

The epidemiology of and outcome from pancreatoduodenal trauma in the UK, 1989–2013

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ABSTRACT

INTRODUCTION Pancreatoduodenal (PD) injury is an uncommon but serious complication of blunt and penetrating trauma, associated with high mortality. The aim of this study was to assess the incidence, mechanisms of injury, initial operation rates and outcome of patients who sustained PD trauma in the UK from a large trauma registry, over the period 1989–2013.

METHODS The Trauma Audit and Research Network database was searched for details of any patient with blunt or penetrating trauma to the pancreas, duodenum or both.

RESULTS Of 356,534 trauma cases, 1,155 (0.32%) sustained PD trauma. The median patient age was 27 years for blunt trauma and 27.5 years for penetrating trauma. The male-to-female ratio was 2.5:1. Blunt trauma was the most common type of injury seen, with a ratio of blunt-to-penetrating PD injury ratio of 3.6:1. Road traffic collision was the most common mechanism of injury, accounting for 673 cases (58.3%). The median injury severity score (ISS) was 25 (IQR: 14–35) for blunt trauma and 14 (IQR: 9–18) for penetrating trauma. The mortality rate for blunt PD trauma was 17.6%; it was 12.2% for penetrating PD trauma. Variables predicting mortality after pancreatic trauma were increasing age, ISS, haemodynamic compromise and not having undergone an operation.

CONCLUSIONS Isolated pancreatic injuries are uncommon; most coexist with other injuries. In the UK, a high proportion of cases are due to blunt trauma, which differs from US and South African series. Mortality is high in the UK but comparison with other surgical series is difficult because of selection bias in their datasets.

KEYWORDS

Trauma – Pancreatic trauma – Pancreatic duct injury – Duodenal trauma

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Trauma is a major global health problem. Each year 5.8 million people die from injury. It is the leading cause of death of men and women under 45 years of age, and it is responsible for more productive years of life lost than heart disease and cancer combined.¹ Pancreatoduodenal (PD) trauma is uncommon but associated with mortality rates varying from 3% to 44%, depending on inclusion criteria.^{2–14} This is often due to an associated vascular injury, owing to the proximity of the pancreas to the aorta, inferior vena cava, portal and superior mesenteric vessels. Early deaths are from haemorrhage, and late deaths from infection and sepsis.

The relative scarcity of literature pertaining to this problem leads to the difficulty of determining the optimal management of these injuries. Timely diagnosis of PD trauma is challenging because of the retroperitoneal location of the pancreas and duodenum, the non-specific nature of accompanying symptoms and signs, and the lack of accuracy of serological tests and imaging modalities.^{15,16} This is

particularly the case in blunt PD trauma. Once a diagnosis of PD trauma has been made, the optimal management is not well established. The situation has become increasingly complex in the new era of non-operative management of PD trauma. The literature mainly consists of single centre, small series, especially of cases managed exclusively by operative means. New technology and new surgical strategies may have rendered many previous conclusions invalid.

Most reported series, to date, are from the US^{2–4,6,9,11,12,14} and South Africa,^{5,15} and report a high proportion of penetrating trauma. The findings from these studies may therefore not be directly applicable to other countries with different patterns of trauma, such as the UK and much of Europe. The aim of this study was to assess the incidence, mechanisms of injury, management and outcome of patients who sustained PD trauma in the UK, from a large trauma registry, over the period 1989–2013.

Methods

The Trauma Audit and Research Network (TARN) database was searched for details of any patient with blunt or penetrating trauma to the pancreas, duodenum or both. TARN is a collaboration of hospitals from England, Wales and Northern Ireland. The aims of TARN are to collect and analyse clinical and epidemiological data (thereby providing a statistical base to support clinical audit), to aid the development of trauma services and to inform the research agenda. TARN has been operating since 1989 and has grown from an initial group of 13 hospitals to 100% of trauma receiving hospitals in England and Wales ($n=192$). The TARN database is the largest trauma database in Europe, with more than 350,000 records.

