Predictors of Morbidity after Traumatic Pancreatic Injury
Lillian S. Kao, MD, Eileen M. Bulger, MD, David L. Parks, Gregory F. Byrd, MD, and Gregory J. Jurkovich, MD

Background: Although relatively uncommon, traumatic pancreatic injury is associated with significant morbidity and mortality. The objectives of this review were to validate the American Association for the Surgery of Trauma organ injury grading system for pancreatic injury by defining its relationship to subsequent morbidity and to characterize the independent predictors of postoperative complications.

Methods: We undertook a retrospective review of all patients with a pancreatic injury, confirmed by laparotomy, admitted to our Level I trauma center from 1986 and 1999. Pancreatic injury severity was assessed on the basis of the operative report. Outcome parameters included mortality, pancreatic complications (pancreatic fistula, pseudocyst, pancreatitis), intensive care unit (ICU) complications (acute respiratory distress syndrome, pneumonia, renal failure, multiple organ failure syndrome), abdominal complications (abscess, wound infection, ventral hernia, enteric fistula), and length of stay.

Results: There were 193 patients identified. Mortality was 12%. Overall morbidity in the series was 50%, with a 22% prevalence of pancreas-related complications. Multivariate analysis revealed that the grade of pancreatic injury was an independent predictor of both pancreatic complications (odds ratio, 4.4; 95% confidence interval, 1.9–10) and mortality (odds ratio, 2.6; 95% confidence interval, 1.2–5.8). Pancreatic and ICU complications were associated with longer ICU and hospital stays.

Conclusion: The American Association for the Surgery of Trauma Organ Injury Score predicts the development of complications and mortality after pancreatic injury and identifies patients who will require extensive resources and may benefit from transfer to a Level I trauma center.

Key Words: Pancreatic trauma, Abdominal trauma, Pancreatic fistula.

Pancreatic injury remains uncommon and its management complex. Pancreatic trauma occurs in only 0.2% of blunt injuries and 1.1% of all patients with penetrating wounds. Penetrating pancreatic injury is usually diagnosed at laparotomy and carries a high mortality because of associated injuries of neighboring major blood vessels. Blunt pancreatic injury is complicated by difficulty in establishing the diagnosis, which can lead to delay in diagnosis and increased morbidity.

Grading of pancreatic injury severity has been proposed to help with management and comparison of outcomes. The pancreatic Organ Injury Score (OIS) of the American Association for the Surgery of Trauma (AAST) is listed in Table 1. The major points of this grading system are the location of the injury (proximal vs. distal pancreas) and the status of the main pancreatic duct. Although this scoring system was developed by a committee of experts, it has not undergone formal validation. The purpose of this study was therefore to validate the AAST-OIS for the pancreas by defining its relationship to subsequent morbidity and mortality and to characterize the independent predictors of postoperative complications.

MATERIALS AND METHODS
We undertook a retrospective review of all patients with a pancreatic injury, confirmed by laparotomy, admitted to our Level I trauma center from January 1985 to December 1999. Complete records were available for 193 patients. Medical records were reviewed and data collected using a standardized data abstraction form. Approval was obtained from the University of Washington Institutional Review Board for Human Subjects before data collection. Data collected included age, gender, mechanism of injury (blunt vs. penetrating), Injury Severity Score (ISS), abdominal Abbreviated Injury Severity Scale (AIS) score, presence of shock at admission, select laboratory and imaging studies, presence of concomitant bowel injury or other solid organ injury, AAST-OIS grade of pancreatic injury, operative management, length of stay, postoperative complications, and mortality.

Patients with gunshot wounds underwent exploration in the operating room with few preoperative diagnostic studies. Patients with stab wounds underwent local wound exploration and, if fascial penetration was evident, diagnostic peritoneal lavage or computed tomographic (CT) scanning. Patients with blunt abdominal trauma were evaluated by diagnostic peritoneal lavage, ultrasound, or CT scanning de-
pending on their hemodynamic stability and level of suspicion for intra-abdominal injury. A delay in diagnosis was defined as a time interval greater than 24 hours between injury and diagnosis. Pancreatic injuries were graded according to the pancreatic injury severity score as defined by the AAST (Table 1). This was done retrospectively, on the basis of review of the operative note.

