Resection of complex pancreatic injuries: Benchmarking postoperative complications using the Accordion classification

Jake E Krige, Eduard Jonas, Sandie R Thomson, Urda K Kotze, Mashiko Setshedi, Pradeep H Navsaria, Andrew J Nicol

AIM
To benchmark severity of complications using the Accordion Severity Grading System (ASGS) in patients undergoing operation for severe pancreatic injuries.

METHODS
A prospective institutional database of 461 patients with pancreatic injuries treated from 1990 to 2015 was reviewed. One hundred and thirty patients with AAST grade 3, 4 or 5 pancreatic injuries underwent resection (pancreatoduodenectomy, n = 20, distal pancreatectomy, n = 110), including 30 who had an initial damage control resection. The Accordion Severity Grading System (ASGS) was used to benchmark severity of complications.
Laparotomy (DCL) and later definitive surgery. AAST injury grades, type of pancreatic resection, need for DCL and incidence and ASGS severity of complications were assessed. Uni- and multivariate logistic regression analysis was applied.

RESULTS
Overall 238 complications occurred in 95 (73%) patients of which 73% were ASGS grades 3-6. Nineteen patients (14.6%) died. Patients more likely to have complications after pancreatic resection were older, had a revised trauma score (RTS) < 7.8, were shocked on admission, had grade 5 injuries of the head and neck of the pancreas with associated vascular and duodenal injuries, required a DCL, received a larger blood transfusion, had a pancreatic-duodenectomy (PD) and repeat laparotomies. Applying univariate logistic regression analysis, mechanism of injury, RTS < 7.8, shock on admission, DCL, increasing AAST grade and type of pancreatic resection were significant variables for complications. Multivariate logistic regression analysis however showed that only age and type of pancreatic resection (PD) were significant.

CONCLUSION
This ASGS-based study benchmarked postoperative morbidity after pancreatic resection for trauma. The detailed outcome analysis provided may serve as a reference for future institutional comparisons.

Key words: Pancreas; Injury; Complications; Accordion classification

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Core tip: Pancreatic injuries result in considerable morbidity and mortality rates if the injury is inadequately treated. This analysis benchmarked the severity of complications after pancreatic resection for trauma using the Accordion Severity Grading System. By applying univariate logistic regression analysis, the mechanism of injury, a revised trauma score < 7.8, shock on admission to hospital, the need for an initial damage control laparotomy, an increasing pancreatic injury grade and the type of pancreatic resection were found to be significant variables for complications. However, multivariate logistic regression analysis showed that only age and the type of pancreatic resection were significant. Post-operative morbidity after pancreatic resection for trauma in this study was substantial and an increasing complication severity grade, as measured by the Accordion severity scale, required escalation of intervention and prolonged hospitalisation.

INTRODUCTION
Major pancreatic resections are technically complex procedures, especially so when performed as an emergency in severely injured patients who also have multiple other injuries[1,2]. There are wide-ranging disparities in the reported overall postoperative morbidity rates after pancreatic injuries due to non-standardised analyses and a lack of comprehensive datasets which specifically document outcome after resection of complex pancreatic injuries[3-5]. The absence of an appropriate and defined methodology to measure and register peri-operative outcome, precludes the generation of validated outcome data, fundamental to accurate benchmarking of surgical performance and internal quality control[6]. Both the number and severity of postoperative complications are recognised key short-term surrogate markers of the quality of operative intervention and surgical outcome[7].

The development and application of internationally accepted and validated International Study Group of Pancreatic Surgery (ISGPS) definitions of complications in elective pancreatic surgery has provided accurate, robust and consistent data which has allowed reliable comparisons of, for example, the incidence of post-operative pancreatic fistulas[8], bleeding[9] and delayed gastric emptying (DGE)[10]. Similarly, the 6-scale Accordion Severity Grading System (ASGS) which discriminates post-operative complication severity following elective surgery on the basis of escalating intervention criteria, is now widely accepted as a credible, scoring system which is easy to apply and is reproducible with minimal inter-observer variability[11].

