Signature: © Pol J Radiol, 2008; 73(3): 37-45

Polish Journal of Radiology
www.PolRadiol.com
ORIGINAL ARTICLE

Received: 2008.03.06
Accepted: 2008.05.27

Imaging of blunt pancreatic trauma: The value of initial and sequential CT examinations

Wojciech Szmigielski[1], Adham Darweesh[2], Hassan Kassem[2], Shatha Alhilli[2], Mustafa Ismail[3], Hisham Allam[4]

[1] Department of Radiology, Hamad Medical Corporation, Al Amal Hospital, Doha, Qatar
[2] Department of Radiology, Hamad Medical Corporation, Hamad General Hospital, Doha, Qatar
[3] Department of Radiology, Hamad Medical Corporation, Rumailah Hospital, Doha, Qatar
[4] Department of Surgery, Hamad Medical Corporation, Hamad General Hospital, Doha, Qatar

Author's address: Wojciech Szmigielski, Department of Radiology, Hamad Medical Corporation, Al Amal Hospital, P.O. Box 3050, Doha, Qatar, e-mail: w.szmigielski@gmail.com

Summary

Background: The purpose of the study was to assess the value of initial, repeated and sequential computed tomography (CT) in patients with blunt pancreatic trauma, and then define and correlate CT findings with endoscopic retrograde cholangiopancreatography (ERCP) or magnetic resonance cholangiopancreatography (MRCP), ultrasound (US), both laboratory and surgical findings.

Material/Methods: This retrospective study covers an eight-year period from 1999 to 2007. The material includes 21 patients (17 males and 4 females) with confirmed pancreatic injury. CT was performed on admission in all cases and in 15 cases follow-up CT was performed from 24 hrs to 14 days later. US was performed in 9 cases, ERCP in 8 cases and MRCP in one case. Serum amylase level was obtained at the admission in all cases.

Results: The CT at admission was positive in 17 patients (81.0%); the diagnosis was missed in 4 patients (19.0%), all performed on single row spiral CT. In all these four cases repeated CT was positive. ERCP showed rupture of the main pancreatic duct in 7 cases, one was inconclusive. One MRCP was positive. The serum amylase was elevated in 14 cases (66.7%) Specific CT features in initial and repeated examinations together were: organ fracture – 33.3%, swelling – 38.1%, haematoma/contusion – 38.1%, fluid between splenic vein and pancreas – 19.0%. Non-specific features were: thickening of anterior-renal fascia – 23.8%, fluid in lesser sac – 28.6%, extra peritoneal fluid – 42.9%, associated splenic injury – 14.3% and intraperitoneal fluid – 38.1%. On retrospective analysis, two out of four false negative CT results could have been avoided. No correlation between the CT features and the outcome of surgical and conservative management could be found in this study.

Conclusions: A proper technique and accurate reading of images are mandatory for the diagnosis of pancreatic injury. When CT performed on admission is negative and there is abdominal pain and an elevated serum amylase, CT examination should be repeated within 24-48 hours.

Key words: pancreas • injury • CT • ERCP • MRCP • ultrasound

PDF file: http://www.polradiol.com/fulltxt.php?ICID=866877

Background

Injuries to the pancreas are uncommon and account for 2–12% of severe abdominal trauma [1–3]. Most pancreatic injuries occur in young men, often following blunt or penetrating trauma. Blunt trauma is far more common, and usually results from motor traffic accidents, when an unrestrained driver is thrown onto the steering wheel, or secondary to lap seat belt injury [4]. These injuries occur after a sudden force compresses the pancreas against the lumbar spine. Handlebars may cause similar injuries to motorcyclists or children on bicycles [1].

The proper and timely diagnosis is very important, since any delay in recognition of pancreatic injury can cause the delay in effective treatment and significantly increases morbidity and mortality [5–7].

Pancreatic injuries occurring to the right of the mesenteric vessels are defined as proximal, while those to the left of the mesenteric vessels were defined as distal [8]. Transsection of the pancreas is more common to the left of the mesenteric vessels and occurs when there is compression over the spine. Injuries to the right of the midline may cause more serious crushing injuries of the pancreatic head and duodenum [4].