For the purpose of data analysis, postoperative morbidity was divided into three groups: pancreatic complications, non-pancreatic abdominal complications, and intensive care unit (ICU) complications. Pancreatic complications included pancreatic fistula, pseudocyst, and pancreatitis. A pancreatic fistula was defined as persistent drainage of amylase-rich fluid for greater than 14 days. A pseudocyst was defined as an encapsulated peripancreatic fluid collection, and was diagnosed by CT scan. Pancreatitis was defined as persistent inflammation of the pancreas manifested by continued hyperamylasemia (amylase > 100 IU) and abdominal pain.

Abdominal complications included intra-abdominal abscesses, enterocutaneous fistulas, wound infections, and ventral hernias. An intra-abdominal abscess was defined as a purulent fluid collection requiring percutaneous or operative drainage. Wound infections were characterized by erythema or drainage requiring that the wound be opened and drained.

ICU complications included the acute respiratory distress syndrome (ARDS), renal failure, pneumonia, and multiple organ failure syndrome (MOFS). ARDS was defined by the definition as developed by the American-European Consensus Conference as follows: $\frac{P_a O_2}{F_i O_2}$ ratio less than 200, bilateral opacities on chest radiograph, and pulmonary capillary wedge pressure less than or equal to 18 or no clinical evidence of cardiogenic pulmonary edema. Pneumonia was diagnosed by the presence of an infiltrate on chest radiography or purulent sputum in combination with a fever greater than 38.5°C or leukocytosis and treatment with antibiotics. Renal failure was defined by the need for dialysis. MOFS was defined as the failure of more than one organ system during the ICU course.

The data were analyzed using Stata, a statistical software program. Univariate statistical analysis of discrete variables was performed using $\chi^2$ analysis and continuous variables were analyzed using Student’s $t$ test. Logistic regression was used for categorical values and linear regression for continuous variables. Independent predictors of morbidity and mortality were determined by stepwise logistic regression. Significance was defined as a value of $p < 0.05$.

## RESULTS

### Demographics

Over this 14-year period, a total of 49,054 trauma patients were admitted, with 193 having laparotomy-documented pancreatic injury (0.004%). The mean age of the population was 29.8 years and ranged from 1 to 88 years old. The group of patients included 69% male and 31% female patients. The mechanism of injury was blunt in 61% of patients and penetrating in 39%. Blunt abdominal injury was primarily caused by motor vehicle collisions (68%). Penetrating injuries included gunshot (62%) and stab wounds (38%). Other mechanisms of injury are listed in Table 2. The mean ISS was 23 ± 11 (range, 4–59) and the mean AIS score for the abdomen was 3.3 ± 0.9 (range, 2–5). At admission, 34 patients (18%) were in shock, defined as a systolic blood pressure less than 90 mm Hg.

The pancreatic injuries were graded according to the AAST-OIS for the pancreas. The majority of the patients (47%) had grade I injuries. There was no statistical difference

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>AAST-OIS</th>
<th>AAST-OIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Hematoma</td>
<td>Minor contusion without duct injury</td>
<td>Minor contusion without duct injury</td>
</tr>
<tr>
<td>II</td>
<td>Laceration</td>
<td>Superficial laceration without duct injury</td>
<td>Superficial laceration without duct injury</td>
</tr>
<tr>
<td>III</td>
<td>Laceration</td>
<td>Major contusion without duct injury</td>
<td>Major contusion without duct injury</td>
</tr>
<tr>
<td>IV</td>
<td>Laceration</td>
<td>Major laceration without duct injury or tissue loss</td>
<td>Major laceration without duct injury or tissue loss</td>
</tr>
<tr>
<td>V</td>
<td>Laceration</td>
<td>Distal transection or parenchymal injury with duct injury</td>
<td>Distal transection or parenchymal injury with duct injury</td>
</tr>
</tbody>
</table>

* Data from Moore et al., 1990.† Proximal pancreas is to the patients’ right of the superior mesenteric vein.‡ Advance one grade for multiple injuries to the same organ.§ Based on most accurate assessment at autopsy, laparotomy, or radiologic study.

