Predictors of outcome in penetrating gastric injuries

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Abstract

Introduction: Both solid and hollow organs are open to injury in penetrating abdominal trauma. Morbidity and mortality related to gastric injury in penetrating abdominal trauma are uncommon. Isolated gastric injuries occur less frequently.

Aim: To examine the morbidity associated with penetrating gastric injuries.

Material and methods: Data for 45 patients collected between 2000 and 2010 were analyzed retrospectively. The patients were grouped as those with isolated gastric injuries and those with concomitant organ injuries, and then grouped according to the presence of complications. Logistic regression was used to determine the independent predictors of morbidity following gastric injury.

Results: The sample comprised 40 males (88.9%) and 5 females (11.1%), with a mean age of 28.56 ±11.66 (range 15–75) years. The mechanism of injury was stab wounds in 26 patients and gunshot wounds in the remainder. Mortality was 8.9% (4/45 patients). The forward stepwise binary logistic regression analysis of the results revealed three risk variables: 2 patient measures (injury severity score and number of injured intra-abdominal organs) and the mechanism of injury. The odds ratios and confidence intervals for the three variables were 3.74 (2.40–5.83), 3.41 (1.60–7.28), and 3.00 (1.96–4.59), respectively.

Conclusions: We identified the risk factors for morbidity in penetrating gastric injuries using a binary logistic model.

Introduction

Penetrating trauma to the stomach is more common than blunt trauma [1]. Gastric injuries occur in 7–20% of patients with penetrating abdominal trauma, and are usually accompanied by injuries to other organs [2–7]. Isolated gastric injuries occur less frequently [3, 8].

Morbidity and mortality related to gastric injury in penetrating abdominal trauma are infrequent, occurring in 6% and 0.4% of patients, respectively. Morbidity and mortality in patients with gastric injury are usually the result of associated injuries [3].

Aim

This study evaluated the factors resulting in the morbidity of penetrating gastric injury using a binary logistic model.

Material and methods

Forty-five patients with penetrating abdominal trauma treated at the General Surgery Department of Dicle University Medical School between January 2005 and December 2010 were evaluated retrospectively. The age and sex of the patients, causes of injury, occurrence and duration of shock, length of hospital stay (LOS), intra-abdominal organ injuries, injuries of associated systems, injury severity score (ISS), treatment methods, and causes of morbidity and mortality were recorded for each patient using pre-prepared forms. The patients were divided into two groups: group 1 comprised isolated gastric injuries and group 2 consisted of patients with gastric injuries accompanied by injuries to other abdominal organs. Subsequently, the patients were divided into those with and without complications. They were compared in terms of age, sex, cause of injury, preoperative time, hypotension, ISS, and LOS.

All patients underwent fluid resuscitation on admission. The hemodynamic status was determined using the heart rate and systolic blood pressure on admission. Patients with a heart rate < 100 beats per minute and a systolic blood pressure > 90 mm Hg were defined as hemodynamically stable, whereas those with a heart

rate > 100 beats per minute and systolic blood pressure < 90 mm Hg were defined as unstable. All patients were resuscitated in the emergency room. Patients who were hemodynamically unstable despite resuscitation underwent rapid laparotomies without further diagnostic tests, whereas consultations and the necessary tests related to concomitant injuries were carried out in those who were hemodynamically stable. Stable patients who were observed to have an intact peritoneum during local wound exploration were simply observed. All gunshot wounds (GSWs) in the stomach area were operated on, whereas the indications for surgery in stab wounds were the presence of omentum or organ evisceration, hypovolemic shock (systolic blood pressure < 90 mm Hg, heart rate > 100 beats/min), acute abdominal findings on physical examination, and positive results of local wound exploration, laboratory tests, and radiological examinations. Patients who were managed conservatively after penetrating abdominal trauma and those who underwent explorative laparotomies or damage-control surgery were excluded from the study. Preoperatively, all patients underwent a detailed physical examination, complete blood count, anteroposterior chest X-ray, and direct abdominal X-ray in the standing position. The ISS was used to grade the severity of the injury, according to the description by Van Nata et al. [9].

Statistical analysis

All continuous variables are presented as means and standard deviations, and all categorical variables are presented as numbers of patients and percentages. The medians of the two groups were compared using the Mann-Whitney U-test. Categorical variables were analyzed using Fisher's exact test or the χ^2 test. Binary logistic regression analysis was performed to obtain the risk ratios (odds ratios) of predictors of morbidity. A forward stepwise procedure was performed for the binary logistic regression. For all statistical analyses, $p \leq 0.05$ was considered significant. The SPSS software was used to perform all statistical analyses (ver. 15.0; SPSS Inc., Chicago, IL, USA).