Hospital data coordinators entered data on all those injured patients who either had a length of stay of >3 days, were admitted to an intensive care area, died or were transferred for specialist care. TARN excludes all simple isolated limb injuries and isolated fractured neck of femur/pubis in patients aged over 65 years. Patients meeting the above criteria were identified initially in the accident and emergency department, and were followed up by a local TARN coordinator, who collected details on patient demographics, type and mechanism of injury, haemodynamic stability on presentation, injuries sustained, management and outcome. Patients were followed to three months, discharge or death.

TARN recorded the type of first operation undertaken but not details of any subsequent operations prior to 2005. Injuries were described and scored using the abbreviated injury scale (AIS) 2005 revision described by the Association for the Advancement of Automotive Medicine.¹⁷ Pancreatic trauma patients were defined as those sustaining any of the AIS codes 542810–542899 and duodenal trauma patients as those sustaining any of the AIS codes 541010–541099. Additional grading of injury used the American Association for the Surgery of Trauma (AAST) organ injury scales.¹⁸ The injury severity score (ISS) was determined to assess the severity of overall injuries sustained.¹⁹

Data validation and quality assurance

An online electronic data collection and reporting system (EDCR) has been in use since September 2005. The EDCR prevented users from dispatching submissions with incomplete obligatory data fields. Prior to this, submissions were provided on paper and scanned into a disk operating system form database. Validation procedures were in place that checked for accuracy in date/time sequencing, physiological measurements and investigations, during both periods. All coders were trained in injury coding, and their work was subjected to validation and internal quality checks on a weekly basis.

Statistical analysis

Differences between subgroups of patients were tested by using chi-squared, Fisher's exact and Mann–Whitney U tests. Independent predictor variables for the outcome of

pancreatic trauma were analysed using multiple logistic regression. Overall model fit assessment was with the Hosmer–Lemeshow (goodness of fit) test. Two-tailed p -values of <0.05 were considered statistically significant. All analyses were undertaken using SPSS® version 16 (SPSS, Chicago, IL, US).

Results

Overall, 1,155 (0.32%) of the 356,534 trauma cases on the TARN database sustained blunt or penetrating PD trauma between 1989 and 2013. This represents 4.7% of the 24,595 cases with abdominal trauma. A total of 901 patients (78.0%) sustained blunt PD trauma and 254 (22.0%) sustained penetrating PD trauma. Of the 901 with blunt trauma, 529 patients (58.7%) sustained pancreatic trauma, 309 (34.3%) sustained duodenal trauma, and 63 (7.0%) sustained an injury to both the pancreas and duodenum. Of the 254 with penetrating trauma, 119 patients (46.9%) sustained pancreatic trauma, 122 (48.0%) sustained duodenal trauma, and 13 (5.1%) sustained an injury to both the pancreas and duodenum. These different proportions based on type of injury pattern were statistically significant ($p<0.001$).

The median age was 27 years (interquartile range [IQR]: 16–45 years) for blunt PD trauma and 27.5 years (IQR: 21–40 years) for penetrating PD trauma. The male-to-female ratio was 2.5:1. The median ISS was 25 (IQR: 14–35) for blunt trauma and 14 (IQR: 9–18) for penetrating trauma ($p<0.001$). Further characteristics of the population are described in Table 1.

Mechanism of injury

The ratio of blunt to penetrating PD trauma was 3.6:1. Road traffic collision was the most common mechanism of injury, accounting for 664 of the 901 cases (73.7%) with blunt PD trauma and 673 of the 1,155 total number of cases (58.3%). Stab injuries accounted for 163 of 254 patients sustaining penetrating PD trauma (64.2%). Gunshot injuries accounted for 50 of 254 patients sustaining penetrating PD trauma (11.8%). Appendix 1 (available online) gives further information on the mechanisms of injury.

Extent of associated injuries and grade of PD trauma

Pancreatic trauma was associated with injuries to other intra-abdominal organs or other extra-abdominal regions including the abdomen (86.5%), chest (44.8%), head (17.8%), extremities (35.6%) and spine (19.0%). Associated intra-abdominal injuries most commonly affected other solid organs: 386 (33.4%) had liver injury, 290 (25.1%) had splenic injury and 208 (18.0%) had renal injury. Further details of associated intra-abdominal injuries are given in Table 2. Patients had a mean of 7 other injuries.