## Table 2 Mechanism of Injury

<table>
<thead>
<tr>
<th>Mechanism of Injury</th>
<th>Total Patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blunt</td>
<td>117</td>
<td>61</td>
</tr>
<tr>
<td>Motor vehicle collision</td>
<td>80</td>
<td>41</td>
</tr>
<tr>
<td>Motorcycle collision</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Pedestrian vs. vehicle</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Fall</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Crush injury</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Assault</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Bicycle collision</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Injury by animal (horse, bull)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Penetrating</td>
<td>76</td>
<td>39</td>
</tr>
<tr>
<td>Gunshot wound</td>
<td>47</td>
<td>24</td>
</tr>
<tr>
<td>Stab wound</td>
<td>29</td>
<td>15</td>
</tr>
</tbody>
</table>

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Table 3  Stratification of Patients by Grade

<table>
<thead>
<tr>
<th>Grade</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>91</td>
<td>54</td>
<td>36</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>% of total</td>
<td>47</td>
<td>28</td>
<td>19</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>27 ± 15</td>
<td>32 ± 16</td>
<td>33 ± 17</td>
<td>31 ± 13</td>
<td>27 ± 11</td>
</tr>
<tr>
<td>ISS</td>
<td>24.9</td>
<td>19.4</td>
<td>24.6</td>
<td>22.9</td>
<td>19.3</td>
</tr>
<tr>
<td>AIS abdomen</td>
<td>3.3</td>
<td>3.4</td>
<td>3.8</td>
<td>3.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Mortality</td>
<td>6</td>
<td>7</td>
<td>30</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Pancreatic morbidity</td>
<td>13</td>
<td>33</td>
<td>64</td>
<td>33</td>
<td>33</td>
</tr>
</tbody>
</table>

in age, ISS, or abdominal AIS score between patients with different grades of injury (Table 3).

Operative Management

The operative procedure correlated with the grade of the injury. See Table 4 for the operations performed. The majority of patients with a grade I or II injury, in which by definition the pancreatic duct is intact, underwent exploration alone or with drainage. Distal pancreatectomy was performed primarily in patients with grade III or IV injuries, although in a few cases of grade II injuries, the surgeon could not convincingly exclude a ductal injury. Grade IV injuries were not treated in any one consistent manner, although all patients who survived greater than 48 hours with a grade V injury by necessity underwent a pancreaticoduodenectomy.

Evaluation of the Main Pancreatic Duct

Intraoperative assessment of the pancreatic duct was performed in 19 patients using cholecystography with retrograde filling of the pancreatic duct (n = 11), duodenotomy with cannulation of the ampulla of Vater (n = 7), and intraoperative endoscopic retrograde pancreateography (ERCP) (n = 1). Intraoperative imaging of the pancreatic duct was successful in 15 (79%) of the patients. Two patients had main pancreatic ductal disruptions, 2 patients had extravasation from a tertiary pancreatic radical with an intact main duct, and the remaining 11 patients had no evidence of a ductal injury. The two patients with main ductal disruptions underwent distal resections at the demonstrated site of injury, and the two patients with extravasation from tertiary radicals underwent drainage alone. Both of the patients who underwent resection, as did both of the patients with leakage from radicals, developed postoperative pancreatic fistulas. Of the remaining patients, none developed a fistula, but one patient did develop postoperative pancreatitis.