Results

In total, 968 patients underwent various surgical procedures because of penetrating abdominal trauma at the General Surgery Department of Dicle University Medical School between January 2005 and December 2010. Of these, 45 (4.64%) had gastric injuries.

Table I. Clinical characteristics of 45 patients with penetrating gastric trauma

Gender (M/F)	40/5
Age, $\bar{x} \pm$ SD, range [years]	28.56 ±11.66, 15–75
Mechanism of injury, n (%)	
GSW	19 (42.2)
SW	26 (57.8)
Localization, n (%)	
Anterior	26 (57.8)
Anterior-posterior	19 (42.2)
Presurgery time, $\bar{x} \pm$ SD, range [h]	2.16 ±1.02, 1–5
Systolic blood pressure, n (%)	
Stable	42 (93.3)
Unstabil	3 (6.7)
Shock, n (%)	3 (6.7)
Hemoglobin, n (%) [mg/dl]	
> 10	41 (91.1)
< 10	4 (8.9)
ISS, $\bar{x} \pm$ SD, range	9.87 ±6.43, 4–25
Complication, n (%)	
Present	12 (26.7)
Absent	33 (73.3)
The average length of hospital stay, $\bar{x} \pm$ SD, range [days]	10.78 ±5.76 (0–28)
Mortality, n (%)	4 (8.9)

Table II. Frequency of the additional organ injuries injury in group II patients treated for penetrating gastric injury

Intraabdominal	No. of patients	Percentage
Duodenum	2	5
Small bowel	9	22.5
Colon	7	17.5
Liver	5	12.5
Spleen	4	10
Pancreas	1	2.5
Gallbladder	2	5
Kidney	2	5
Bladder	2	5
Diaphragm	4	10
Major vessels	2	5
Extraabdominal	**No. of patients**	**%**
Head-neck	1	10
Chest	4	40
Upper extremity	1	10
Lower extremity	1	10
Pelvic fracture	3	30

Table III. Distribution and statistical comparison of group properties

Parameter	Group 1	Group 2	Value of p
Gender, n (%)			NS
Female	0	5 (19.2)	
Male	19 (100)	21 (80.8)	
Age, $\bar{x}$ ± SD, range [years]	30.11 ±16.18, 15–75	27.42 ±6.91, 15–40	NS
Presurgery time, $\bar{x}$ ± SD, range [h]	2.32 ±1.16, 1–5	2.04 ±0.91, 1–4	NS
Systolic blood pressure, n (%)			NS
Stable	19 (100)	23 (88.5)	
Unstable	–	3 (11.5)	
Mechanism of injury, n (%)			0.002
GSW	3 (15.8)	16 (61.5)	
SW	16 (84.2)	10 (38.5)	
Localization			0.014
Anterior	15 (78.9)	11 (42.3)	
Anterior-posterior	4 (21.1)	15 (57.7)	
Shock, n (%)	–	3 (11.3)	NS
Duration of shock [h]:			NS
0–1	–	3 (11.5)	
2–3	–	1 (3.8)	
Hemoglobin level:			
Normal	18 (94.7)	23 (88.5)	NS
Low	1 (5.3)	3 (11.5)	
ISS, $\bar{x}$ ± SD, range	5.63 ±3.53, 4–16	12.96 ±6.35, 4–25	< 0.001
Complication, n (%)	2 (10.5)	10 (38.50)	0.036
LOS, $\bar{x}$ ± SD, range [days]	8.37 ±4.62, 5–25	12.53 ±5.94	0.015
Number of complication, $\bar{x}$ ± SD	0.11 ±0.32	0.77 ±1.07	0.023
Mortality, n (%)	–	4 (15.38)	NS

Group 1 – isolated injury to the stomach, group 2 – associated with abdominal organ injury, ISS – injury severity score, GSW – gunshot wound, SW – stab wound, LOS – length of hospital stay, NS – not significant

Of the patients with gastric injury, 40 (89%) were male and 5 (11%) were female, with a mean age of 28.56 ±11.66 (range 15–75) years. Gunshot wounds caused 42.2% of the penetrating gastric injuries. Anterior wall injuries were found in 26 patients (57.8%). Complications were identified in 12 patients. The mean ISS was 9.87 ±6.43 (range 4–25). The mortality rate was 8.9% (n = 4). The general characteristics of the patients are summarized in Table I.

The most commonly associated injured intra-abdominal organs were the small bowel (22.5%) and colon (17.5%), and the most commonly associated injured extra-abdominal organs were the chest (40%) and pelvis (30%). The distribution of additional organ injuries is presented in Table II.