Earlier studies assessing outcome after pancreatic resections for major pancreatic injuries have applied unqualified primary endpoints with differing descriptions and definitions which consequently have resulted in flawed conclusions. Our group has previously evaluated other aspects of pancreatic trauma and, as one of the world’s busiest high volume academic trauma centers, has sufficient prospective granular data available to investigate organ-specific research questions[12-15]. The aim of this research project was to provide a detailed analysis to benchmark the severity of complications after pancreatic resection for severe trauma in a civilian patient population using the ASGS.

MATERIALS AND METHODS

Study design
Groote Schuur Hospital is a high-volume, integrated academic referral centre serving a population of 3 million people with an annual operative trauma volume averaging 13000 patients. All HPB trauma is managed in the Level 1 Trauma Centre in conjunction with the Hepatopancreatobiliary and Surgical Gastroenterology units. A retrospective analysis of prospectively collected data derived from a comprehensive and dedicated institutional pancreatic trauma database which includes clinical, operative and postoperative information on all
patients treated for pancreatic trauma was performed of all adult patients who had a resection for a pancreatic injury between January 1990 and April 2015. Current guidelines of good clinical practice were followed and data collection and analysis were approved by the departmental, institutional and university research and ethics review boards. A statistical review of the study was performed by a biomedical statistician.

Data collection
The medical records including operative, intensive care, radiology and endoscopy reports were reviewed and data abstracted were entered by a specially trained nurse reviewer and recorded using a standardised data form after affirmation by a senior study surgeon. Details of the methodology used to record the variables for each patient have previously been published.[12–17] A comprehensive data set of complications and related key variables were recorded.

Classification of surgical complications
Postoperative complications were scored using the expanded ASGS[11] (Table 1). In this study grade 1 and 2 complications were regarded as minor, grade 3 as moderate, 4 as serious and grade 5 complications as life-threatening. Grade 6 complications resulted in the death of the patient and included death from any cause within 30 d of surgery. The overall complication rate was reported as the number of patients with at least one complication. In patients with several complications, the highest graded complication was used for analysis of the complication severity.

Definitions
Shock was defined as a systolic blood pressure less < 90 mm Hg pre- or intra-operatively. Pancreatic injury grade[18], pancreatic fistula[19], organ dysfunction[19], infectious complications and septic shock[20] were defined and graded according to internationally consensus guidelines.

Initial management
Initial resuscitation was implemented using Advanced Trauma Life Support (ATLS) guidelines. Emergency surgery was undertaken in patients who had an acute abdomen with clinical signs of peritonitis or evidence of major intra-abdominal bleeding. From 1995 onwards hemodynamically unstable patients who had major associated organ and visceral vascular injuries had an initial damage control laparotomy (DCL) before later definitive intervention.[21] Patients in whom imaging revealed the need for intervention or had a high clinical suspicion of a major pancreatic injury underwent urgent exploration.

Operative management of pancreatic injury
Operative management of the pancreatic injury was based on our institutional trauma protocol, based on the hemodynamic stability of the patient, the magnitude and extent of associated injuries and the location and severity of the pancreatic injury.[12,22] In brief, major lacerations of the body or tail of the pancreas with likely duct injury were treated by distal pancreatectomy. Panreatoduodenectomy (PD) was restricted to patients with non-salvageable injuries who had disruption of the ampulla of Vater or major devitalising injuries of the pancreatic head and duodenum and was done as a primary procedure during the initial operation if the patient was stable or as a secondary staged procedure after the DCL. A pylorus-preserving PD was the preferred pancreatic head resection.[23] All pancreatic resections were drained intra-operatively.

DCL
DCL was applied in critically injured patients with severe metabolic acidosis as indicated by a pH < 7.2, hypothermia with a core temperature < 35 °C or coagulopathy.[22] This involved an abbreviated laparotomy for rapid control of intra-abdominal bleeding, closure of visceral perforations and temporary abdominal wall closure. Patients were transferred to an intensive care unit for invasive monitoring, cardiopulmonary support and urgent volume replacement to correct acidosis, coagulopathy and hypothermia and restore normal physiology.[23]