The majority of patients had AAST grade I injuries for pancreatic ($n=498$) and duodenal ($n=269$) trauma (Table 3). The median AIS was 3 for blunt (IQR: 2–4) and 2 for penetrating (IQR: 2–2) pancreatic trauma. The median AIS was 3 for blunt (IQR: 2–4) and 3 for penetrating (IQR: 2–3) duodenal trauma.

Table 1 Characteristics of the population with pancreatoduodenal injuries

		Type of injury		p-values
		Blunt (n=901)	Penetrating (n=254)	
Median age (IQR)		27 (16–45)	27.5 (21–40)	0.071*
Median ISS (IQR)		25 (14–35)	14 (9–18)	<0.001*
Median GCS (IQR)		15 (13–15)	15 (15–15)	<0.001*
Haemodynamic compromise	SBP 90mmHg	809 (89.8%)	226 (89.0%)	0.758**
	SBP <90mmHg	92 (10.2%)	28 (11.0%)	
Sex	Male	619 (68.7%)	210 (82.7%)	<0.001**
	Female	282 (31.3%)	44 (17.3%)	

IQR = interquartile range; ISS = injury severity score; GCS = Glasgow coma scale; SBP = systolic blood pressure

*Mann–Whitney U test; **chi-squared test

Table 2 Numbers of patients with additional abdominal injuries

Injuries (n=735, 63.6%)	n
Liver	386 (33.4%)
Spleen	290 (25.1%)
Kidneys	208 (18.0%)
Colon	140 (12.1%)
Stomach	95 (8.2%)
Inferior vena cava	31 (2.7%)
Mesentery	16 (1.4%)
Bladder	12 (1.0%)
Adrenal glands	3 (0.3%)

Isolated PD injuries

Only 156 patients (13.5%) had an isolated PD injury; 132 of these were due to blunt mechanisms and 24 were due to penetrating mechanisms. The median age was 16 years (IQR: 9–24 years) for blunt injury patients and 24 years (IQR: 18–36 years) for penetrating injury patients ($p=0.0005$). Of the 156 patients, 114 were male and 42 female. The median ISS was 9 (IQR: 4–16) for blunt PD trauma and 7 (IQR: 4–9) for penetrating PD trauma ($p=0.026$). Sixty-six patients (50.0%) with isolated blunt PD injury underwent surgery while for cases with isolated penetrating PD injury, twenty-one (87.5%) underwent surgery ($p=0.003$). None of the patients with an isolated PD injury died. The postoperative complication rate was 11.5%. Appendix 2 gives further information on the isolated PD injury group.

Diagnosis and management

Diagnosis of PD trauma was made by computed tomography (CT) in 634 cases and other imaging in 229 cases.

Table 3 Frequency of grades of pancreatic and duodenal trauma, according to the American Association for the Surgery of Trauma organ injury scales

Pancreas	n
Grade I	498 (68.8%)
Grade II	23 (3.2%)
Grade III	87 (12.0%)
Grade IV	46 (6.4%)
Grade V	70 (9.7%)
Total	724 (100%)
Duodenum	n
Grade I	269 (53.1%)
Grade II	28 (5.5%)
Grade III	84 (16.6%)
Grade IV	64 (12.6%)
Grade V	62 (12.2%)
Total	507 (100%)

Almost two-thirds (61.9%) of cases with blunt PD trauma underwent an initial operation for trauma. For penetrating PD trauma, the proportion was higher (79.9%). These first operations were categorised as laparotomies ($n=532$, 46.0%), musculoskeletal procedures ($n=82$, 7.1%), neurosurgery ($n=27$, 2.3%) and thoracotomies ($n=25$, 2.2%). Four hundred and ninety patients had more than one category of operation.

A third of patients ($n=394$, 34.1%) had no operation during their hospital admission. Over half ($n=650$, 56.3%) required admission to an intensive therapy unit, with a median length of stay of 4 days (IQR: 2–11 days).

