SAJS
General Surgery

Gastric trauma: A straightforward injury, but no room for complacency

T. E. MADIBA, M.B. CH.B., M.MED. (CHIR.), PH.D., F.C.S. (S.A.)
M. HLOPHE, M.B. CH.B.
Department of Surgery, University of KwaZulu-Natal and King Edward VIII Hospital, Durban

Summary

Background. Injuries to the stomach are common following abdominal trauma, and there are few management controversies. This study was undertaken to document experience with the management of gastric injuries in a single surgical ward in a tertiary institution.

Patients and methods. This prospective study was of a cohort of all patients found at laparotomy to have gastric injuries, over a 7-year period (1998 - 2004). Demographic data, clinical presentation, findings at laparotomy, and outcomes were documented. Prophylactic antibiotics were given at induction of anaesthesia. All patients found to have gastric injuries were given antifungal therapy.

Results. Of the 488 patients undergoing laparotomy for abdominal trauma over this period, 99 (20%) were found to have gastric injuries, of whom 6 were female (M:F ratio 14:1). The mean age (± standard deviation (SD)) was 28.9±11.1 years. Mean delay before surgery was 7.6±5.2 hours. Seventeen patients presented in shock. Injury mechanisms were firearms (52), stabbing (43) and blunt trauma (4). The mean injury severity score (ISS) was 13.6±7.4. Forty-two patients required management in the intensive care unit (ICU), with a mean ICU stay of 4.7±4.6 hours. Twenty-nine patients developed complications, and 14 died. There was only 1 gastric injury-related complication. Causes of death were multiple organ dysfunction syndrome (MODS) (8) and hypovolaemic shock (4), septic shock (1) and renal failure (1). Patients presenting in shock had a significantly higher mortality than those without shock ($p<0.0001$). Delay before laparotomy did not influence outcome. There were 20 patients with isolated gastric injuries, none of whom died. Mean hospital stay was 8.8±7.7 days.

Conclusion. We reaffirm that stomach injuries are common following abdominal trauma. Isolated gastric injuries are uncommon. Complications specific to gastric injuries are uncommon but devastating. Mortality is related to associated injuries.

Injuries to the stomach are commonly associated with abdominal trauma because of its anterior position and its susceptibility to rupture when filled with food.[1] This is despite the thick muscular walls of the stomach, which make it more resistant to injury than other organs,[1,2] and its well-protected location in the thoraco-abdominal region, which deters many external insults. Penetrating trauma to the stomach is more common than blunt trauma.[4] Breach of the stomach wall leads to leakage of gastric contents into the peritoneal cavity, in turn leading to chemical peritonitis, which mandates laparotomy. Delay in recognition of the injury and failure to deal with the peritonitis promptly result in increased morbidity and mortality.[2]

There have been few, if any, reports addressing gastric trauma in recent years, no doubt because of the standardised management of hollow visceral injuries, with few management controversies and even fewer complications related to anastomotic dehiscence.[2] This study was undertaken in a single surgical ward at a tertiary hospital to document outcomes of the current management of gastric injuries.

Patients and methods

This prospective study was of all patients treated for gastric injuries in a single surgical ward at King Edward VIII Hospital, Durban, over a period of 7 years, from 1998 to 2004. Demographic data, clinical presentations, findings at laparotomy, and outcomes were documented. The delay before laparotomy included both pre-hospital and in-hospital delays.

Shock was defined as a systolic blood pressure of ≤90 mmHg. Patients with peritonitis or peritonism underwent emergency laparotomy. Patients with blunt trauma and with equivocal findings underwent computed tomography (CT) scan to exclude solid visceral injury, and were managed expectantly. The injury severity score (ISS) was used to grade severity of injury.[4] The amount of blood transfused was documented.

Antimicrobial prophylaxis was given at induction of anaesthesia before laparotomy. Patients found to have gastric perforations were given antifungal prophylaxis. A double-layer repair with absorbable sutures was performed. All other injuries were managed according to their merits.

Data were collected on a proforma document and then transferred onto a computer database. Analysis of the demographic data was performed using the Statistical Package for the Social Sciences (SPSS), version 11.5. The chi-squared method was used to assess the influence of shock and delay on outcomes and, where numbers were very small, Fisher's exact test was used. The one-way ANOVA test was used to assess the influence of injury mechanism

on outcomes. A p-value of <0.05 was taken as statistically significant.

