munro A. Surgical treatment of incisional hernia. *Br J Surg* 2002;**89**(5):534–545
9. Campanelli G, Nicolosi FM, Pettinari D, Contessini Avesani E. Prosthetic repair, intestinal resection, and potentially contaminated areas: safe and feasible? *Hernia* 2004;**8**(3):190–192
10. Alvarez JA, Baldonedo RF, Bear IG, Solı's JA, Alvarez P, Jorge JI. Incarcerated groin hernias in adults: presentation and outcome. *Hernia* 2004;**8**(2):121–126
11. Saidi HS, Karuri D, Nyaim EO. Correlation of clinical data, anatomical site and disease stage in colorectal cancer. *East Afr Med J* 2008;**85**(6):259–262
12. Marino BS, Fine KS. *Blueprints Pediatrics*. Philadelphia, PA: Lippincott Williams and Wilkins, 2008