Table 4 Logistic regression analysis predicting outcome (mortality) for all pancreatoduodenal trauma patients; Hosmer–Lemeshow test: $\chi^2=5.41$, $df=8$, $p=0.713$

Predictors	OR	95% CI	p-value
Age	1.038	1.028–1.048	<0.001
Injury severity score	1.085	1.066–1.104	<0.001
Haemodynamic compromise (yes)	2.254	1.321–3.845	0.003
Had operation (yes)	0.477	0.314–0.725	0.001
Year of admission	0.937	0.910–0.965	<0.001
Number of injuries	1.038	0.996–1.083	0.080

OR = odds ratio; CI = confidence interval

Mortality

The overall mortality rate for blunt PD trauma was 17.6%; for penetrating PD trauma, it was 12.2%. For blunt trauma cases, mortality rates were 21.2% for pancreatic trauma, 13.6% for duodenal trauma and 20.6% for combined PD trauma. The corresponding mortality rates for penetrating trauma were 16.8% for pancreatic trauma, 7.4% for duodenal trauma and 15.4% for combined PD trauma.

Logistic regression was used to determine factors associated with outcome (mortality). This was undertaken via a forward selection procedure. Variables predicting mortality after pancreatic trauma were increasing age, ISS, haemodynamic compromise (defined as a systolic blood pressure of <90mmHg) and not having undergone an operation (Table 4). Year of attendance was also an important predictor, reflecting general improving trauma outcomes over the study period. Factors found not to be related to outcome were sex, mechanism of injury and number of associated intra-abdominal or extra-abdominal injuries.

Discussion

This study shows that PD trauma is an uncommon but serious complication of blunt and penetrating trauma: 1,155 cases of PD trauma were recorded on the TARN database of over 350,000 cases, between 1989 and 2013. This represents 0.32% of all trauma or 4.7% of all abdominal trauma recorded by TARN during this time. The associated mortality with PD trauma is high. For blunt trauma, the mortality rate for PD trauma was 17.6% and for penetrating trauma, the mortality rate was 12.2%. PD trauma is predominantly a disease of young men. Perhaps most significantly, 78.0% of this UK series consisted of trauma caused by blunt mechanisms, especially road traffic collisions. Isolated pancreatic injuries are uncommon; most coexist with other intra-abdominal or extra-abdominal injuries.

The epidemiological findings from this study are comparable with those of other studies. The Scottish Trauma Audit Group (STAG), who collected data using similar methodology to TARN between 1992 and 2002, identified 111 patients (0.2%) with pancreatic trauma from their database of 52,676 trauma patients.⁷ Series derived from other large databases

have produced similar results: 70 (0.2%) of 32,744 trauma patients in South Africa⁵ as well as 72 (0.4%) of 16,188 patients² and 76 (0.6%) of 12,252 patients from the US.⁹ In general, higher pick-up rates are found in the series from well established trauma centres in the US and lower rates from developing countries or countries where trauma services have only recently undergone centralisation, such as the UK.

The most obvious difference between trauma in the UK and studies from the US and South Africa revealed by this study is a practically inverse proportion of cases due to blunt rather than penetrating trauma. A recent notable review of pancreatic trauma in *The American Surgeon* stated that 'pancreatic injury due to penetrating mechanisms is more common [than blunt trauma] in adults'.²⁰ While this may be true in the US and particularly in South Africa, it is not true in the UK. Over three-quarters (78%) of the cases in this TARN series consisted of trauma caused by blunt mechanisms, especially road traffic collisions. This proportion differs from that reported from the US and South Africa; in the latter country, up to 78% of PD trauma cases were due to penetrating mechanisms of injury.^{5,15}

The median age was 27 years for blunt PD trauma and 27.5 years for penetrating PD trauma. Almost three-quarters (71%) of the patients were male. The median age in the STAG study was 32 years,⁷ and very similar medians have been reported from the US and South Africa.^{3–6,9,11–14} The male-to-female ratio is also very consistent with these studies: 76% of the patients in the STAG study were male⁷ and 71% of 230 patients with PD trauma were male in a recent large series from the US.¹² The highest proportion of male patients was recorded from two series in South Africa, where 94–95% of patients with PD trauma were male.^{5,15} The link between male sex and trauma is well established, and it is most pronounced in series with a higher proportion of penetrating trauma, especially due to gunshot injuries.¹⁵

Isolated pancreatic injuries are uncommon; most coexist with other intra-abdominal or extra-abdominal injuries. The most common intra-abdominal organs to be injured were the liver, spleen and kidney. The grade of injury (according to AIS and AAST) was predominantly low. The median AIS was 3 for pancreatic trauma, 3 for blunt duodenal trauma and 3 for penetrating duodenal trauma. Many classification systems exist, especially for the pancreas,²¹ but the key distinction for surgical management is between those with pancreatic ductal integrity and those without. This corresponds to grade III or higher in the AAST classification and accounted for 23% of patients in this series. Of the 111 patients with pancreatic trauma in the STAG study, 18 (16.2%) had an AIS of 3 or higher.⁷ This is similar, if not directly comparable, as an AIS of 3 includes those AAST grade II patients with a major laceration but without duct injury.

