Don't mess with the pancreas! A multicenter analysis of the management of low-grade pancreatic injuries

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INTRODUCTION: Current guidelines recommend nonoperative management (NOM) of low-grade (American Association for the Surgery of Trauma-Organ Injury Scale Grade I–II) pancreatic injuries (LGPIs), and drainage rather than resection for those undergoing operative management, but they are based on low-quality evidence. The purpose of this study was to review the contemporary management and outcomes of LGPIs and identify risk factors for morbidity.

METHODS: Multicenter retrospective review of diagnosis, management, and outcomes of adult pancreatic injuries from 2010 to 2018. The primary outcome was pancreas-related complications (PRCs). Predictors of PRCs were analyzed using multivariate logistic regression.

RESULTS: Twenty-nine centers submitted data on 728 patients with LGPI (76% men; mean age, 38 years; 37% penetrating; 51% Grade I; median Injury Severity Score, 24). Among 24-hour survivors, definitive management was NOM in 31%, surgical drainage alone in 54%, resection in 10%, and pancreatic debridement or suturing in 5%. The incidence of PRCs was 21% overall and was 42% after resection, 26% after drainage, and 4% after NOM. On multivariate analysis, independent risk factors for PRC were other intra-abdominal injury (odds ratio [OR], 2.30; 95% confidence interval [95% CI], 1.16–15.28), low volume (OR, 2.88; 1.65, 5.06), and penetrating injury (OR, 3.42; 95% CI, 1.80–6.58). Resection was very close to significance (OR, 2.06; 95% CI, 0.97–4.34) ($p = 0.0584$).

CONCLUSION: The incidence of PRCs is significant after LGPIs. Patients who undergo pancreatic resection have PRC rates equivalent to patients resected for high-grade pancreatic injuries. Those who underwent surgical drainage had slightly lower PRC rate, but only 4% of those who underwent NOM had PRCs. In patients with LGPIs, resection should be avoided. The NOM strategy should be used whenever possible and studied prospectively, particularly in penetrating trauma. (*J Trauma Acute Care Surg.* 2021;91: 820–828. Copyright © 2021 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Therapeutic Study, level IV.

KEY WORDS: Pancreas; trauma; pancreatectomy; cholangiopancreatography.

Management of pancreatic trauma presents many challenges. Diagnosis of pancreatic injury and assessment of main pancreatic duct (MPD) integrity is hindered by the retroperitoneal position of the gland and limitations of laboratory and imaging tests.[1–5] Associated injuries are common and are typically the root cause of early mortality and other adverse outcomes.[5–7] Surgical management of pancreatic injuries can be complex, and the choice of the optimal intervention for any given patient requires consideration of numerous factors.[4,8] Compounding the complexity of management is the fact that pancreatic injuries are uncommon, resulting in a lack of experience among practicing trauma surgeons and a dearth of high-quality data guiding management.[3,9,10]

Injury to the MPD has long been recognized as a major risk factor for morbidity, and most of the recent literature in the field has focused on the management of high-grade pancreatic injuries (HGPIs) (American Association for the Surgery of Trauma-Organ Injury Scale [AAST-OIS][11] Grade III–V).[2,5] However, it is well recognized that injuries of all grades can be associated with significant morbidity.[7,12–14] Current national and international guidelines recommend nonoperative management (NOM) of low-grade pancreatic injuries (LGPIs) (AAST-OIS[11] Grade I–II) in patients without other reasons for laparotomy (LAP), and drainage or no intervention for LGPIs discovered intraoperatively—but these recommendations were made on the basis of very low-quality evidence.[3,9,10] For example, the Eastern Association for the Surgery of Trauma practice management guideline[10] conditionally recommended NOM for patients with LGPIs identified by CT scan, based on just 124 patients across 11 studies. The incidence of pancreatic fistula or leak after NOM (7%) was derived from just 44 patients in seven studies. The recommendation for nonresectional over resectional management of LGPIs discovered at LAP was based on lower incidence of pancreatic fistula or leak (11% vs. 14%, $p = 0.70$) and pancreatic abscess (9% vs. 43%, $p = 0.0009$), in a literature base consisting of 299 patients in 14 studies.[10]

The purpose of this study was to review the contemporary management and outcomes of LGPIs. We hypothesized that NOM is associated with the lowest rate of pancreas-related complications (PRCs), and that nonresectional management is associated with fewer PRCs than resectional management.

METHODS

This was a secondary analysis of a retrospective multicenter study of pancreatic injuries. Inclusion criteria were 15 years or older, AAST-OIS[11] Grade I to II pancreatic injury, and admission to participating Level I and II trauma centers between January 2010 and September 2018. Exclusion criteria for

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outcomes analyses included early deaths (<24 hours) and transfers from other hospitals after LAP or pancreatic intervention.