Table 1 Expanded Accordion Classification

| Expanded Accordion Classification (levels of severity) | Mild | Moderate | Severe | Severe | Severe | Deaths |
|--------------------------------------------------------|------|----------|--------|--------|--------|--------|
| Requires only minor invasive procedures that can be done at the bedside physiotherapy and the following drugs are allowed: | Antiemetics, antipyretics, analgesics and electrolytes | Requires pharmacologic treatment with drugs other than such allowed for minor complications, for instance antibiotics | Blood transfusions and total parenteral nutrition are also included | Invasive procedure/no GA, requires management by an endoscopic, interventional procedure or re-operation without general anaesthesia | Invasive procedure under GA or single organ system failure requires management by an operation under general anesthesia or results in single organ system failure | Organ system failure and invasive procedure under GA or multisystem organ failure, such complications would normally be managed in an increased acuity setting but in some cases patients with complications of lower severity might also be admitted to an ICU |
| Deaths | Postoperative death |

GA: General anaesthetic; ICU: Intensive care unit.

Management of postoperative intra-abdominal, pancreatic and duodenal complications
Postoperative intra-abdominal collections were drained...
Table 2  Demographic and clinical data for patients with and without complications

|                          | Total (n = 130) | Those with complications (n = 95) | Those without complications (n = 35) | P-value |
|--------------------------|-----------------|----------------------------------|-------------------------------------|---------|
| Age (yr), median (range) | 26 (13-73)      | 28 (13-73)                       | 24 (15-59)                          | 0.0064* |
| Mechanism of injury      |                 |                                  |                                     |         |
| GSW                      | 88 (67.7%)      | 83 (66.3%)                       | 5 (27.3%)                           | 0.6490* |
| Stab                     | 7 (5.4%)        | 6 (6.3%)                         | 1 (2.86%)                           |         |
| Blunt                    | 35 (26.9%)      | 26 (27.3%)                       | 9 (25.71%)                          |         |
| Hospital stay, median (range) | 8 (1-255)    | 23 (1-255)                       | 9 (5-58)                            | 0.0000* |
| ICU stay                 | 77 (59.2%)      | 66 (71.58%)                      | 9 (25.71%)                          | 0.0000* |
| Number ICU days, median (range) | 3 (0-153)     | 4 (0-153)                        | 3 (0-7)                             |        |
| RTS                      | < 7.8           | 49 (37.69%)                      | 44 (46.32%)                         | 0.001b  |
|                         | 7.8             | 81 (62.3%)                       | 51 (53.68%)                         | 0.0176* |
| Patients shocked on admission (n, %) | 46 (35.4%) | 42 (44.21%)                     | 4 (11.43%)                          | 0.001b  |
| Patients who received a blood transfusion (n, %) | 103 (79.2%) | 79 (83.16%)                     | 24 (68.57%)                         | 0.069c  |
| Units of blood transfused, median units (range) | 84.5 (0-124) | 8 (0-124)                       | 2 (0-28)                            | 0.0000* |
| Damage control surgery   | 30 (23.1%)      | 27 (28.42%)                      | 3 (8.57%)                           |         |
| Pancreatic injury site   |                 |                                  |                                     |         |
| Head and neck of pancreas| 24 (18.5%)     | 20 (21.05%)                      | 4 (11.43%)                          | 0.0443* |
| Body of pancreas         | 57 (43.8%)      | 44 (46.32%)                      | 13 (37.14%)                         |         |
| Tail of pancreas         | 49 (37.7%)      | 31 (32.63%)                      | 18 (51.43%)                         |         |
| AAST                     |                 |                                  |                                     |         |
| Grade 3                  | 107 (82.3%)     | 74 (77.89%)                      | 33 (94.28%)                         | 0.0297* |
| Grade 4                  | 4 (3.1%)        | 3 (3.16%)                        | 1 (2.86%)                           |         |
| Grade 5                  | 19 (14.6%)      | 18 (18.95%)                      | 1 (2.86%)                           |         |
| Associated abdominal injuries |           |                                  |                                     |         |
| Nil (isolated injury)    | 14 (10.8%)      | 10 (10.53%)                      | 4 (11.43%)                          | 0.8833* |
| 1 or 2 organs injured    | 51 (39.2%)      | 37 (38.95%)                      | 14 (40%)                            |         |
| 3 or more injured        | 65 (50%)        | 48 (50.53%)                      | 17 (48.57%)                         |         |
| Associated injured organs|                 |                                  |                                     |         |
| Liver                    | 53 (40.7%)      | 40 (42.11%)                      | 13 (37.14%)                         | 0.6109  |
| Kidney                   | 53 (40.7%)      | 34 (35.79%)                      | 19 (54.29%)                         | 0.0579  |
| Spleen                   | 52 (40%)        | 39 (41.05%)                      | 13 (37.14%)                         | 0.6876  |
| Stomach                  | 49 (37.7%)      | 32 (33.68%)                      | 17 (48.57%)                         | 0.1217  |
| Diaphragm                | 38 (29.2%)      | 28 (29.47%)                      | 10 (28.57%)                         | 0.9204  |
| Colon                    | 32 (24.6%)      | 22 (27.82%)                      | 5 (14.29%)                          | 0.0983  |
| Duodenum                 | 22 (16.9%)      | 20 (21.05%)                      | 2 (5.71%)                           | 0.0393* |
| Pancreatic resection type|                 |                                  |                                     |         |
| Pancreaticoduodenectomy  | 20 (15.4%)      | 19 (20%)                         | 1 (2.86%)                           | 0.0004* |
| Distal pancreatectomy and splenectomy | 95 (73%)      | 70 (73.68%)                      | 25 (71.4%)                          |         |
| Distal pancreatectomy with spleen preservation | 15 (11.5%)  | 6 (6.32%)                        | 9 (25.71%)                          |         |
| Associated vascular injuries | 24 (18.5%)    | 24 (25.26%)                      | 0 (0%)                              | 0.001c  |
| Patients who had a repeat laparotomy (n, %) | 58 (44.6%) | 55 (57.89%)                     | 3 (8.57%)                           | 0.0000* |
| No. of repeat laparotomies done, median (range) | 0 (1-10)      | 1 (0-10)                         | 0 (0-1)                             | 0.0000* |
| Death                    | 19 (14.62%)     | 19 (20%)                         | 0 (0%)                              | 0.004*  |