Postoperative ERCP was attempted in eight cases and was successful in seven instances. Three of the patients underwent immediate postoperative ERCP within 24 hours of the initial laparotomy, in an attempt to clarify the status of the duct. In one of the three immediately attempted ERCPs, the patient had a ductal transaction that prompted return to the operating room for definitive management. The second patient had a normal duct and the third patient had an unsuccessful ERCP. The five remaining patients underwent delayed postoperative ERCPs for persistent pancreatic fistulae (four of five) and hyperbilirubinemia (one of five). In three of the four cases performed for fistulae, the pancreatograms were normal without evidence of main duct injury or stricture. In the fourth patient, a pancreatic ampullary stent was placed. The patient with hyperbilirubinemia had a normal ERCP. Management was therefore altered in two of eight (25%) patients total on the basis of postoperative ERCP. Overall, pancreatography was attempted in 27 patients, and the status of the pancreatic duct was successfully determined in 22 patients (81%).

Morbidity

Overall, 50% of patients had one or more postoperative complications. The complications were subdivided into pancreatic, nonpancreatic abdominal, and ICU-related complications.

Pancreatic Complications

The pancreas-related morbidity of the series was 21.8% (42 of 193). These complications included pancreatic fistula (n = 42 [22%]), pancreatitis (n = 19 [10%]), and pseudocyst (n = 5 [3%]). Pancreatic fistulae were managed by drainage, usually with intraoperatively placed drains. Octreotide was used in the management of 16 of the 42 patients with pancreatic fistulae. In 98% of the patients, the fistulae resolved without further intervention. One patient underwent postoperative ERCP with stenting of the pancreatic duct. None of the patients with pseudocysts required operative drainage, and all of the patients with traumatic pancreatitis had mild, self-limiting courses.

The length of intensive care unit stay was significantly longer in patients with a pancreatic complication than in those
without (13 ± 23 days vs. 6.5 ± 9.7 days, \( p = 0.01 \)). The total hospital stay was also significantly longer in patients with a pancreatic complication (36 ± 39 days vs. 17 ± 18 days, \( p < 0.001 \)). Patients with a pancreatic complication required an increased number of subsequent operations as well (1.5 ± 0.9 vs. 1.1 ± 0.6, \( p < 0.001 \)).

The independent predictors of pancreatic complications included grade of injury (odds ratio [OR], 4.4; 95% confidence interval [CI], 1.9–10) and the presence of an associated bowel injury (OR, 2.4; 95% CI, 1.1–5). Age, presence of an associated solid organ injury, shock at admission, and ISS were not predictive of the development of pancreatic complications.

### Abdominal Complications

Forty patients (21%) developed at least one abdominal complication. These included intra-abdominal abscesses (\( n = 34 \) [17.6%]), enterocutaneous fistulas (\( n = 11 \) [5.7%]), wound infections (\( n = 20 \) [10.3%]), and ventral hernias (\( n = 9 \) [4.7%]). The independent predictors of an abdominal complication were grade of injury (OR, 3.2; 95% CI, 1.6–11.3; \( p = 0.003 \)) and the presence of a pancreatic complication (OR, 14; 95% CI, 5.7–34; \( p < 0.001 \)).

### ICU Complications

The ICU-related morbidity of the series was 33% (64 of 193) and included pneumonia (\( n = 64 \) [33%]), ARDS (\( n = 35 \) [18%]), MOFS (\( n = 23 \) [12%]), and renal failure (\( n = 8 \) [4%]). The independent predictors of ICU complications included age \( > 55 \) (OR, 20; 95% CI, 2.3–169), ISS (OR per category, 2.0; 95% CI, 1.2–3.0), and the presence of a pancreatic complication (OR, 2.9; 95% CI, 1.4–6.0).

### Mortality

There were 24 deaths, for an overall mortality of 12.4%. Eighteen (75%) of the deaths occurred within the first 48 hours of admission (Table 5). In all of the cases, the pancreatic injury was not the cause of death; rather, associated solid organ or vascular injuries were primarily responsible. When the patient did not immediately exsanguinate, drainage was
performed for grade I or II injuries and distal pancreatectomy with splenectomy was performed for grade III injuries. Six deaths occurred after 48 hours of admission and were secondary to sepsis, ARDS, MOFS, or severe neurologic injury. Only one of the patients with a late death had a pancreatic complication. Mortality was dependent on grade of pancreatic injury (OR, 2.6; 95% CI, 1.2–5.8), age (OR, 11.9; 95% CI, 1.4–104), ISS (OR, 2.5; 95% CI, 0.6–11), and shock at admission (OR, 1.8; 95% CI, 0.3–12).