Data Collection

After institutional review board (IRB) approval, each site provided deidentified data for patients with pancreatic injuries included in the institution's trauma registry. The case report form included demographic and injury data, diagnostic testing, interventions, and outcomes. The timing and specific findings of imaging studies, operative and endoscopic interventions, and decision making were recorded.

Pancreatic injury grade was recorded for both computed tomography (CT) and intraoperative inspection. When there was a discrepancy between grades, case report forms were evaluated for other information to ascertain a definitive grade (e.g., magnetic resonance cholangiopancreatography [MRCP] or endoscopic retrograde cholangiopancreatography [ERCP] results); if there was still uncertainty, the site principal investigator was queried and assigned a final grade. Indications for ERCP and stenting were recorded as either empiric/prophylactic therapy for a newly diagnosed injury or treatment of a PRC. The primary outcome of interest was PRCs (pancreatic leak, peripancreatic abscess, pancreatic fistula, or delayed pancreatic pseudocyst); pancreas-related mortality was a secondary outcome of interest.

Statistical Analysis

Patient demographics and characteristics are reported using descriptive statistics, including mean, median, interquartile range, and proportions. Continuous variables were compared using *t* test; for not normally distributed data, Wilcoxon rank sum test were performed. The χ^2 test, Fisher's exact test, two-proportion z test, or one-proportion z test were used to compare categorical variables. Predictors of PRCs were analyzed using multivariate logistic regression. Youden's index was calculated to identify optimal value to distinguish between high and low volume sites. Statistical significance was defined as a *p* value less than 0.05. All statistical tests were performed using R software (Version 3.6.3; The R Foundation, Vienna, Austria).

RESULTS

Patients

Twenty-nine centers (27 Level I, 2 Level II) from the United States, Canada, and Israel provided complete data on 1,165 adult patients, of whom 728 had LGPI (Fig. 1). The average annual number of LGPI patients from each trauma center ranged from less than one (ten centers) to 9.5 (Fig. 2). Based on Youden's index, 3.5 patients per year was identified as the optimal number to distinguish between "HIGH" and "LOW" volume centers. Nineteen centers treated 3.5 or fewer LGPIs per year (LOW, n = 218), while 10 centers treated more than 3.5 per year (HIGH, n = 510) (Fig. 2). The overall population was 76% men, with a mean age of 38 years and median Injury Severity Score (ISS) of 24 (Table 1). Sixty-three (9%) patients were 65 years or older. Two hundred and seventy-one (37%)

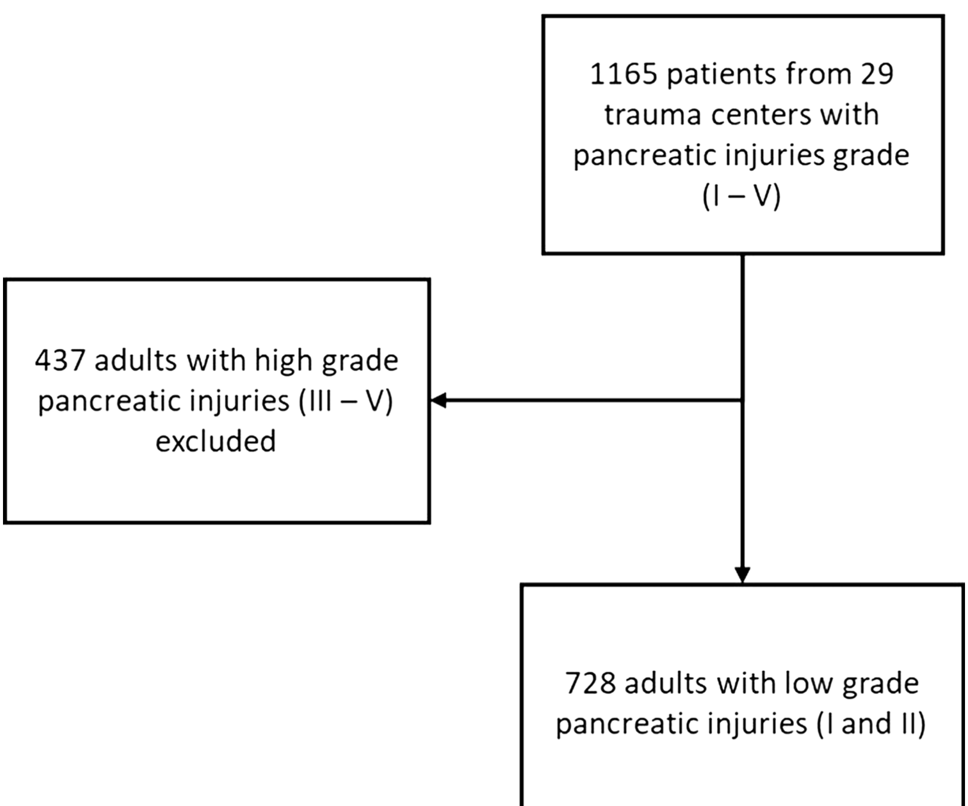

Figure 1. Derivation of final population of adult low-grade (I-II) pancreatic injuries.