Results

A total of 488 patients underwent laparotomy for abdominal trauma during this period, of whom 99 (20%) were found to have gastric injuries. Their mean age (and standard deviation (SD)) was 28.9±11.1 years (range 13 - 69 years). There were 93 males, giving a male to female ratio of 14:1. The mechanisms of injury were firearm (52), stabbing (43) and blunt trauma (4).

All 99 patients presented with varying degrees of peritonism. Seventeen patients (14 stabs and 3 firearms) presented with disembowelment. Seventeen patients were in shock on admission. The mean delay before laparotomy was 7.6±5.2 hours (range 0.5 - 30 hours). Eighty-seven patients experienced delays of ≤12 hours before laparotomy, and the remaining 12 experienced delays of >12 hours. Sixty-one patients required blood transfusion, receiving an average of 4.1±3.5 units.

Associated injuries occurred in 79 patients, and there were 20 isolated gastric injuries – 3 from firearm injuries and the rest from stabs. Table I shows associated organ injuries. The most common associated injury was to the liver, and the most common associated injury to a hollow visceral organ was to the colon. The mean injury severity score (ISS) was 13.6±7.4 (range 9 - 43). The ISS for stabs was 12.2±5.3 and that for firearms was 14.74±8.8, while the median ISS for blunt trauma was 11. Two patients had pyloric injuries, and 3 had injuries to the oesophago-gastric junction. All except 2 patients were managed by primary repair by 2 layers of absorbable suture, including the patients with pyloric and oesophago-gastric injuries. In 1 patient, a serosal tear from blunt trauma was repaired in 1 layer. The other patient had disembowelment and the stomach was herniated through the abdominal wall defect causing necrosis; wedge resection and repair was performed. None of the patients underwent formal gastrectomy. The 2 patients with pyloric injuries underwent primary repair but one of them had an additional pyloric exclusion for associated duodenal injury.

Twenty-nine patients developed complications, as shown in Table II. Chest infections were the most common. One patient with a firearm injury had a missed posterior wall injury and required a re-look laparotomy and repair. He subsequently developed a gastro-cutaneous fistula, which was the only complication directly related to the gastric injury; it was managed non-operatively by nutritional means and healed after 38 days. There were 2 pancreatic fistulas, 1 following a re-look laparotomy for pancreatic abscess. Both pancreatic fistulas were managed non-operatively and healed after 7 and 20 days, respectively. Twenty-four of the 87 patients with a delay of ≤12 hours developed complications, compared with 4 of the 12 patients with a delay of >12 hours (p=0.736). There were 4 (20%) complications from isolated stomach injuries, compared with 25 (29%) in patients with associated injuries (p=0.418).

Forty-two patients required management in the intensive care unit (ICU), with an average ICU stay of 4.7±4.6 days (range 1 - 24 days). Nine patients required re-laparotomy; 3 were for removal of packs (having had damage control laparotomy at the initial operation), 1 for pancreatic abscess, 1 for a mesenteric bleeder, and 4 for peritonitis, 1 case of which was due to the missed gastric injury.

Fourteen patients died, giving a mortality rate of 14%; 8 from multiple organ dysfunction syndrome (MODS), 4 from hypovolaemic shock, 1 from septic shock, and 1 from renal failure. Eight (29%) of the 28 patients with complications died, compared with 6 (9%) of the 71 patients without complications (p=0.021). Nine (53%) of the 17 patients admitted with shock died, compared with 5 (6%) of the

TABLE I. ASSOCIATED INJURIES IN 99 PATIENTS WITH GASTRIC INJURIES

Organ	*N*
Liver	**38**
Colon	**34**
Small bowel	**31**
Diaphragm	**22**
Retroperitoneal bleeding	**22**
Duodenum	**10**
Pancreas	**10**
Spleen	**9**
Kidney	**6**
Gallbladder	**5**
Major vessels (aorta, IVC, portal vein)	**3**
Bladder	**2**

IVC = inferior vena cava.

TABLE II. COMPLICATIONS IN 99 PATIENTS UNDERGOING LAPAROTOMY FOR GASTRIC INJURIES

Complication	*N*
Chest	**11**
MODS	**10**
Wound complications	**5**
Hypovolaemic shock	**4**
Fistula	**3**
Bleeding	**2**
Peritonitis	**2**
Septic shock	**2**
Intestinal obstruction	**2**
Cardiac failure	**1**
Renal failure	**1**
Gastrointestinal bleed	**1**
Pancreatic abscess	**1**
Empyaema	**1**
Total number of patients with complications	**29**

MODS = multiple organ dysfunction syndrome.
Some patients had more than 1 complication.