Isolated pancreatic injuries are uncommon due to retroperitoneal location and proximity of multiple organs and major vascular structures. Therefore, they are usually associated with other visceral injuries, e.g. the duodenum, spleen, liver, kidney or with fractures of the lumbar spine [7,9]. As a result of associated injuries, pancreatic trauma might be overlooked at presentation [4]. Radiological findings maybe subtle in the acute phase, compared with lesions in the liver and spleen. Associated injuries may be assumed to be responsible for free intraperitoneal fluid or inflammatory changes in the upper abdomen [4].

The aim of the study

The purpose of the study was to assess the value of initial, repeated and sequential CT examinations in patients with blunt pancreatic trauma and to define and correlate CT findings with endoscopic retrograde cholangiopancreatography (ERCP) and magnetic resonance cholangiopancreatography (MRCP), both laboratory and operative findings.

Material and Methods

This retrospective study covers an eight-year period from 1999 to 2007 and includes material of 21 patients (17 males and 4 females) with confirmed pancreatic injury (Table 1). The age range was 4–38 years (mean age 19,7 years). Six (28.6%) of our patients were children below 14 years old. The causes of pancreatic trauma were: car accidents – 10, bicycle accidents – 5, fall from a camel – 3 and hit by heavy object – 3 cases. All patients had CT examination on admission to the hospital after having sustained blunt abdominal trauma. In 15 cases follow-up CT was performed from 24 hrs to 14 days later. US was done prior to the CT in 9 cases. ERCP in 8 cases and MRCP in one case.

First 15 patients were examined on a fourth generation, one row helical CT scanner (Somatom Plus 4, Siemens, Germany). A spiral volume was acquired, using 8 mm collimation (pitch 1:1) from the diaphragm to iliac crest. This was followed by another spiral acquisition with collimation of 10 mm to cover the rest of the pelvis. In selected areas an overlapping reconstruction at 2–3 mm intervals was obtained. The scanning followed an i.v. administration of 110–130 ml of non-ionic contrast medium (Iohexol 300 mg Iodine/ml, Schering, Germany) at an injection rate of 2–3 ml/sec. Total injected volume and injection rate was adjusted according to the patient's age, weight, estimated cardiac output and size of the cannula through which injection was given. 3% Gastrografin (Schering, Germany) or non-ionic Gastromiro (Bracco, Italy) were used as oral contrast administered 30 min – 1 hour before the examination. In unstable patients an immediate scanning with the use of only i.v. contrast was performed. The last 5 patients were examined with the use of 64-multislice CT (Sensation 64, Siemens Germany). A spiral acquisition volume covered the chest, abdomen and pelvis with 8 mm collimation followed by 2 mm reconstruction and multiplanar reformatting.

Thirteen patients underwent surgical treatment. Four patients had CT guided drainage. Five patients were treated conservatively. Serum amylase level was obtained at the admission in all cases. The medical charts, laboratory data, CT scans and operative details were analysed retrospectively.

The analysis of CT images was based on CT findings of blunt pancreatic trauma, which include specific and non-specific features [4]. For the purpose of grading, a modified classification of Lucas [10] was used, which also considers combined duodenal and main pancreatic duct lesions (Table 2).

Results

The results are shown in Table 1 and Figures 1–4. CT at admission was positive in 17 patients (81.0%). The diagnosis was missed in 4 patients (19.0%), all performed on single row spiral CT. However, repeat CT in these all four cases proved positive, with either specific or non-specific features of pancreatic trauma.

Out of a total of 21 patients with pancreatic trauma, in 9 (42.9%) injury occurred in the tail, in 9 (42.9%) at the head and neck and in 3 cases (14.3%) in the body of the organ. Nine patients (42.9%) had an isolated pancreatic injury and twelve (57.1%) had combined with other abdominal organ injuries. An extraluminal accumulation of the oral contrast medium was observed in one patient (4.8%) and retroperitoneal gas in one patient (4.8%); in both perforation of the duodenum was confirmed at surgery. Injury of the liver was found in six cases (28.6%), and contusion of the spleen in three cases (14.3%). Renal contusion was found in four patients (19.0%); there were three right and two left kidneys injured. This includes one patient with both kidneys injured. The haematoma of the suprarenal gland (left) was found in one case (4.8%). Brain contusion, fractures of the spine and extraxial skeleton were observed in two cases.