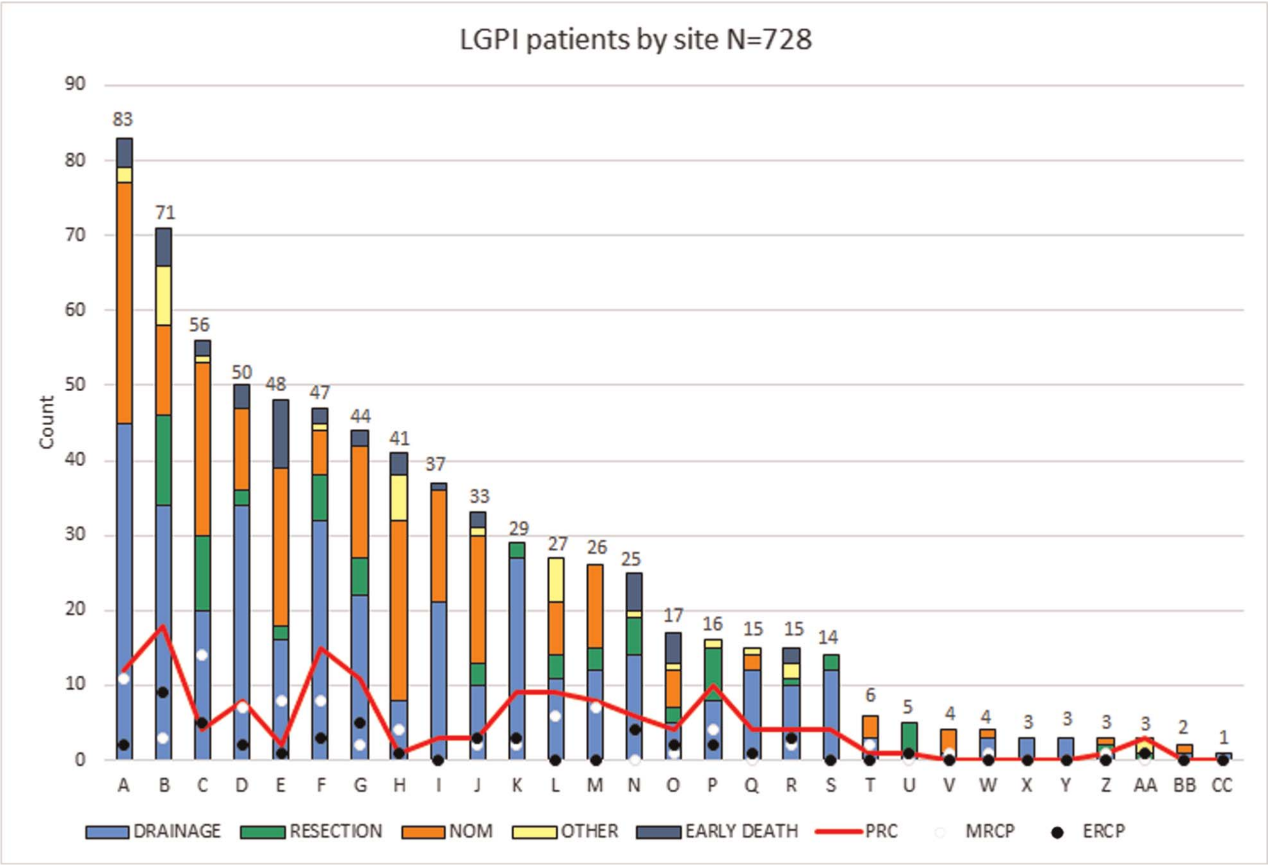

Figure 2. Contribution of patient data by site, including management strategies and outcomes.

patients sustained penetrating trauma. Two hundred and seventy-four (38%) were taken directly to the operating room without cross-sectional imaging, and 435 (60%) had focused abdominal sonographic examination for trauma. A comparison of blunt and penetrating injury patients is shown in Table 1. The percentage of penetrating injuries was greater in Grade II injuries than Grade I (43% vs. 32%, $p = 0.003$). Six hundred and eight (84%) of the patients had other intra-abdominal injuries in addition to the pancreas.