*p-value < 0.05 was considered statistically significant.

RESULTS

Patient demographics

Between January 1990 and April 2015 a total of 461 patients were treated for pancreatic injuries of whom 130 had a pancreatic resection for either grade 3, 4 or 5 injuries. Most patients were men and 74% had sustained penetrating injuries, predominantly gunshot wounds (GSW) (Table 2). One third of patients were shocked on admission and 30 patients (23.1%) had an emergency operation.

Anatomic site and severity of injury

One-fifth of patients had pancreatic head or neck injuries and four-fifths had injuries involving either the pancreatic body or tail. More than 80% sustained AAST grade 3 injuries and 18% had grade 4 or grade 5 pancreatic fluid collections[24,25].

Statistical analysis

The data were analysed using Stata version 11 (Stata Corp. 2009. Stata: Release 11. Statistical Software. College Station, TX: StataCorp LP). For bivariate analysis the Pearson chi-square or Kruskal-Wallis tests were used for categorical variables, and the non-parametric Wilcoxon rank-sum test for numerical variables. Univariate and multivariate logistic regression models were used to evaluate the odds ratios (OR) and 95% confidence intervals of clinical variables (while excluding collinearity). All statistical tests were two-tailed and a P-value < 0.05 was considered statistically significant.
injuries (Table 2).

**Associated injuries**
Fifty-two patients (40%) had 77 extra-abdominal injuries of whom 65 (50%) had three or more associated adjacent organ injuries, predominantly involving the liver and spleen. Fourteen patients had an isolated pancreatic injury. Twenty-four patients (18%) had associated vascular injuries, of whom 15 had an IVC injury. The presence of an associated vascular injury correlated significantly ($P = 0.007$) with shock at presentation.

**Surgery**
The 130 patients underwent a total of 287 laparotomies. Their surgical therapy is detailed in Figure 1. Thirty of the 130 patients (23%) had an initial DCL. Twenty patients had a PD, 14 of which were completed during the index laparotomy and 6 at a second laparotomy. Thirteen patients underwent a pylorus-preserving PD, and 7 for small bowel obstruction. Ninety-five patients (73.1%) had a distal pancreatectomy and splenectomy, and 15 (11.5%) had a spleen-preserving distal pancreatectomy.