The specific and non-specific diagnostic features for blunt pancreatic trauma in our 21 cases are shown in Tables 3 and 4, with grading of severity of pancreatic injury in Table 5.

No correlation between the CT features and the outcome of surgical and conservative management could be found in this study.

ERCP was performed in eight cases and in seven of them (88%) the rupture of the pancreatic duct was found, one examination was inconclusive. Out of seven ERCP positive cases, rupture of the main pancreatic duct was missed by

Table 1. Patients' data, clinical and radiological findings in blunt pancreatic trauma.

Case No	Sex/age; type of injury	Amylase (U/L) at admission (normal 30–100)	CT at admission	Follow-up CT	ERCP*/ MRCP**	Lucas classification	Treatment
1	M/22; fall from a camel	90	Missed pancreatic injury, Rt kidney haematoma	Swelling of pancreatic tail with fluid around	Not done	I	CT guided drainage,
2	F/22; hit by a car	175	Pancreatic body contusion with peri-pancreatic collection, injury to the liver and Lt kidney	Increased peri-pancreatic collection	*Rupture of the main pancreatic duct	IVa	Conservative
3	M/12; fall from bicycle	1105	Pancreatic head swelling and neck laceration	Not done	*Rupture of the main pancreatic duct	III	Caudal pancreatectomy and sump drainage
4	F/4; fall from bicycle	620	Liver injury; missed pancreatic injury	Tear of the body with pancreatic and peripancreatic collection	*Rupture of the main pancreatic duct	IVa	Sump drainage
5	M/8; fall from bicycle	105	Transsection of the neck with peri-pancreatic collection	Increased collection and pseudocyst formation	*Rupture of the main pancreatic duct	III	Cystogastrostomy
6	M/22; car accident	920	Injury to the both kidneys, Lt adrenal, liver and spleen; missed pancreatic injury	Superficial contusion of the pancreatic tail	Normal	I	Conservative
7	M/21; car accident	80	Pancreas swollen with fracture of the body	Pancreatic haematoma	*Rupture of the main pancreatic duct	II	Caudal pancreatectomy and sump drainage
8	M/33; car accident	110	Pancreatic tail contusion, haemoperitoneum and splenic injury	Not done	Not done	II	Sump drainage
9	M/33; fall from a camel	250	Swelling of the pancreatic tail with minimal heterogenicity	Pseudocyst formation	Not done	I	CT guided drainage of the pseudocyst
10	M/26; car accident	1250	Rupture of the duodenum with contrast leak and retroperitoneal gas	Not done	Not done	IVa	Sump drainage
11	M/16; fall from a camel	80	Ruptured pancreatic tail	Not done	Not done	II	Conservative
12	M/21; car accident	1200	Missed pancreatic injury	CT after 48 hrs: pancreatic tail rupture	Not done	II	Caudal pancreatectomy
13	M/30; car accident	95	Tear of pancreatic tail; splenic contusion	No gross interval changes	Not done	II	Caudal pancreatectomy
14	F/10; fall from bicycle	550	Rupture of the pancreatic neck, duodenal haematoma and liver contusion	Not done	*Rupture of the main pancreatic duct	IVa	Sump drainage
15	M/5; all from bicycle	30	Rupture of the tail of the pancreatic tail and haematoma	Not done	Not done	II	Sump drainage
16	F/6; hit by a heavy object	58	Swollen pancreatic tail and intra- and retro-peritoneal fluid	Minimal increase intra- and retro-peritoneal fluid	Not done	I	Conservative

Table 1 continued. Patients' data, clinical and radiological findings in blunt pancreatic trauma.