Forty-four (6%) died within 24 hours, including 17 (5%) with Grade I and 27 (8%) with Grade II injuries. At least 11 (25%) were attributed to blood loss, and three (7%) to massive brain injury; attribution was not clear for the remaining 30 patients. The deaths were equally divided between blunt and penetrating mechanisms, and at least 12 (27%) died intraoperatively. The early deaths are included in Table 1 to accurately depict the population and early management and allow comparison with previously published series. However, only those surviving more than 24 hours (n = 684) were included in analyses of definitive management and related outcomes (Tables 2–4).

Imaging

One hundred nine (15%) patients underwent initial CT and subsequent LAP. Concordance between CT and operating room injury grades was 74%: 84% for Grade I, 66% for Grade II. Of the 28 (26%) patients who had a discrepancy, 24 (86%) were graded higher on intraoperative grading—including 8 who had no injury seen on initial CT. In those who went to CT before the operating room, 81 (74%) of CT scans were obtained within 2 hours after arrival to the trauma center. Eighty-six (12%) of

TABLE 1. Summary Demographics by Mechanism of Injury, Including Early Deaths

	Blunt	Penetrating	Total	p value
	455 (63%)	271 (37%)	726*	<0.0001
Mean age (SD)	41.7 (17.8)	31.9 (13.3)	38.1 (16.9)	<0.0001
Male sex (%)	308 (68)	241 (89)	549 (76)	<0.0001
Median ISS (IQR)	26 (17, 38)	20 (14, 29)	24 (16, 34)	<0.0001
Grade I (%)	252 (55)	119 (44)	371 (51)	0.0028
Grade II (%)	203 (45)	152 (56)	355 (49)	0.0028
GSW (%)	—	215 (79)	215 (30)	—
Stab Wound (%)	—	52 (19)	52 (7)	—
Directly to operating room (%)	75 (16)	199 (73)	274 (38)	<0.0001
FAST examination (%)	304 (67)	131 (48)	435 (60)	<0.0001
FAST positive (%)	124 (41)	79 (60)	203 (28)	0.0002
Early deaths (%)	31 (7)	13 (5)	44 (6)	0.27
Late deaths (%)	42 (9)	26 (10)	68 (9)	0.87

*2 Patients had unknown mechanism.
p value = Blunt vs. Penetrating.
t Tests, Wilcoxon Test, and Two proportion z-tests were performed.
IQR, interquartile range; SD, standard deviation; GSW, gunshot wound; FAST, focused assessment with sonography in trauma.

TABLE 2. Characteristics and Management of Patients with Grade I vs. Grade II Injuries in 24 Hour Survivors

	Grade I	Grade II	Total	p
24-h Survivors	355 (52%)	329 (48%)	684	0.32
Mean age (SD)	38.8 (16.8)	37.1 (16.7)	37.9 (16.8)	0.21
Male sex (%)	265 (75)	248 (75)	513 (75)	0.83
Median ISS (IQR)	22 (14, 34)	22 (16, 34)	22 (14, 34)	0.81
Blunt mechanism (%)	238 (67)	186 (57)	424 (62)	0.0047
Penetrating mechanism (%)	116 (33)	142 (43)	258 (38)	0.0047
Direct to operating room (%)	108 (30)	146 (44)	254 (37)	0.0001
Imaging first (%)	247 (70)	183 (56)	430 (63)	0.0001
Pancreatectomy (%)	14 (4)	57 (17)	71 (10)	<0.0001
Operative drainage (%)	181 (51)	190 (58)	371 (54)	0.08
OPP (%)	8 (2)	24 (7)	32 (5)	<0.0001
NOM (%)	152 (43)	58 (18)	210 (31)	<0.0001
MRCP (%)	28 (8)	58 (18)	86 (13)	0.0001
ERCP (%)	17 (5)	31 (9)	48 (7)	0.02
Stent (%)	13 (4)	12 (4)	25 (4)	0.99

p value = Grade I vs. Grade II.
t tests, Wilcoxon test, and two-proportion *z* tests were performed.

LGPI patients underwent MRCP—59 (13%) of blunt and 27 (10%) penetrating trauma patients ($p = 0.19$). Forty-eight (7%) patients had ERCP—19 (4%) of blunt injury and 29 (11%) penetrating trauma patients ($p = 0.0008$). The use of MRCP and ERCP by center is indicated in Figure 2. A comparison of HIGH and LOW centers revealed that MRCP was obtained in 59 (12%) HIGH vs. 27 (13%) LOW ($p = 0.81$), and ERCP in 31 (6%) HIGH vs. 17 (8%) LOW ($p = 0.42$).