Patients with additional organ injuries were classified as group 2. The sample comprised 19 (42.2%) pa-

Table IV. Distribution of the complications

Complications	Group I (n = 19)	Group II (n = 26)
Intra-abdominal abscess	1	2
Wound infection	2	8
Atelectasis	1	3
Pneumonia	None	2
Empyema	None	2
Sepsis	None	1
Multi-organ failure	None	1
Total	4	19

tients in group 1 and 26 (57.8%) patients in group 2. Sex, age, time before surgery, shock, and duration of shock did not differ significantly between the two groups (p > 0.05). The mechanism of injury (MI), location, ISS,

Table V. Distribution and statistical comparison of group with complication or without complication

Parameter	With complication	Without complication	Value of p
Gender			0.109
Female, n (%)	3 (25)	2 (6)	
Male (%)	9 (75)	31 (94)	
Age, $\bar{x} \pm$ SD, range [years]	24.91 ±7.31, 15–40	29.87 ±12.72, 15–75	0.211
Presurgery time, $\bar{x} \pm$ SD, range [h]	2.00 ±0.95, 1–3	2.21 ±1.05, 1–5	0.544
Systolic blood pressure, n (%)			1.00
Stable	11 (91.6)	31 (94)	
Unstable	1 (8.4)	2 (6)	
Mechanism of injury, n (%)			0.045
GSW	8 (66.6)	11 (33.4)	
SW	4 (33.4)	22 (66.6)	
Localization, n (%)			1.00
Anterior	7 (58.3)	19 (57.6)	
Anterior-posterior	5 (41.7)	14 (42.4)	
Shock, n (%)			
Present	11 (91.6)	31 (94)	1.00
Absent	1 (8.4)	2 (6)	
Hemoglobin level, n (%)			
Normal	11 (91.6)	30 (91)	NS (1.00)
Low	1 (8.4)	3 (9)	
ISS, $\bar{x} \pm$ SD, range	14.33 ±5.89, 9–25	8.24 ±5.90, 4–25	0.004
LOS, $\bar{x} \pm$ SD, range [days]	17.66 ±4.81, 12–28	8.27 ±3.65, 0–17	< 0.001
Group, n (%)			
I	2 (16.6)	17 (51.52)	0.036
II	10 (83.34)	16 (48.48)	
Mortality, n (%)			
Yes	2 (16.66)	31 (94)	NS (0.286)
No	10 (83.34)	2 (6)	
Extra-abdominal organ injury, n (%)			0.448
Present	4 (33.34)	7 (21.21)	
Absent	8 (66.66)	26 (78.79)	
NIO, $\bar{x} \pm$ SD, range	1.66 ±0.98, 0–3	0.5 ±0.75, 0–3	< 0.001

Group 1 – isolated injury to the stomach, group 2 – associated with abdominal organ injury, ISS – injury severity score, GSW – gunshot wound, SW – stab wound, LOS – length of hospital stay, NS – not significant, NIO – number of intra-abdominal injured organs

Table VI. The outcomes of logistic regression

Variable	β	SE	Odds	95% CI	Wald	Value of p
ISS	1.321	0.226	3.74	2.40–5.83	34.16	< 0.001
NIO	1.229	0.386	3.41	1.60–7.28	10.13	< 0.001
MI	1.100	0.217	3.00	1.96–4.59	25.69	< 0.001

β – coefficient regression, SE – standard error, Odds – odds coefficient, 95% CI – confidence interval predicted at the 95%, Wald – the value of Wald statistics, p – the level significant, NIO – number of intra-abdominal injured organs, MI – the mechanism of injury, ISS – injury severity score

complications, and LOS differed significantly between the groups ($p < 0.05$). The two groups are summarized in Table III. As shown in Table III, the complication rates differed significantly between groups 1 and 2 (16.6% vs. 83.34%; $p = 0.036$). The most frequent complication was wound infection. The distribution of the complications is shown in Table IV.

As Table V shows, GSW, ISS, group, LOS, extra-abdominal organ injury, and number of intra-abdominal injured organs (NIO) were significantly higher in patients with complications ($p < 0.05$).

The outcome of the logistic regression model is presented Table VI, which shows that ISS, NIO, and MI were significant predictors of morbidity ($p < 0.001$). The odds ratios and 95% confidence intervals of these three variables were 3.74 (2.40–5.83), 3.41 (1.60–7.28), and 3.00 (1.96–4.59), respectively.

Discussion

Both solid and hollow organs are open to injury in penetrating abdominal trauma. The most frequently injured solid organ is the liver (19%), and the most frequently injured hollow organ is the small intestine (30%). These organs are closely followed by the colon (18%), stomach (7–20%), pancreas, and duodenum [5, 8, 10–12]. Isolated gastric injuries due to abdominal trauma are rare; gastric injuries are usually accompanied by abdominal or extra-abdominal organ injuries [7, 10, 13]. As in our study, the most frequently reported accompanying injured abdominal organs are the small intestine and colon, and the most frequently injured extra-abdominal organs are the lungs and pelvis [14].