Case No	Sex/age; type of injury	Amylase (U/L) at admission (normal 30–100)	CT at admission	Follow-up CT	ERCP*/ MRCP**	Lucas classification	Treatment
17	M/25; car accident	348	Swelling and contusion of the pancreatic head, duodenal wall haematoma, intra- and retro-peritoneal fluid	Mild increase in intra- and retro-peritoneal fluid	Not done	II	Conservative
18	M/23; hit by a heavy object	1427	Contusion and haematoma of pancreatic head, intra- and retro-peritoneal fluid	Increase of pancreatic head haematoma and intra- and retro-peritoneal fluid, pseudocyst formation	Inconclusive	III	Drainage of the pseudocyst and haematoma
19	M/28; car accident	61	Swelling and contusion of pancreatic head, duodenal wall thickening, mesenteric contusion, liver laceration, bilateral renal contusion and left renal subcapsular haematoma, intra- and retro-peritoneal fluid	Thrombosed superior mesenteric vein	Not done	III	Rt. hemicolectomy with superior mesenteric vein repair
20	M/24; car accident	327	Swollen pancreatic head with minimal peri-pancreatic fluid; small liver laceration	4-days - post operative CT follow-up; infected collection in gall bladder fossa, oedematous wall of hepatic flexure and ascending colon	**Non-visualised proximal part of pancreatic duct	IVa	Surgery revealed duodenal perforation with ruptured proximal pancreatic duct; gastro-jejunostomy, choledocho-jejunostomy and pancreatoje-junostomy, CT guided drainage of the abscess
21	M/22; hit by a heavy object	123	Duodenal injury with retroperitoneal fluid and gas, intraperitoneal and lesser sac fluid, swollen pancreatic head	14-days postoperative CT follow-up: normal	Not done	II	Laparotomy with duodenal repair

Table 2. Pancreatic injury – modified classification of Lucas [10].

Grade	Parenchyma	Main pancreatic duct
1. Haematoma, laceration	Minor contusion, peripheral	–
2. Haematoma, laceration	Body, tail; major contusion, transsection	±
3. Laceration	Head, neck; transsection	+
4. Combined pancreatico-duodenal laceration	Damage: a. proximal transsection involving ampulla b. total disruption of head, devascularisation of duodenum	± +