Comparison with other surgical series is unreliable because of selection bias in the latter datasets. Most series report only those patients managed exclusively by operative means or, less commonly, non-operative means but most authors agree that determining duct integrity is

crucial to the management of pancreatic injuries.^{2,5,6–8,10,15–16,22} Mortality associated with PD trauma is high. For blunt trauma, the mortality rate for PD trauma was 17.6% and for penetrating trauma, it was 12.2%. At first glance, these rates may seem alarmingly high compared with other series. However, similar considerations of selection bias exist when making comparisons with series of operative and non-operatively managed PD trauma. Series from the US frequently report mortality rates in single digits but these have often excluded those who have died in the resuscitation room, during the first 24 or 48 hours, or those who had coexisting vascular injury.^{4,9,11,14}

Variables predicting mortality after pancreatic trauma in this study were increasing age, ISS, haemodynamic compromise and having undergone an operation. Similar findings have been found by STAG, who identified overall number of injuries, age, male sex, blunt trauma and haemodynamic compromise as independent risk factors for death.⁷ The study of Chinnery *et al* with 219 civilian gunshot injuries to the pancreas from Cape Town, South Africa, found that age, shock on admission, need for damage control surgery, high grade injury and associated vascular injuries were associated with mortality on multivariate analysis.¹⁵ We conclude that patients with PD trauma die mainly from exsanguinating injuries to other organs rather than as a consequence of PD trauma itself.

There are a number of limitations to this study. These include a lack of data that might have shed some light on the specific management of isolated PD trauma. The diagnostic accuracy of CT is dependent on the grade of injury and the timing of the imaging. It remains uncertain how this has changed over time, especially with the introduction of modern spiral and multichannel scanners. Low sensitivity for detecting PD injury is still being reported, even with 16 and 64-multidetector CT scanners.²⁵ Amylase and lipase levels are suggestive of pancreatic injury but are not always diagnostic.^{24,25}

The optimal management of PD trauma, once a diagnosis has been established, remains unclear owing to the lack of high quality evidence. However, guideline documents and algorithms emphasise that identification of pancreatic duct injury is crucial.^{14–16} If present, these cases are best managed operatively. There is a growing trend for non-operative management of lower grade injury.⁹ Randomised studies on the role of octreotide in pancreatic injury are conflicting.^{26,27} Small case series have demonstrated encouraging results with endoscopic transpapillary pancreatic duct stenting^{28,29} but concerns remain about long-term duct stricturing. The TARN database was not designed to address all these controversies but future research should focus on these unresolved questions. Engagement by the general surgical community in the design and collection of data in large scale trauma registries, such as TARN, will enable progress to be made.

The 2007 report of the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) identified that more than half of the patients (415/795, 52%) in its study were subjected to less than good practice in the UK.⁵⁰ Good practice was higher in hospitals with >20 cases. The

development of performance improvement programmes for specialist trauma services identifies opportunities for improvement and reduces preventable death rates in this setting.^{51,52} Supported by these findings, the revised NHS Operating Framework for 2011–2012 stated that all regions should move towards networks for trauma.⁵³ The setup of a majority of regional trauma networks was already in place by April 2012.

Our study also supports the view that major trauma in the UK is insufficiently common for all hospitals to receive adequate volumes of cases to achieve outcomes commensurate with those reported from mature trauma systems in other developed countries. Our data help form a baseline to which the future results of UK major trauma units may be compared.

Conclusions

Our study concerning a 24-year period in the UK shows that PD trauma is a serious albeit uncommon complication of trauma. It is associated with high mortality and is seen overwhelmingly in blunt rather than penetrating trauma.

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