Although gastric injuries most frequently involve the anterior wall (40%), they may also be observed in the greater curvature (23%), lesser curvature (15%), posterior wall (15%), gastroesophageal junction (7%), and pylorus (7%) [15–18]. All of our patients had anterior gastric wall injuries, and 42.2% also had posterior wall injuries. Therefore, when an injury to any part of the stomach wall is detected, a detailed intraoperative exploration should be performed to rule out injuries to other parts of the gastric wall [1, 19–21]. The morbidity rate in gastric injuries related to penetrating trauma is approximately 6%. The position of the stomach within the abdomen, thickness of its wall, rich arterial supply, and its low bacterial content have been suggested as reasons for the low morbidity rate [3, 8, 20, 22].

The MI influences morbidity [7, 10]. In our study, the MI was also an important predictor of morbidity due to the high-energy nature of GSWs, the organ damage frequently accompanying the injury, and the fact that these are usually multiple injuries.

The ISS, which we used as a trauma score, was a predictor identified in our study. The ISS is the scoring system most commonly applied to patients with trauma involving more than one organ. Most studies have demonstrated a good correlation between survival and the ISS [23]. Mortality significantly parallels an increase in the ISS [24]. The ISS is usually low in gastric injuries caused by penetrating trauma [10]. In our patients, the mean ISS differed significantly between those with and without complications and between those with and without mortality ($p < 0.05$; Figure 1).

The ISS assesses the single organ with the highest score among the intra-abdominal organs injured [25]. However, the method does not supply information on the number of injured organs, which we found to predict morbidity. A greater degree of hemorrhage, higher risk for intra-abdominal contamination, or higher ISS might be among the factors leading to this outcome [26].

Mortality is significantly higher in trauma patients older than 50 years, even in the absence of concomitant disease. However, 78% of all deaths between the ages of 15 and 24 years are due to trauma [27]. In our study, most patients with penetrating gastric trauma were young adult males, concurring with the findings of previous reports [14, 28]. Similarly, age and sex were not associated with the outcome of penetrating gastric injury in this study.

In gastric injuries related to penetrating trauma, an early diagnosis is the most important step to minimize morbidity and mortality. The diagnosis can be based on vital signs, clinical presentation, physical examination, plain-film chest X-ray (signs of pneumoperitoneum), abdominal ultrasound, computed tomography, laparoscopy, or exploratory laparotomy. The clinical presentation of gastric injuries usually involves abdominal pain, peritoneal irritation, or findings related to the concomitant organ injuries [15, 17].
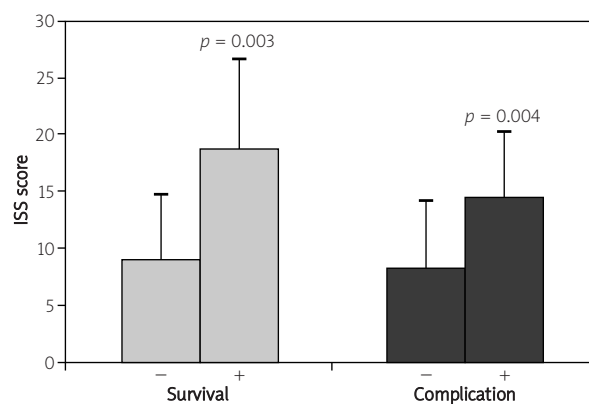

Fig. 1. The mean ($\bar{x}$) and standard deviation (SD) of survival and non-survival, complication and non-complication of ISS values

The reported mortality rates range from 0.4% to 17%, reflecting the variety in presentation [3, 8, 19]. Isolated gastric injuries are rare and are associated with low morbidity and mortality rates [3, 10]. In this study, no mortality was observed in patients with isolated gastric injuries and all four patients who died had concomitant organ injuries; however, this difference in mortality between the two groups was not significant.

Although primary repair with debridement of the wound edges is adequate for stab wounds and low-velocity GSWs due to the thick muscle layer of the stomach and its rich arterial supply, larger injuries may occur to the stomach in high-velocity GSWs due to the shock-wave phenomenon. Such injuries may require more extensive debridement or a partial gastrectomy [1, 3, 8, 14, 29, 30]. In addition, care must be taken regarding postoperative strictures in injuries to the gastroesophageal junction or pylorus. All patients in our study underwent primary repairs and no stricture developed in any patient.

Conclusions

Isolated gastric injuries can be treated with a low complication rate. In our series, ISS, NIO, and MI predicted the development of complications due to penetrating gastric injury based on logistic regression analysis.

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