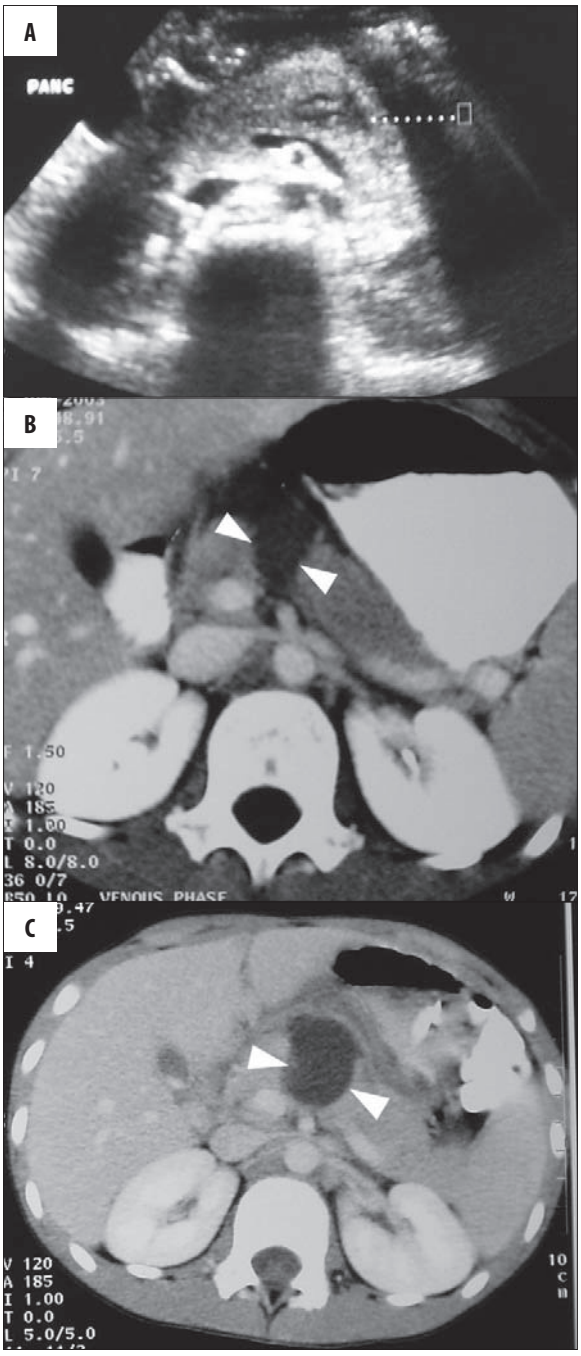

Figure 1. Case 5. (**A**) Ultrasound: an hypocheoic area in the neck and body of the pancreas. (**B**) CT at admission: transsection of the pancreatic neck (arrowheads). (**C**) Follow-up CT three days later: formation of a pseudocyst (arrowheads).

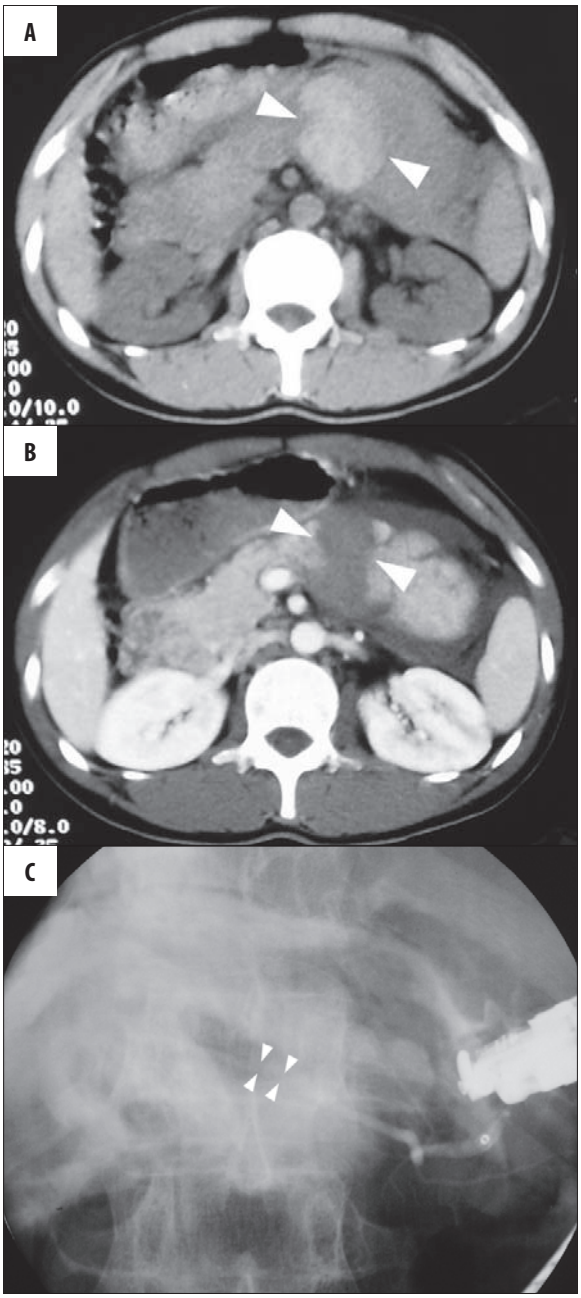

Figure 2. Case 7. (**A**) Un-enhanced initial CT: hyperdense haematoma at the body of the pancreas (arrowheads). (**B**) Contrast enhanced CT: an hypodense area at the body of pancreas indicating fracture with peripancreatic collection (arrowheads). (**C**) ERCP: non-visualisation of the mid portion of the pancreatic duct (arrowheads), associated with extravasation of contrast medium.

CT in 2 cases. MRCP, done in one case, revealed non-visualisation of the proximal part of the pancreatic duct, thus raising suspicion of a rupture, which was missed by CT but confirmed at surgery.