82 patients admitted without shock (p<0.0001). All the 14 patients who died were from the 87 patients with a delay ≤12 hours before surgery (16%), compared with none of the 12 patients with a delay >12 hours (0%), (p=0.352). Eleven out of 52 patients with firearm injuries died (21%), compared with 3 out of 43 stab injuries (7%), and 1 out of 3 blunt trauma patients (33%). There was associated diaphragmatic injury in 23 patients (25%). All the patients who died had associated organ injuries; none of the patients with isolated gastric injury died (p=0.117). Mortality increased with increasing associated injuries (Table III). The average hospital stay was 8.8±7.7 days (range 1 - 54 days). The number of patients with blunt injuries was too small to make meaningful comparisons of injury mechanisms.

TABLE III. RELATION OF MORTALITY TO NUMBER OF ASSOCIATED ORGANS

No. of associated organs	*N*	Mortality (%)
0	**20**	**0**
1	**29**	**0**
2	**24**	**25**
3	**14**	**29**
≥4	**12**	**33**

Discussion

The variables that influence outcomes in penetrating trauma of the stomach include the type of weapon, and wound trajectory.[2] Blunt abdominal trauma, on the other hand, more frequently damages solid organs than hollow organs because of the greater absorption of disruptive kinetic energy through their relatively higher specific density.[3] The mechanisms for blunt trauma to the stomach include tangential tearing along fixed points, increased intraluminal pressure, and crushing against vertebral bodies;[2] the fundus tends to be the most commonly damaged part of the stomach.[6]

Gastric injuries accounted for 20% of abdominal injuries in this study, which falls within the 7 - 24% range reported in the literature.[3,7,8] Other studies addressing intra-abdominal organ injury have shown the stomach to be one of the most commonly injured organs, at 35 - 38%.[9,10] It is interesting that, despite an increase in firearm-induced injuries in South Africa,[11] the proportion of firearm injuries (53%) was lower in this study than in that by Wilkinson in 1989 (67%).[3] Blunt trauma occurred in 2%, which compares well with the 0.9 - 1.7% reported in the literature.[2,3] The incidence of stomach injuries associated with penetrating thoraco-abdominal injury was 7 - 20%.[2] Diaphragm injuries occurred in 25% of patients in this series, which compares favourably with the 27% reported in the literature.[8]

As with all other injuries, gastric injuries require immediate recognition to minimise their otherwise high mortality and morbidity.[6] However, prompt identification of hollow visceral injury in general and gastric injury in particular, in the absence of peritoneal irritation and peritonitis, remains a diagnostic challenge as pre-operative diagnosis is difficult. Furthermore, the presence of free air under the diaphragm on the plain film is not consistent.[2,12] If present, sub-diaphragmatic air and an outlined falciform ligament on CT scan may be helpful diagnostic tools.[2] Ultrasonography and diagnostic peritoneal lavage are not helpful in the diagnosis of gastric injuries.[2]

The trauma surgeon should always bear in mind that where there is an injury to one wall of the stomach, there is probably injury to another part.[4] It is therefore mandatory to expose both anterior and posterior gastric walls by opening the lesser sac widely through the gastro-colic omentum. A diligent examination of both anterior and posterior walls of the stomach from the pylorus to the oesophago-gastric junction is then mandatory.[4]

Injuries due to stabs and low-velocity firearm injuries can be managed surgically by debriding the edges and doing a primary repair.[2,4] Because the stomach has a thick wall and rich vascular supply, the injury is best closed in 2 layers to prevent bleeding from the suture line.[2,4,8] Absorbable sutures such as polyglactin, polyglycolic acid and polydioxanone are preferable as a running suture because they are relatively acid-resistant.[8,13] The rich blood supply ensures that gastric repairs heal well.[3] In high-velocity bullet injuries, the resultant shockwave phenomenon leads to extensive injury to the stomach that is not immediately apparent to the surgeon.[4] This type of injury requires wide debridement or partial gastrectomy. However, if such high-velocity injury is suspected but not immediately apparent, a repeat laparotomy should be planned to look for subsequent demarcation of viable from non-viable tissue. Postoperative decompression with a nasogastric tube is recommended.[2]

Great care should be taken when repairing injuries to the narrow proximal and distal ends of the stomach, such as the oesophago-gastric junction and the pylorus, to avoid postoperative narrowing. This injury occurred in 5 patients in this series and was repaired primarily. Neither developed narrowing.