Relationship between Grade of Injury and Outcome
Mortality for injuries without disruption of the main pancreatic duct (grades I and II) was 7% versus 29% for more severe injuries (grades III, IV, and V; \( p = 0.005 \)) (Fig. 1). In addition, postoperative morbidity increased with increasing grade of injury (Fig. 2). As illustrated, the rate of ICU and abdominal complications increased with each successive grade of injury; however, the rate of pancreatic complication was highest for patients with grade III injuries (62%). This was most likely because of a high rate of pancreatic fistula formation for patients undergoing distal pancreatectomy (39%).

The Relationship between Delay in Diagnosis and Outcome
Seventeen patients had a delay in diagnosis, defined as recognition and treatment of a pancreatic injury more than 24 hours after the traumatic event. Fifteen (13%) of the 117 patients who sustained blunt abdominal trauma had a delay in diagnosis. The other two patients presented to the hospital late after stab wounds. Overall, the rate of pancreatic complications was higher in the blunt trauma patients with a delayed diagnosis (6 of 15 [40%]) when compared with those patients diagnosed within 24 hours (18 of 102 [18%]). ICU complications occurred in 38 of 102 (37%) patients without a delay in diagnosis compared with 6 of 15 (40%) patients with a delayed diagnosis. Only one patient with a delay in diagnosis died.

The majority of the pancreatic injuries in this subpopulation (12 of 17 [71%]) were grade I or II. Of the five patients with grade III or IV injuries, four patients survived greater than 48 hours. Two of the four patients (50%) developed a complication, and two patients (50%) developed an ICU complication. As a comparison, 14 patients who had a grade III or higher pancreatic injury from blunt abdominal trauma, without a delay in diagnosis, survived greater than 48 hours. Five patients (36%) developed a pancreatic complication and five patients (36%) developed an ICU complication. Among the initial survivors, the average length of stay for patients with a grade III or higher injury with a delay in diagnosis was 45 ± 37 days compared with 23 ± 18 days for patients without a delay in diagnosis. Likewise, the length of ICU stay was longer in cases with a delay (18 ± 26 days vs. 7 ± 5 days) for these patients.

DISCUSSION
These data support the use of the AAST-OIS for the pancreas in defining a population of patients likely to have a complicated postoperative course. Furthermore, they emphasize the importance of determining the status of the main pancreatic duct in defining the injury grade.

Previous authors have documented a correlation between ductal status and outcome using a scoring system similar to the AAST-OIS system. Smego et al. demonstrated a correlation between grade of pancreatic injury and outcome using this scale. Patients with duct transection and proximal crush injuries who were managed with resection had increased morbidity as opposed to the less severely injured patients who were managed with drainage alone. These authors concluded that ductal status is an important predictor of outcome in pancreatic trauma and is essential for establishing the basis for treatment decisions. Bradley et al. similarly reported a significant association between a main pancreatic duct injury and an increased incidence of pancreas-related complications (\( p = 0.040 \)), and in particular, an increased incidence of pancreatic fistula (\( p = 0.018 \)).

The AAST-OIS for the pancreas does take into account the status of the main pancreatic duct and the location of the

**Fig. 1.** Relationship of grade to mortality.

**Fig. 2.** Relationship of grade to pancreatic and abdominal complications.
Pancreatic injury. Pancreas-related complications are reported to occur in 11% to 62% of patients after traumatic pancreatic injury, with an average morbidity rate of 36.6%. The most commonly reported complications are pseudocysts, pancreatitis, pancreatic fistula, and abscess. Our series demonstrated comparable figures, with 22% of patients having had at least one pancreas-related complication (pseudocyst, fistula, and pancreatitis). The rate increased to 30% if patients with intra-abdominal abscesses were included as well. The prevalences of the individual complications were also comparable to those described by other authors: 22% pancreatic fistulas (7–15%), 8% intra-abdominal abscesses (8–25%), 9.8% pancreatitis (7–14%), and 2.5% pseudocysts (2–3%).