The diagnosis of pancreatic injury was missed on the initial CT examination in four cases (19.0%). Two of them showed no specific findings on the CT done at admission. On retrospective analysis two out of four false negative initial CT results could have been avoided.

One patient had injury of the right kidney (Table 1, case No. 1). On the repeated CT done on the following day, a fluid collection related to the pancreatic tail appeared. CT guided drainage was performed.

The initial CT of the second case (Table 1, case No. 4) showed liver injury with no definite pancreatic trauma. ERCP performed on the same day showed rupture of the main pancreatic duct and CT carried out the subsequent

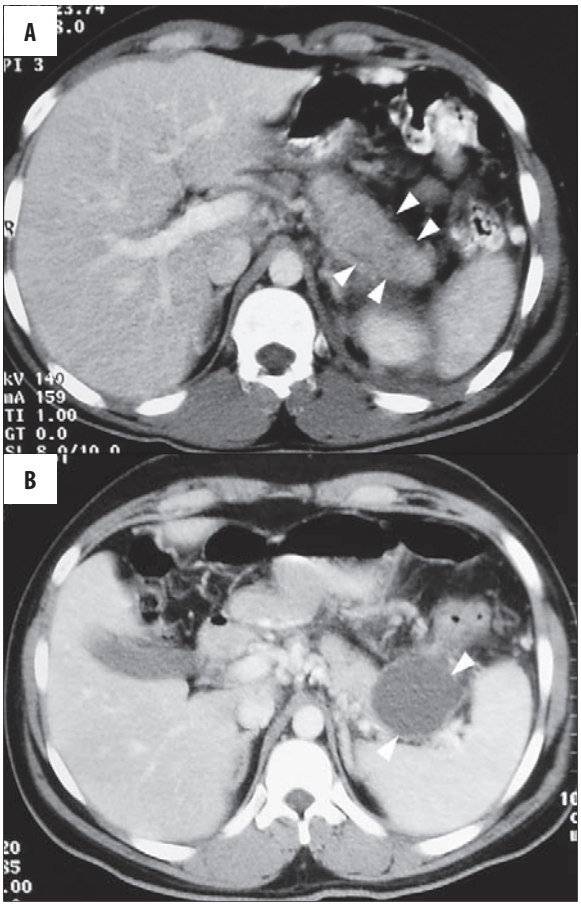

Figure 3. Case 9. (**A**) Contrast enhanced CT at admission: mild swelling with subtle heterogenicity of the pancreatic tail (arrowheads). (**B**) Follow-up CT five days later: formation of a pseudocyst (arrowheads).

day demonstrated body tear associated with pancreatic and peripancreatic collections. Sump drainage was applied.

In the third patient (Table 1, case No. 6), the initial CT revealed injuries of the liver, both kidneys and adrenals, associated with a retroperitoneal haematoma. Since the patient had a high serum amylase level, CT was repeated on the next day, revealing pancreatic tail injury. The patient was treated conservatively.

The fourth patient (Table 1, case No. 12) had no definite injury at the initial CT. Due to the high level of serum amylase, a second CT was performed after 48 hours and revealed rupture of the pancreatic tail, which was treated by caudal pancreatectomy. The subsequent two CT examinations demonstrated increasing amount of the fluid with development of a pseudocyst and then formation of an abscess.

In one case (Table 1, case No. 20) initial CT showed swollen pancreatic head with minimal peripancreatic fluid, which was considered Grade 1 in Lucas scale. However, MRCP did not visualise the proximal part of he the pancreatic duct, thus raising suspicion of its injury. Surgery revealed rupture of the pancreatic duct with duodenal perforation, thus increasing grading up to IVa.