Definitive Management and Outcomes

Overall, 210 (31%) of patients with LGPI were managed nonoperatively. This included 56 (27%) patients who underwent LAP but the pancreas was not touched. Surgical drainage alone was performed in 371 (54%); resection (distal pancreatectomy) in 71 (10%) and other pancreatic procedures (OPPs) (debridement, suturing, inspection) in 32 (5%) (Table 2). There was a difference in management between injury grades ($p < 0.0001$); this applied to all interventions studied except stent placement ($p = 1.0$) and operative drainage ($p = 0.08$) (Table 2). In HIGH as compared with LOW centers, resection (8% vs. 15%, $p = 0.0094$) was performed less, while drainage (51% vs. 62%, $p = 0.0052$) and OPPs (4% vs. 6%, $p = 0.1913$) did not differ, and NOM was more frequent (37% vs. 16%, $p < 0.0001$). Only 25 (4%) patients received pancreatic duct stents. Nine (36%) were placed empirically/prophylactically; the other 15 (64%) were placed to treat PRCs.

A comparison of patients managed nonoperatively versus surgically is shown in Table 3. The patients who underwent NOM were older and less frequently male; their median ISS was essentially the same but statistically lower. More NOM patients had Grade I injuries (72% vs. 43%) and blunt mechanisms (90% vs. 50%). Late death rate was not different, but PRCs occurred in 4% of NOM patients versus 28% of operatively managed patients ($p = <0.0001$).

TABLE 3. Characteristics of NOM Patients NOM Versus Operatively

	NOM	Operative	Total	p
24-h survivors	210 (31%)	474 (69%)	684	—
Mean age (SD)	39.9 (17.6)	37.1 (16.7)	37.9 (16.8)	0.04
Male sex (%)	140 (67)	248 (75)	513 (75)	<0.0001
Median ISS (IQR)	21.5 (12, 33)	22 (16, 34)	22 (14, 34)	0.01
Grade I (%)	152 (72)	203 (43)	355 (52)	<0.0001
Grade II (%)	58 (28)	271 (57)	329 (48)	<0.0001
Blunt mechanism (%)	188 (90)	236 (50)	424 (62)	<0.0001
Penetrating mechanism (%)	21 (10)	237 (50)	258 (38)	<0.0001
Late death (%)	19 (9)	49 (10)	68 (10)	0.60
PRC (%)	9 (4)	132 (28)	141 (21)	<0.0001

p = NOM vs operative.
t Tests, Wilcoxon test, and two-proportion *z* tests were performed.

Factors related to the occurrence of PRCs are presented in Table 4. There was a significant difference in PRCs between Grade I (17%) and Grade II (25%) injuries. There were more PRCs after penetrating (37%) compared with blunt (11%) injuries, and more PRCs among patients who were taken directly to operating room compared with imaging first (33% vs. 13%). There were notable differences in PRCs based on the definitive management strategy. Those undergoing NOM had a significantly lower rate of PRCs than other management strategies (4%; $p < 0.001$). Among those who had surgical intervention on the pancreas, there were significantly more PRCs following resection compared with drainage alone (42% vs. 26%, $p = 0.006$). Of the 71 patients undergoing resection, the impact of a drain was evaluated: 63 (89%) had a drain and 44% of them had PRCs, vs. 25% PRCs among patients without a drain ($p = 0.50$). The method of management of the stump was also examined, and

TABLE 4. PRCs by Grade by Various Factors/Management

	Grade I, n = 355	Grade II, n = 329	Total	p
Overall (%), n = 684	60 (17)	81 (25)	141 (21)	**0.01**
Mechanism				
Blunt (%), n = 424	20 (8)	26 (14)	46 (11)	0.07
Penetrating (%), n = 258	40 (34)*	55 (39)*	95 (37)*	0.48
Initial triage				
Direct to operating room (%), n = 254	31 (29)**	53 (36)**	84 (33)**	0.20
Imaging first (%), n = 430	29 (12)	28 (15)	57 (13)	0.28
Management				
Pancreatectomy (%), n = 71	5 (36)†	25 (44)†	30 (42)†	0.58
Drainage (%), n = 371	47 (26)	50 (26)	97 (26)	0.94
OPP (%), n = 32	1 (13)	4 (17)	5 (16)	1
NOM (%), n = 210	7 (5)	2 (3)	9 (4)	0.71

p value = Grade I vs Grade II.
*Significant difference from Blunt in given column.
**Significant difference from Imaging First in given column.
†Significant difference between Pancreatectomy vs. Drainage vs. OPP vs. NOM in given column.
χ^2 test and two-proportion z tests were performed.

there was no difference between stapled with duct suture, stapled without duct suture, and hand-sewn without stapling ($p = 0.22$). Only seven (11%) patients had the pancreas hand-sewn, with 29% PRCs, while the stapling techniques were associated with 45% PRCs combined. The rate of PRCs was higher in the LOW centers (31% vs. 16%, $p < 0.0001$).