**Complications**
Of the 130 patients who had a pancreatic resection, 35 made an uneventful recovery without any postoperative complications. A total of 238 complications occurred in the remaining 95 patients. The severity of postoperative complications as classified using the ASGS is summarized in Table 3. Twenty-nine events were related to bleeding (intra-abdominal bleeding: $n = 11$, DIC: $n = 18$), 52 patients had respiratory related complications (21.8% of all events) and 20 had renal complications (8.4% of all events). Systemic sepsis occurred in 19 patients, intra-abdominal infections in 42 and wound infection in nine. Overall complications occurred in 95% of patients who had a PD compared to 69% who had a distal pancreatectomy ($P = 0.0004$).

Thirty-three patients had a total of 36 pancreatic complications following pancreatic resection (Table 4). Twenty-four patients developed a pancreatic fistula, 15 of which resolved on conservative management alone. Nine patients with persistent fistulae had ERCP with sphincterotomy and pancreatic duct stenting ($n = 7$) or pancreatic duct sphincterotomy only ($n = 2$). Two patients developed symptomatic pseudocysts which were treated with endoscopic ultrasound-guided transgastric stent drainage. Eight patients had peri-pancreatic fluid collections of which seven were successfully drained percutaneously. One patient with a complex pancreateocolo-cutaneous fistula underwent a left hemicolectomy.

Three of 20 patients (15%) developed a pancreatic fistula after PD compared to 21 of 110 (19%) after a distal pancreatectomy (Table 4).

Duration of hospital stay was analysed for the different ASGS grades. In patients with more than one complication the highest grade was used. Those with no post-operative complications (grade 0, $n = 35$) had a median 9 (range: 5-58) day post-resection hospital stay. Grade 1 patients ($n = 3$) spent 14, 23 and 34 d in hospital, grade 2 ($n = 14$, median 22, range 6-94 d), grade 3 ($n = 17$, median 24, range: 9-58 d), grade 4 ($n = 40$, median 33, range: 7-255 d), grade 5 ($n = 2$, 9 and 19 d) and grade 6 ($n = 19$, median 14, range: 1-52).

**Mortality**
Nineteen patients (14.6%) died post-operatively (GSW 15, blunt 3, stab 1) of whom 13 were shocked on admission, 10 had major vascular injuries, 11 had 3 or more associated abdominal organ injuries required a median of 25 units of blood (range 4-89). Five
deaths occurred within the first 24 h as a result of complications related to bleeding, DIC and shock due to a combination of complex peri-pancreatic visceral vascular injuries. Fourteen patients died after 24 h (median 17 d, range 2-52 d) of multi-organ failure (MOF), respiratory failure ($n = 9$), DIC ($n = 5$), septic shock ($n = 3$), renal failure ($n = 1$) and abdominal bleeding ($n = 1$). Four patients (20%) died after PD, including two of the six patients who underwent a delayed PD and reconstruction after DCL (Table 4).

Patients who were older, those who had a RTS $\geq 7.8$, were shocked on admission, had grade 5 injuries with associated vascular or duodenal injuries, required a DCL, received a larger blood transfusion, had a PD or repeat laparotomies were more likely to have complications after pancreatic resection (Table 2). Applying univariate logistic regression analysis mechanism of injury, RTS $\geq 7.8$, shock on admission, DCL, greater AAST grade and type of pancreatic resection (PD) were significant variables for complications (Table 5). Multivariate logistic regression analysis, however showed only age and type of pancreatic resection (PD) to be significant (Table 5).

**DISCUSSION**

The present study is the largest series to date of consecutive patients undergoing a major pancreatic resection for trauma and represents a select cohort of severe pancreatic injuries with the common denominator a main pancreatic duct injury. To our knowledge, this is the first study to examine ASGS metrics to assess the usefulness of the scoring system to benchmark the spectrum and severity of complications after pancreatic resection for trauma. Unlike the planning and precision of elective pancreatic resections performed under controlled conditions with prior knowledge of co-morbidities, extent of pathology and anatomical considerations, the complexities and unpredictable operative demands surgeons are faced with during a pancreatic resection for trauma frequently require flexible or innovative strategies.