The most common pancreatic complication, both in this series and in the literature, is a pancreatic fistula. Although there appears to be a consensus regarding the significant contribution of a main pancreatic ductal injury to the development of a pancreatic fistula, the literature is controversial regarding the extent of perioperative assessment required to determine the presence of such an injury. Several authors advocate intraoperative assessment alone for the determination of operative strategy. Opponents of this approach argue that the addition of pancreatography or intraoperative ERCP adds operative time, increases operative risk, and does not contribute significantly to the management algorithm. In a study by Patton et al., patients were categorized as having either a proximal injury (to the right of the mesenteric vessels) that was managed with closed suction drainage alone or a distal injury that was managed with either drainage alone or resection and drainage, the decision made on the basis of the surgeon’s assessment of probability of a ductal injury. They noted no difference in overall morbidity in patients with an indeterminate injury who were managed with drainage alone versus those managed with distal resection (27 vs. 33%, p = 0.60) and concluded that the high morbidity was associated with the severity of the underlying pancreatic injury rather than the management strategy. They further argued that assessment of the ductal status intraoperatively (other than direct inspection) was not indicated, as the information gained would not alter the choice of operative procedure. However, because the status of the duct was never directly determined in those patients in whom drainage alone was used, these conclusions remain as opinion.

Other authors argue that intraoperative inspection alone is inadequate and that determination of the ductal status changes management. Berni et al. reported a 40% decrease in major pancreatic complications, from 55% to 15% after institution of intraoperative pancreatography. Furthermore, other studies have suggested that resection versus drainage are not equivalent treatment options for patients with a distal pancreatic ductal injury, reporting lower morbidity and mortality associated with resection rather than drainage.

In our series, three of four (75%) patients with a grade III injury treated with drainage alone developed pancreatic fistulas versus 13 of 42 (31%) patients treated with resection. Although the data are limited, the higher rate of pancreatic fistulas with drainage alone suggests that these patients probably should have undergone distal resection for management of the suspected ductal injury. Intraoperative pancreatography was used selectively in this series (19 of 193), and was successful in demonstrating the main pancreatic duct in 15 of 19 (78%). Two of the patients had a change in operative strategy dictated by the demonstration of a main ductal injury, namely, they underwent distal pancreatic resection. Although limited, these data suggest intraoperative imaging of the pancreatic duct is successful the majority of the time, and if an unsuspected pancreatic duct injury is found, distal resection should be used. However, because these numbers are small, further prospective studies are required to confirm the role of intraoperative imaging of the pancreatic duct in assessing the injury grade and guiding management.

This study does demonstrate that grade of injury is predictive of a pancreatic complication (OR, 4.4; 95% CI, 1.9–10). Grade III injuries were associated with the highest prevalence of a pancreatic fistula (Fig. 1), because of the high rate of pancreatic fistulas. In this series, 32 patients were determined retrospectively to have a grade III injury. Four of these patients underwent drainage alone and three (75%) developed a fistula. Twenty-six patients with grade III injuries underwent distal pancreatectomy with or without splenectomy, and 12 (43%) developed a pancreatic fistula. This leak rate is significantly higher than the 14% to 26% rate reported in recent studies of complications after distal pancreatectomy for all indications. The reason for the increased rate observed in our patients is unclear but may be related to the definition of a “fistula.”

A pancreatic fistula has been variably defined, ranging from drainage of more than 50 mL/day of fluid with elevated amylase level for at least 3 consecutive days to drainage of fluid high in amylase from trans-abdominal drains for greater than 10 days. For the purposes of this study, a pancreatic fistula was defined as drainage of amylase-rich fluid for greater than 14 days. The lack of a standardized definition may contribute to differences in reported rates of fistulas; nonetheless, the prevalence was still high in our series.