The incidence of PRCs in the presence of another intra-abdominal injury was 23%, whereas in the absence of other intra-abdominal injury it was 5% ($p < 0.0001$). There was no significant increase in PRCs related to associated duodenal, spleen, liver or kidney injuries; however, the incidence of PRCs was significantly higher in the presence of stomach (39% vs. 20%, $p < 0.0001$), small bowel (33% vs. 22%, $p = 0.03$), colon (32% vs. 21%, $p = 0.02$), or "any bowel" (30% vs. 18%, $p = 0.0006$) injuries. A multivariate model was created to identify independent predictors of PRCs, using the variables shown in Table 5. Other intra-abdominal injury (odds ratio [OR], 2.30; 95% confidence interval [95% CI], 1.16, 15.28), LOW volume (OR, 2.88; 95% CI, 1.65, 5.06) and penetrating injury (OR, 3.42; 95% CI, 1.80, 6.58) were significant independent risk factors. Resection was very close to significance (OR, 2.06; 95% CI, 0.97, 4.34) ($p = 0.0584$).

There were 68 (9%) late deaths; 2 (3%) were potentially attributed to a PRC. The subgroup of patients older than 65 years had a similar distribution of pancreatic injury grades, ISS, early death rate and PRCs compared with those younger than 65 years; however, their late death rate was 22%, compared with 8% among younger adults ($p = 0.0002$).

TABLE 5. Predictors for Pancreatic Related Complications (n = 667)

Predictor	PRC, OR (95% CI)	*p*
Grade (II)	1.14 (0.65–1.99)	0.65
Resection	2.06 (0.97–4.34)	0.0584
Other intra-abdominal injury	3.50 (1.16–15.28)	0.0490
Low volume	2.88 (1.65–5.06)	0.0002
ISS	0.99 (0.98–1.02)	0.97
Direct to operating room	1.30 (0.68–2.46)	0.43
Penetrating injury	3.42 (1.80–6.58)	0.0001

Predictor interpretations for multivariate model.
Train data set: n = 467; Test data set: n = 200.
• Grade: for Grade II injuries, the odds of pancreatic complication is 1.14 (0.65, 1.99) times as large as the odds for Grade I injuries.
• Resection: for a resections, the odds of pancreatic complication is 2.06 (0.97, 4.34) times as large as the odds for nonresections.
• Other intra-abdominal injury: when a patient has another intra-abdominal injury, the odds of a pancreatic complication is 3.50 (1.16, 15.28) times as large as the odds for those with no other intra-abdominal injuries.
• Low volume: when a patient is treated at a low volume site, the odds of a pancreatic complication is 2.88 (1.65, 5.06) times as large as the odds for a patient treated at a high volume site.
• ISS: from 0 when the ISS of a patient increases by 1, the odds of a pancreatic complication decrease by 1% (−2%, +2%).
• Direct to operating room: when a patient goes direct to operating room, the odds of a pancreatic complication is 1.30 (0.68, 2.46) times as large as the odds of those who had imaging first.
• Penetrating injury: for a penetrating injury, the odds of a pancreatic complication is 3.42 (1.80, 6.58) times as large as the odds of blunt injuries.
Multivariate pancreatic complication model fit stats.
• AUC (95% CI): 0.76 (0.697–0.8301).

DISCUSSION

According to current national and international guidelines, the management of LGPIs should be relatively standardized and straightforward: NOM of those without other reasons for LAP, and drainage or no intervention for those with LGPIs discovered intraoperatively.[3,9,10] That being said, there is very little high-quality evidence supporting those recommendations. To our knowledge, this is the largest current series of LGPIs based on granular patient-level data. There are a number of notable findings from this analysis that highlight the nuances that complicate management of LGPIs and provide data supporting a minimally invasive approach.

Diagnosis

The study of choice for diagnosing pancreatic trauma is CT scan, and it was used uniformly in those patients stable enough to undergo imaging, as well as many postoperative patients. In total, 592 patients had a CT scan. The accuracy of CT for diagnosis of MPD injury is known to be suboptimal, but there are well-described findings that are associated with higher-grade injuries.[1,2,15] In this study, the site investigators were confident in CT excluding MPD injury in more than 90% of cases, allowing NOM in many patients. There was 74% concordance between CT and OR c grading; of note, 86% of the discordant cases were graded higher in the operating room. This raises the possibility of bias, but is also consistent with the known issue of early CT potentially missing an evolving injury. The concordance might have been improved with delayed imaging.[4,15]