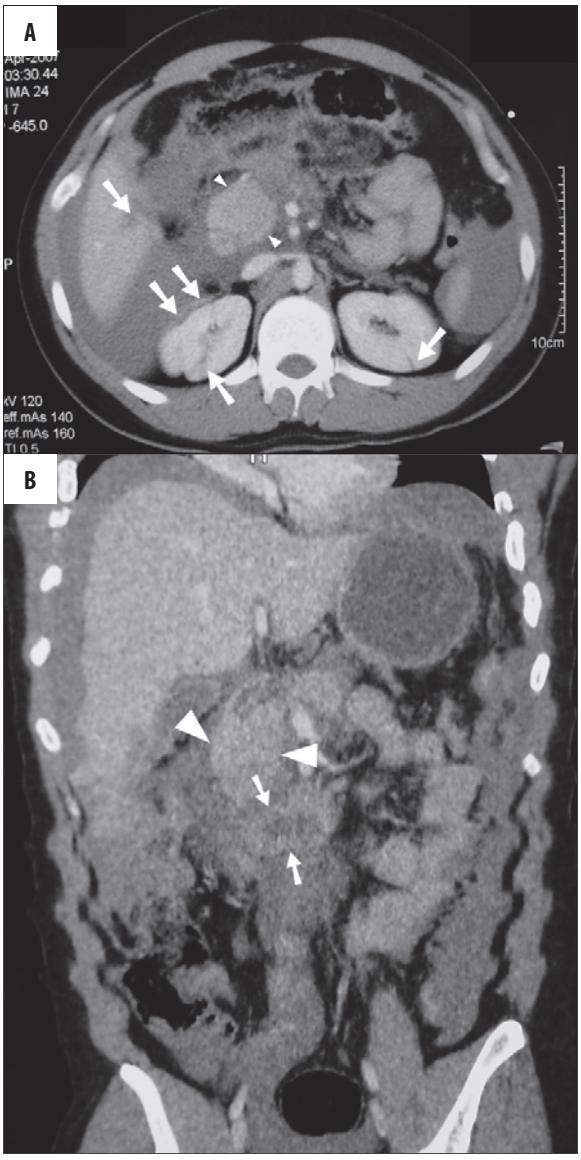

Figure 4. Case 19. (**A**) Contrast enhanced axial CT ad admission: swelling of the pancreatic head (arrowheads), intra- and retro-peritoneal fluid, liver laceration (arrows), bilateral renal contusion and right renal subcapsular haematoma (arrows). (**B**) Coronal reformatted image: swollen and heterogeneous pancreatic head indicating contusion (arrowheads), dilated third part of the duodenum (arrows) with thickened wall, retro- and intraperitoneal fluid.

In our material all CT examinations repeated within 24–48 hours were positive. Only in one case (No. 20), the CT performed 14 days after injury appeared normal.

The serum amylase was elevated in 14 cases (66.7%) at the day of admission. The remaining 7 patients had (33.3%) had normal serum amylase levels.

US was performed at admission in 9 patients and was positive in three cases (33.3%) and inconclusive in six cases.

Thirteen patients (61.9%) required surgical intervention; one of them also had CT guided drainage of post-surgical

Table 3. CT in pancreatic trauma – specific features in 21 patients

Feature	No of cases (%)
Fracture of the pancreas	8 (38.1%)
Pancreatic enlargement/swelling	7 (33.3%)
Haematoma/contusion	8 (38.1%)
Fluid between the splenic vein and pancreas	4 (19.0%)

Table 4. CT in pancreatic trauma – non-specific features in 21 patients.

Feature	No of cases (%)
Thickening of anterior renal fascia	5 (23.8%)
Fluid in lesser sac	6 (28.6%)
Extraperitoneal fluid	9 (42.9%)
Associated splenic injury, e.g.	3 (14.3%)
Intraperitoneal fluid	8 (38.1%)

infected collection. Caudal pancreatectomy was performed in 4 cases (19.0%); two of which also had sump drainage. Five patients (23.8%) only required sump drainage. Gastrojejunostomy, choledochojejunostomy and pancreaticojejunostomy were done in one patient (4.8%) and one patient had duodenal perforation repair (4.8%). Another patient had laparotomy for an associated abdominal organ injury. Cystogastrostomy was performed in one patient (4.8%) with pancreatic pseudocyst. In three patients, treated non-surgically, CT guided drainage was applied (14.3%). Five patients (23.8%) were treated conservatively.