Morbidity directly related to gastric injury in penetrating trauma is infrequent, occurring in 6% of cases.[2,8] The low morbidity is due to the protected position of the stomach, its thick wall and its rich blood supply.[8] Furthermore, bacterial flora is sparse in the resting stomach and consist mainly of salivary organisms in concentrations of about 10^3 organisms per millilitre.[8,14] After ingestion of food, the drop in gastric pH allows concentrations of ingested salivary flora to increase to as much as 10^6/ ml.[8,15] Bacterial contamination of the peritoneal cavity is therefore more likely to occur in patients with a full stomach who sustain injuries.[8]

Empyema of the left hemithorax is common, occurring in 12.5% of gastric trauma cases, and the incidence of empyema in patients with combined diaphragm and gastric injuries is 3 - 4 times higher than that seen in penetrating thoracic trauma alone.[2,8] The infection is caused by contamination of the chest cavity with food particles from the stomach lesion,[2] and occurred in only 1 patient in this series, arising from a combined injury. The incidence of intra-abdominal abscess after penetrating gastric injury is 6%, and abscesses are located most commonly in the upper quadrants and sub-diaphragmatic area.[2,8] Apart from 1 pancreatic abscess which later developed into a pancreatic fistula, there were no other abdominal abscesses in this series. Although bleeding from the suture line is a recognised complication in traumatic and non-traumatic gastric operations,[8] this did not occur in the present series. Delay before surgery and the presence of associated injury did not influence morbidity. Most of the

patients were admitted within 30 hours of injury, and delay was therefore not long enough to have an effect on morbidity.

Complications arising solely from stomach injuries are uncommon unless an injury is missed, especially if the stomach, including the posterior wall, is not well examined.[3,14,16] Only 1 patient in this series had a firearm injury on the posterior wall of the stomach, which was missed because of inadequate exploration of the posterior gastric wall. This resulted in a gastro-cutaneous fistula, the only gastric-related complication in this series. Although this missed injury occurred in only 1 patient in this series and in 0.3 - 2% in other series,[3,8] it is a significant source of morbidity which is preventable.

The decision to use antifungal therapy in patients with gastric trauma in this setting was based on the finding of gastro-duodenal colonisation with candida in 47% of patients with peptic ulcer, compared with 15% of patients with normal endoscopy,[17] and is extrapolated from studies showing an association of perforated gastric ulcer with fungal peritonitis from gastric contents,[18] as well as recent data from trauma units suggesting a reduction in colonisation with candida and sepsis in patients receiving prophylaxis with fluconazole.[19-21] Furthermore, positive peritoneal fungal culture is a significant risk factor for adverse outcomes in patients with perforated peptic ulcer[18,21] and is associated with an increased rate of surgical site infection, mortality rate and hospital stay.[22] The use of antifungal prophylaxis in gastric injuries has not been subjected to randomised controlled trials, and it has not been conclusively proven to date that it influences outcome. In view of the potential risks of fungal peritonitis from these injuries, we have adopted this treatment policy pending the outcome of randomised controlled trials.

The mortality rate following gastric injuries is reported at 0.4 - 17% and is determined by the complexity of other associated lesions.[2,3,8] The stomach lies in close proximity to other vascular viscera that often have associated injuries resulting in haemorrhage, which becomes the main cause of death.[3,4,23] The mortality rate of 14% in this series falls within this range. There were associated injuries in 80% of patients in this series. Isolated gastric injury is rare and, when it occurs, is associated with low morbidity and mortality;[23] this occurred in 20% of patients in this study (mainly stab wounds), none of whom died. The mortality rate directly related to gastric trauma found by Durham *et al*. was 0.4%;[8] none of the patients in this series died as a direct result of the gastric injury. Although the difference in mortality between isolated gastric injury and gastric injury with associated injury was not statistically significant, it was significant that none of the deaths occurred in the group of patients with isolated injury.

Edelmann *et al*.,[23] in a study of 544 patients with gastric injury, demonstrated a higher mortality rate for proximal gastric injuries than for distal injuries, and that patients requiring more than primary repair had a higher mortality rate, required more blood transfusions, and had an increased rate of surgical site infections and increased length of stay. That observation is supported by the present study, which showed a significantly higher mortality rate in patients with shock.

All the patients who died were in the group with a delay of ≤12 hours after injury; this can probably be explained by the fact that most patients who arrive early in hospital have major associated injuries which contribute to the high hospital mortality rate. Among those with delay on presentation, patients with severe injuries have a higher probability of dying before arrival in hospital, whereas those who survive to reach hospital usually do not have fatal injuries.