*Pancreatic-colo-cutaneous fistula (one patient), Abdominal wall sepsis, Jaundice, Bed sore, GA: General anaesthetic; DIC: Disseminated intravascular coagulation.*
The accurate intra-operative assessment of major pancreatic injuries may be complex and the surgeon may be faced with a range of uncertainties, some of which only become apparent during the procedure[16,17,22]. When major blood loss and shock occur, strategies including rapid haemostasis and damage control intervention become imperative, necessitating deferred resection and/or reconstruction at a more opportune time when abnormal physiological parameters have been restored[17,26]. After resection, technical difficulties may arise in the reconstruction of the pancreatic and biliary anastomoses due to a mismatch in size with non-dilated biliary and pancreatic ducts, often aggravated by gross edema of the jejunum and small bowel mesentery and soft pancreatic parenchyma[12,16]. Although 20 patients in our study had a PD for grade 5 injuries, a procedure of this magnitude is seldom necessary and should only be undertaken in stable patients when lesser operations are not feasible[22]. Although pancreas-specific complications were surprisingly low after PD, the overall complication rate in this category of resection was high. This emphasizes the need for combined and integrated management were further compounded by associated vascular injuries present in one of every five patients. The dominant complications were infective, both intra-abdominal and systemic, respiratory, renal and related to bleeding. A substantial number of patients required a repeat laparotomy either for definitive management following an initial DCL (i.e., delayed resection) or for intra-abdominal infection unresolved after percutaneous catheter drainage, control of intra-abdominal bleeding, or for small bowel obstruction.

### Table 4 Outcome according to type of pancreatic resection performed

| Risk factor | Pancreatoduodenectomy (n = 20) | Distal pancreatectomy and splenectomy (n = 95) | Distal pancreatectomy with spleen preservation (n = 15) |
|-------------|---------------------------------|-----------------------------------------------|---------------------------------------------------|
| No. of patients with any complication | 19 (95%) | 70 (73.7%) | 6 (40%) |
| Complications non-surgical | 15 (75%) | 58 (61.1%) | 2 (13.3%) |
| Complications surgical (Other) | 12 (60%) | 37 (38.9%) | 4 (26.7%) |
| Complications pancreatic | 3 (15%) | 25 (26.3%) | 5 (33.3%) |
| Days in hospital, median (range) | 22 (3-94) | 17 (1-255) | 15 (5-58) |
| ICU admissions | 19 (95%) | 55 (57.9%) | 3 (20%) |
| Days in ICU, median (range) | 4 (1-20) | 7 (1-153) | 7, 9, 16 respectively |
| Outcome died | 4 (20%) | 14 (14.7%) | 1 (6.7%) |

1Kruskal Wallis. ICU: Intensive care unit.

### Table 5 Logistic regression analysis of risk factors for developing complications

| Risk factor | Odds ratio | 95%CI | P-value |
|-------------|------------|-------|---------|
| Age median, range | 0.9 | 0.58-1.43 | 0.699 |
| Mechanism of injury | 0.9 | 0.89-0.98 | 0.017 |
| RTS (< 7.8) | 5.1 | 1.85-14.5 | 0.002 |
| No. of patients shocked on admission | 6.1 | 2.0-18.8 | 0.001 |
| No. of patients who received a blood transfusion | 2.3 | 0.93-5.53 | 0.073 |
| Damage control surgery | 1.6 | 1.18-2.2 | 0.030 |
| Pancreatic injury site | 1.8 | 0.99-3.15 | 0.050 |
| AAST | 0.5 | 0.23-0.92 | 0.028 |
| Pancreatic resection type | 4.8 | 1.91-12.0 | 0.001 |
| Associated abdominal injuries | 1.1 | 0.32-3.7 | 0.883 |