Method of stump closure and underlying pathophysiology have been proposed as contributing to the development of a pancreatic fistula after distal resection. However, the data are conflicting. Fahy et al. found that pancreatic leaks occurred more frequently in patients who underwent distal pancreatectomy for trauma and who underwent sutured pancreatic stump closure. However, Sheehan et al. found that neither the underlying pathologic process nor the method of stump closure affected the rate of fistula formation. In our series, complete data are not available regarding method of stump closure, so no definitive conclusion could be made.

This study demonstrated that the presence of a pancreatic complication is a risk factor for an ICU complication (OR, 2.9; 95% CI, 1.4–6.0). Figure 3 demonstrates that the prev-
alence of ICU complications rises with increasing grade of pancreatic injury. Furthermore, the presence of a pancreatic complication was associated with a significantly longer ICU stay (13 ± 23 days vs. 6.5 ± 9.7 days, p = 0.01), as was the presence of an ICU complication (19 ± 21 days vs. 2.5 ± 2.8 days, p < 0.001). Overall length of hospital stay was also increased in patients with a pancreatic complication (36 ± 39 days vs. 17 ± 18 days, p < 0.001) and an ICU complication (39 ± 38 days vs. 13 ± 10 days, p < 0.001). Therefore, grade of injury not only is predictive of pancreatic and ICU complications but is associated with an increased use of hospital resources, as demonstrated by a greater need for higher level care and a longer ICU and hospital stay.

A delay in diagnosis of pancreatic injury has been demonstrated to increase pancreas-related morbidity and mortality.16–18 Delays in diagnosis are more common in blunt abdominal trauma, given that most patients with penetrating injuries undergo exploratory laparotomy for associated injuries. Given the retroperitoneal location of the pancreas, diagnosis of a pancreatic injury can be difficult. Symptoms may be minimal, laboratory tests such as serum amylase are not reliable,19,20 and CT scan findings may underestimate the severity of the injury, especially in the first 24 hours after trauma.21,22 In our series, 17 patients had a delay in diagnosis of a pancreatic injury of greater than 24 hours. A delay in diagnosis was associated with increased pancreas-related morbidity. ICU morbidity was similar overall but increased in patients with more severe injuries. In addition, patients diagnosed late had an increased ICU and hospital stay.

The overall mortality of this series was 12.4%, which is comparable to the 19.1% mortality reported by Asensio et al.3 The literature suggests that the cause of mortality differs depending on the temporal relationship to the trauma. Early deaths in patients with pancreatic injury are typically secondary to exsanguination.23,24 Similarly, in our series, 75% of deaths occurred in the first 48 hours after admission, because of massive hemorrhage and subsequent cardiac arrest. Late deaths are usually related to associated injuries rather than the pancreatic injury itself.3,25 In our series, only one late death had a pancreatic complication that contributed to his mortality. Therefore, pancreatic complications did not appear to predict late mortality.

Although pancreatic complications were not significantly associated with mortality, grade of injury was predictive of mortality in our series. Previous studies have attempted to validate the AAST-OIS as a predictor of mortality. Cogbill et al.15 performed a multi-institutional study that failed to demonstrate a conclusive relationship because of a small number of patients and inadequate representation in each category of injury grade. Another study by Glancy25 demonstrated a correlation between operative procedure and mortality. The lowest mortality of 10.9% was associated with drainage alone and the highest mortality of 100% was associated with total pancreatectomy. Because the more complex surgical procedures are typically associated with the higher grade injuries, these results are suggestive of a correlation between grade and mortality. The current series demonstrates a statistically significant correlation between grade of injury and mortality. Grade I and II injuries had a 7% mortality, whereas grades III and IV were associated with 29% mortality. Grade of injury was a predictor of mortality, with an odds ratio of 2.6. Thus, this study validates that grade of pancreatic injury is a predictor of mortality.

In conclusion, the status of the main pancreatic duct and location of the pancreatic injury constitute the basis for the AAST scoring system. This scale should be used as a guide to operative strategy and as a predictor of patient outcome. This study validates the AAST scale as correlating to both pancreatic complications and mortality. Therefore, this scoring system should be used to identify patients who may have a prolonged hospital stay and higher morbidity such that early transfer to a specialized trauma center may be indicated.

**REFERENCES**