In conclusion, gastric injuries are common, and accounted for 20% of all abdominal trauma in this series, with penetrating trauma being more common. Isolated injuries are uncommon and have a low mortality rate. The role of fungal prophylaxis in gastric injuries needs further elucidation in randomised controlled trials. Delay before surgery has no influence on morbidity. Complications specific to gastric injuries are rare and can be avoided by diligent exploration and meticulous inspection of the posterior gastric wall. When gastric injury is recognised early and promptly and appropriately treated, it has a low, or no, mortality. When missed, however, it is an unforgiving injury and associated with significant morbidity and mortality.

REFERENCES

1. Brunsting LA, Morton JH. Gastric rupture from blunt abdominal trauma. *J Trauma* 1987; 27: 887-891.
2. Espinoza R, Rodríguez A. Traumatic and non-traumatic perforation of hollow viscera. *Surg Clin North Am* 1997; 77: 1291-1304.
3. Wilkinson AE. Injuries to the stomach. An analysis of 95 cases. *S Afr J Surg* 1989; 27: 59-60.
4. Lawson HH. Injuries to the stomach (invited comment). *S Afr J Surg* 1989; 27: 60-61.
5. Baker SP, O'Neill B, Haddon W *et al*. The injury severity score: A method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974; 14: 187-196.
6. Lassandro F, Romano S, Rossi G, *et al*. Gastric traumatic injuries: CT findings. *Eur J Radiol* 2006; 59: 349-354.
7. Monzon-Torres BI, Ortega-Gonzalez M. Penetrating abdominal trauma. *S Afr J Surg* 2004; 42: 11-13.
8. Durham RM, Olson S, Weigelt JA. Penetrating injuries to the stomach. *Surg Gynecol Obstet* 1991; 172: 298-302.
9. Madiba TE, Mokoena TR. Favourable prognosis after surgical drainage of gunshot, stab or blunt trauma of the pancreas. *Br J Surg* 1995; 82: 1236-1239.
10. Sikhondze Wl, Madiba TE, Naidoo NM, Muckart DJJ. Predictors of outcome in patients requiring surgery for liver trauma. *Injury* 2007; 38: 65-70.
11. Muckart DJJ, Meumann C, Botha JBC. The changing pattern of penetrating torso trauma in KwaZulu-Natal – a clinical and pathological review. *S Afr Med J* 1995; 85: 1172-1174.
12. Petersen S, Sheldon GF, Peterson SR, Sheldon GF. Morbidity of a negative finding at laparotomy in abdominal trauma. *Surg Gynecol Obstet* 1979; 148: 23-26.
13. Chu CC, Moncrief G. An in vitro evaluation of the stability of mechanical properties of surgical sutures in various pH conditions. *Ann Surg* 1983; 198: 223-228.
14. Gorbach SL. Intestinal microflora. *Gastroenterology* 1979; 60: 1110-1129.
15. Hill N. Normal and pathologgial flora of the upper gastrointestinal tract. *Scand J Gastroenterol* 1985; 111 (Suppl): 1-5.
16. Yajko RD, Seydel F, Trimble C. Rupture of the stomach from blunt abdominal trauma. *J Trauma* 1975; 15: 177-183.
17. Ghoshal UC, Kochhar R, Goenka MK, *et al*. Fungal colonisation of untreated peptic ulcer. *Indian J Gastroenterol* 1994; 13: 115-117.
18. Madiba TE, Nair R, Mulaudzi TV, Thomson SR. Perforated gastric ulcer – reappraisal of surgical options. *S Afr J Surg* 2005; 43: 58-60.
19. Dean DA, Burchard KW. Fungal infections in surgical patients. *Am J Surg* 1996; 171: 374-382.
20. Peters M, Weiner J, Whelan G. Fungal infection associated with gastroduodenal ulceration: endoscopic and pathologic appearances. *Gastroenterology* 1980; 78: 350-354.
21. Shan YS, Hsu HP, Hsieh YH, *et al*. Significance of intraoperative peritoneal culture of fungus in perforated peptic ulcer. *Br J Surg* 2003; 90: 1215-1219.
22. Calandra T, Bille J, Schneider R, *et al*. Clinical significance of candida isolated from peritoneum in surgical patients. *Lancet* 1989; 2: 1437-1439.
23. Edelman DA, White MT, Tyburski JG, Wilson RF. Factors affecting prognosis in patients with gastric trauma. *Am Surg* 2007; 73: 48-53.