The salient features of this study are the high proportion of patients who required a pancreatic resection for major injuries and the substantial morbidity and mortality associated with it. Major injuries to the pancreas remain a significant source of morbidity even when treated in well-resourced high-volume specialist trauma referral centers[21,22,27]. Outcome is influenced by the mechanism, anatomical location, grade and complexity of the pancreatic injury, the amount of blood lost, duration of hypovolemic shock, the quality of resuscitation, number of associated injuries and the appropriateness and quality of surgical intervention[15,27,28]. Overall reported morbidity rates following pancreatic injury range from 30% to 70% with the higher reported percentages generally being the result of severe trauma with higher AAST grades, associated injuries, diagnostic delay and inadequate or inappropriate initial treatment[15,27,28]. In the current study the number and severity of post-operative complications reflect the consequences of surgery in severe multiply injured patients. Associated injuries were common, in keeping with collateral damage seen with abdominal gunshot injuries. One half of patients had three or more associated injuries and the complexities of management were further compounded by associated vascular injuries present in one of every five patients. The dominant complications were infective, both intra-abdominal and systemic, respiratory, renal and related to bleeding. A substantial number of patients required a repeat laparotomy either for definitive management following an initial DCL (i.e., delayed resection) or for intra-abdominal infection unresolved after percutaneous catheter drainage, control of intra-abdominal bleeding, or for small bowel obstruction.
A variety of factors specifically contribute to the development of pancreas-related complications following trauma, including the mechanism and grade of the injury, especially GSWs and associated vascular, hollow viscus and solid organ injuries and neglect of a main pancreatic duct injury may lead to local complications including pseudocysts, fistulas, sepsis and secondary hemorrhage. Pancreatic fistulas occur in up to 38% of patients and intra-abdominal abscesses in 34%. In a study from Los Angeles County Hospital pancreas-related complications developed in 27.9%, including pseudocysts in 14.9% and fistulas 1.9%. Our data concur with the findings of others in that early deaths after major pancreatic trauma are related to the number and severity of associated injuries. Overall mortality in this study was 14.6% with the presence of shock, due to associated vascular injuries being significantly related to early mortality. Late deaths were due to sepsis and MOF. Deaths specifically related to the pancreas were uncommon. A substantial number of patients required a repeat laparotomy either for definitive management following an initial DCL or for postoperative complications that could not be managed by percutaneous or endoscopic intervention. The DCL patients had a mortality of 31%. In a two-centre study from Philadelphia and Columbus, Ohio which sought to determine the optimal initial operative management in damage control operations, 42 patients with pancreatic injuries underwent either packing, drainage or resection. Mortality in their study population was substantial (packing only, 70%; packing with drainage, 25%, distal pancreatectomy, 55%).

Although this study represents the largest detailed analysis of major pancreatic resections for trauma to date, there are several specific limitations that should be taken into account when interpreting the data and outcome. The most substantial concern is that this is a single centre study in a high-volume tertiary referral centre and although these results may be similar to other major academic institutions, the data are not valid for community-based hospitals with lesser resources. The study design sought to avoid possible non-measurable biases that may result from patient selection, referral patterns and local differences in treatment policies by using complications and death as the main outcomes to provide consistent and objective end-points. A further concern is that the ASGS scores only the highest grade complication, without considering the burden of multiple but lesser complications in the same patient. Specific strengths of the current study and of our analysis are the size of the cohort and the use of validated ISGPS definitions to score postoperative complications which have provided dependable and robust data and allowed reliable comparisons.

In conclusion, postoperative morbidity after pancreatic resection for trauma in this study was substantial and an increasing complication severity grade, as measured by the ASGS, required escalation of intervention and prolonged hospitalisation. The injured pancreas is an unforgiving organ, especially if severely damaged. Accurate intraoperative decision-making is crucial for a favourable outcome. A wide spectrum of options need to be considered, including initial damage control with delayed resection and/or reconstruction which is applicable as the default option in a select group of unstable patients. In applying the ASGS, we have established a benchmark for pancreatic resections for trauma by using current standardized definitions for grading severity of pancreatic complication. This will facilitate future comparative assessments and serve as a reference for improving outcome. Benchmarking is not restricted to comparative analyses of outcome, but should serve as a mechanism for transforming surgical practice and enhancing quality of care. To further develop this, future studies should include the calculation of the total burden of multiple complications in individual patients by utilising the comprehensive complication index, a factor which is relevant in trauma patients with several injured organs.