The main determinant of pancreas-related morbidity is MPD disruption, and there is concern that delay in diagnosis of MPD injury is associated with significant morbidity.[12–14] Consequently, MRCP has been recommended for diagnosis of MPD injury in equivocal cases.[3,9,16] In this series, probably because of the confidence in CT scanning, MRCP was used infrequently. There was an increase in MRCP use over time during the study period. Because the accuracy of MRCP has been called into question,[17] we sought to determine whether MRCP may have been responsible for some patients receiving resections—but we could not find such evidence. In this series, ERCP was used in only 7% of cases, generally with the intent of stent placement. We did not have enough information to determine the true concordance in findings and grading between CT, MRCP and ERCP. Any finding of MPD would have given the patient the diagnosis of HGPI and excluded them from this study. Stents were placed in 15 (2%) patients and were used to treat PRC in 64% of cases. Given that this was a study of LGPIs, we did not expect many stents. Details on the position of the stent—that is, ampullary versus main duct versus traversing an injury—were not available. Such details will be important in future studies on the role of stenting in the setting of pancreatic duct injury.

Nonoperative Management

Nonoperative management of adults with LGPIs was supported by studies by Duchesne et al.[18] and Velmahos et al.[19] who reported failure rates of 10% to 14%—generally related to solid organ or intestinal injuries. The current study, with 210 patients managed by NOM, reinforces current recommendations for NOM of adults with LGPIs as the rate of PRCs was just 4%. Although it did not contain specific grading information, a National Trauma Data Bank study by Siboni et al.[20] reported that patients with isolated low-grade pancreatic injuries had significantly lower mortality and length of stay compared with those undergoing LAP or any pancreatic operative procedure.

Recent large database studies have indicated an increasing trend and apparently favorable outcomes with NOM of pancreatic trauma, even among patients with more severe injuries.[21,22] However, those studies do not contain patient-level data or specific injury grading. Siboni et al.[20] noted that patients with more severe pancreatic injuries who underwent NOM had higher mortality and longer hospital stay. Moreover, data from the recent WTA multicenter study[5] do not support routine NOM of HGPIs. Thus, the current findings should not be used to justify NOM of patients with higher-grade injuries.

Operative Management

Pancreatic injuries often result from penetrating or higher-energy blunt trauma; consequently, many patients require operative intervention for other injuries. In the current series, 260 (36%) patients were taken directly to the operating room without imaging, and an additional 264 patients underwent LAP after imaging.

Pancreatic Drainage

For LGPIs discovered intraoperatively, drainage has been recommended by authors for decades,[23–25] and it is the recommended approach in current guidelines.[3,9,10] We were surprised by the relatively high rate of PRCs (26%) in our patients managed with surgical drain placement. The incidence of PRCs was the same in Grade I and Grade II patients. The Memphis group[26] previously reported a much lower morbidity rate after drainage (11%); differences in our study populations are not clear. It is difficult to explain our high rate of PRCs after drainage. It is possible that some of our patients had a missed MPD laceration and some of the injuries were undergraded. It is known that PRCs are relatively frequent (33–44%) when drainage alone is performed for Grade III injuries.[5,27] Perhaps exploration of the lesser sac, opening of the retroperitoneum, and placement of a drain disrupts tissue planes enough that it precludes containment and reabsorption of pancreatic secretions. Alternatively, it may be that the patients who underwent operative management had more severe pancreatic injuries than those who were selected for NOM. We do not have the information to determine the outcomes of lacerations versus contusions, or injuries of different sizes; these factors should be explored in prospective studies.

Pancreatic Resection

The most alarming finding in the current series is the incidence of PRCs after pancreatic resection. Distal pancreatectomy is not recommended for Grade I or II injuries, yet it was performed for 4% of Grade I injuries and 17% of Grade II injuries. The PRC incidence was 40%—the same as we recently found for HGPIs,[5] and similar to that in a recent AAST study.[2] The PRC incidence after resection was not different between blunt or penetrating trauma nor was it impacted by the urgency of the need for surgery. The method of pancreatic closure did not appear to relate to PRCs, but our numbers of resections were small. We did not have data on staple height or the use of Seamguard or other adjuncts.[28] Future studies should focus on measures to reduce leak after resection.

It was difficult to discern the specific reason for resection in these patients. It is recognized that intraoperative grading, like CT grading, is imperfect.[2,5] The CT findings and intraoperative criteria for MPD injury have been described,[12,15] but nothing is 100% accurate. In the operating room, the surgeon must make an assessment. In the interest of decreasing morbidity, the approach espoused by the Memphis group[26,29] is sound: in the absence of highly suspicious intraoperative findings for MPD injury, drainage is recommended over resection.