COMMENTS

Background

The pancreas is the least injured of the intra-abdominal solid organs but results in considerable morbidity and mortality rates if the injury is incorrectly assessed or inadequately treated. Outcome is influenced by the complexity of the pancreatic injury, the number and severity of associated vascular and visceral injuries, the duration of shock and the quality and nature of surgical intervention. Two-thirds of patients who survive more than 48 h have major complications as a result of the pancreatic and associated injuries, and the one-third of patients who die later do so because of intra-abdominal or systemic septic complications or multi-organ failure. Despite the substantial morbidity no studies have previously performed a detailed analysis of complications after pancreatic resection for trauma using standardized methodology.

Research frontiers

There is consensus that the modern management of complex pancreatic trauma is best achieved by collaborative team work between trauma and pancreatic surgeons. However, the optimal management of complex pancreatic injuries remains undefined due to the lack of high quality evidence. Despite a plethora of papers on pancreatic trauma, none have specifically addressed the spectrum of complications as patterns of injury and methods of intervention have progressed. Earlier studies assessing outcome after pancreatic resections for major pancreatic injuries have applied unqualified primary endpoints with differing descriptions and definitions which consequently have resulted in flawed conclusions. This analysis evaluated post-resection complications by applying robust and reliable methodology and objective and reproducible endpoints in a large cohort of consecutive patients treated at a tertiary referral center. Internationally accepted and validated definitions of complications and grading scores including the 5-scale Accordion Severity Grading System (ASGS) were used to benchmark the severity of complications.

Innovations and breakthroughs

The present study represents the largest single centre series of patients undergoing pancreatic resection for trauma. The number and severity of post-operative complications reflect the consequences of surgery in severe multiply injured patients. Associated injuries were common, in keeping with collateral damage seen with abdominal gunshot injuries. One half of patients had three or more associated injuries and the complexities of management were further compounded by associated vascular injuries present in one of every five patients. The dominant complications were infective, both intra-abdominal and systemic, respiratory, renal and related to bleeding. A substantial number of patients required a repeat laparotomy either for definitive management following an initial damage control laparotomy (i.e., delayed resection) or for intra-abdominal infection unresolved after percutaneous catheter drainage.
control of intra-abdominal bleeding, or for small bowel obstruction. Overall 73% of patients had complications of which three quarters were ACG grade 3-6. Patients more likely to have complications after pancreatic resection were older, had a revised trauma score < 7.8, were shocked on admission, had grade 5 injuries of the head and neck of the pancreas with associated vascular and duodenal injuries, required a damage control laparotomy, received a larger blood transfusion, had a pancreaticoduodenectomy and repeat laparotomies. Applying univariate logistic regression analysis, mechanism of injury, revised trauma score < 7.8, shock on admission, damage control laparotomy, increasing AAST grade and type of pancreatic resection were significant variables for complications. Multivariate logistic regression analysis however showed that only age and type of pancreatic resection were significant.

Applications
Postoperative morbidity after pancreatic resection for trauma in this study was considerable and an increasing complication severity grade, as measured by the AGSS, required escalation of intervention and prolonged hospitalisation. Accurate intraoperative decision-making is crucial for a favourable outcome. A wide spectrum of options need to be considered, including initial damage control with delayed resection and/or reconstruction which is applicable as the default option in a select group of unstable patients. In applying the ACCORD scale, the authors have established a benchmark for pancreatic resections for trauma by using current standardized definitions for grading severity of pancreatic complication. This will facilitate future comparative assessments and serve as a reference for improving outcome. Benchmarking is not restricted to comparative analyses of outcome, but should serve as a mechanism for transforming surgical practice and enhancing quality of care. To further develop this, future studies should include the calculation of the total burden of multiple complications in individual patients by utilising the comprehensive complication system which is easy to apply and is reproducible with minimal inter-observer variability.

Terminology
The validated international Study Group of Pancreatic Surgery definitions of complications after pancreatic surgery provided an accurate, robust and consistent method to allow reliable comparisons of the incidence of post-operative pancreatic fistula, bleeding and delayed gastric emptying. Similarly, the 6-scale ACCORD Severity Grading System which discriminates post-operative complication severity following elective surgery on the basis of escalating intervention criteria, is now widely accepted as a credible, scoring system which is easy to apply and is reproducible with minimal inter-observer variability.

Peer-review
This is an interesting article based on the management of complex pancreatic injuries in 461 patients over a twenty five-year period containing a lot of important data. It is a well-written paper, documented and with acceptable outcome in such severe injuries.

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