Outcomes

We found that the presence of other intra-abdominal injuries was associated with a significantly higher rate of PRCs (22% vs. 5%, $p < 0.05$), and was an independent risk factor on multivariate analysis. The presence of a pancreatic injury has been found in contemporary series to increase the morbidity associated with other injuries (e.g., duodenum,[30,31] colon[32]), but the converse has not been conclusively demonstrated. A previous WTA multicenter trial on distal pancreatectomy found that the presence of a hollow viscus injury doubled the risk of intra-abdominal abscess.[33] However, Rozich et al.[34] pointed out that their data and that of others did not support the notion that hollow viscus injuries or multivisceral resections increased the risk of postoperative pancreatic fistula following resection. Thus, our findings in a population of LGPI patients should be studied further. Specific injury patterns may help elucidate patients at higher risk.

Penetrating injury mechanism was another independent risk factor for PRCs. This raises the question of whether a Grade I or II laceration (potentially more likely after penetrating injury) is a higher risk injury than a Grade I or II contusion. In the AAST-OIS grading scale,[11] the differentiation between LGPIs and HGPIs is relatively straightforward. However, the differentiation between Grade I and Grade II injuries is more subjective: there is no clear definition of a minor versus major contusion, or superficial versus major laceration. We found a difference in the rate of PRCs between Grade I and Grade II injuries (17% vs. 25%, $p = 0.01$), but did not have further information on lacerations versus contusions. This may be an important differentiation and more detail on the injury should be included in data collection in future studies.

Patients managed in a “low-volume” center—albeit a relative number in this series—had a higher rate of PRCs. Perhaps not coincidentally, the LOW centers performed more resection and less NOM. This suggests an opportunity to identify best practices from better-performing centers, and highlights the need for prospective study to identify the optimal management strategy. In a model excluding HIGH versus LOW, resection was significant independent risk factor for PRCs (OR, 2.26; 1.11–4.58) ($p = 0.0235$). Given that the distinction between HIGH and LOW centers was small, we feel that resection is an objective risk factor that should not be ignored.

Given that one half of the LAP patients underwent imaging first, it may suggest that avoidance of LAP will offer greater benefit to the patient. The concern over morbidity resulting from delays to surgical treatment of pancreatic injury is not clear at this time, and recent series have been underpowered to answer the question.[5,7] Thus, this is an area deserving of further study. On the other hand, NOM may not be an option in many cases, limiting the ability to improve on the results. Among the LGPI patients, PRCs were more frequent among the patients who were taken directly to the operating room—a surrogate for more severe injury or more physiologic derangement.

Strengths

This multicenter trial represents a broad spectrum of trauma centers and is, to our knowledge, one of the largest reported series of LGPI outside of administrative database studies. We were able to collect more granular patient-level data than what is available in such databases and had opportunities to clarify interventions and timelines. Thus, we have reliable data that are generalizable.

Limitations

This study was retrospective in design and suffers from all the limitations of such studies. Specific to this study, injury grading may have been inaccurate as CT scanning, intraoperative assessment, and MRCP all have shortcomings and trauma registry data may not be correct. We tried to overcome this by having each grade adjudicated, but incomplete data do not allow assessment of concordance in grading. Definitive management may have been influenced by factors other than the injury grade and our ability to determine clinical decision making was limited. The recording of PRCs was based on retrospective review rather than prospective documentation with strict definitions. Data may not be representative of management across the country as the majority was collected from academic centers with WTA members. However, a broad range of centers are represented, so these data and the conclusions should be generalizable. The study period ended in October 2018, so more recent data are not included, and it is possible that ongoing evolution in care is occurring.

CONCLUSIONS

The incidence of PRCs in LGPIs overall is 21%. The rate of PRCs after surgical resection of LGPIs (42%) is equivalent to that seen in HGPIs. Those who underwent surgical drainage had a PRC incidence of 26%, but only 4% of those who underwent NOM had PRCs. The age-old surgical dictum, "Do not mess with the pancreas" remains sage advice. Resection is not indicated for LGPIs—and if given a choice, NOM appears to be preferable to operative drainage. In the presence of highly-suspicious findings on CT (e.g., laceration involving greater than 50% of the width of the pancreas, pancreatic contusion, or active hemorrhage)[15] but no other indications for LAP, cholangiopancreatography should be considered to look for MPD injury. The NOM strategy should be studied prospectively, particularly in patients with other intra-abdominal injuries. Patients managed in a lower-volume center, and those with other intra-abdominal injuries, are at risk of PRCs. Penetrating injury is another independent risk factor; further study is warranted to identify differences between blunt and penetrating pancreatic injuries, and whether the same management strategies apply to both.

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DISCLOSURE

The authors declare no or conflicts of interest.

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