The duration of hospitalisation ranged from 1 to 35 days, mean 28 days. Eleven patients (52.4%) survived pancreatic trauma without any complications. Two patients (9.5%) died from brain injury. Seven patients (33.3%) had complications; three of them (14.3%) developed pancreatic pseudocyst, which in one case became infected and transformed into the abscess. One patient developed post surgical infected collection in the gall bladder fossa (4.8%). The pancreatic fistula occurred in two cases (9.5%), and one patient (4.8%) had delayed pancreatitis.

Discussion

The main causes of blunt pancreatic trauma are road traffic accidents [4]. In our series, 47.6% of patients were involved in motor vehicle accidents, while 23.8% were bicycle riders. Accordingly to the local specificity, 14.3% of pancreatic trauma in our material was caused by fall from a camel and 14% were sequel of hit by a heavy object.

Pancreatic injury is more common in young adults, possibly because of a less amount of retroperitoneal fat to act as a protective buffer [11]. In children, traumatic forces usually affect a larger region of the body than in adults, therefore multisystem injuries are more common in paediatric age group [12]. Our material and results confirm this observation.

Table 5. CT in pancreatic trauma – Lucas classification of injuries in 21 patients.

Grade	No of cases (%)
I	4 (19.0%)
II	8 (38.1%)
III	4 (19.0%)
IV a+b	5 (23.8%)

Most of the studies describe that the pancreatic trauma with associated injuries of other organs are more common than the isolated pancreatic injuries. Figures of 50–98% are widely reported [3,4,9,13]. However, in our study isolated and combined pancreatic injuries were almost in equal proportion, 47.6% and 52.4% respectively.

In blunt abdominal trauma, morbidity and mortality is mainly due to associated injuries [3,14] and the isolated injuries usually indicated good prognosis [15]. Our material also supports this observation.

The typical clinical triad of pancreatic trauma including upper abdominal pain, leukocytosis and hyperamylasaemia are uncommon in an early stage and they are non-specific findings that can result from bowel injury [2,11,16]. This triad may be delayed for 24 hours or even for several days following injury [9,17].

In our series the serum amylase levels were normal at admission in 33.3% of patients, even higher figures are cited elsewhere [9]. Therefore, serum amylase level at admission could be considered an unreliable predictor of pancreatic trauma [9,12].

Ultrasound is suitable for diagnosing focal or diffuse pancreatitis or pseudocyst but this modality generally does not depict pancreatic fracture [11]. Our results support this opinion, as only 33.3% of our patients with performed US examination were positive.

CT is most effective diagnostic modality to diagnose pancreatic fracture [4,9]. In series of Bigattini the CT diagnosis was missed in three out of eight patients (37.5%) with blunt pancreatic trauma, giving the sensitivity of 62.5% [9]. The other sources report a normal initial CT appearance in 40% of significant pancreatic injuries [18]. In our study, the diagnosis was missed in 19.0% of cases at admission, thus the sensitivity of initial CT was 81.0%. The missing of diagnosis was partly due to an observer error. In two cases the attention was focused on the other abdominal visceral injury or potential active bleeding. The lack of oral contrast as well as poor parenchymal enhancement of the pancreas during imaging was also contributing factors in two cases. However, the retrospective analysis showed that two out of four false negative cases could have been avoided. It is worth mentioning that all four cases with missed diagnosis were performed on single row spiral CT.

In our four patients with false negative initial CT, the second CT was positive. The follow-up sequential CT examinations

always gave valuable information about recovery process and potential complications. These results support the thesis that repeated and sequential CT scans may be determinant in the diagnosis and grading of pancreatic injury [19]. Furthermore, it should be remembered that CT scan at admission could be negative, missing or underestimating pancreatic injury, which may delay the necessary surgery [19].

Multislice CT with multiplanar and 3D image reformation offers new diagnostic possibilities, but experience is still limited. In our study, the last five patients were examined with the 64-multisclice CT machine, which allowed us to establish diagnosis with greater confidence when compared with the old CT technology. However, in one of our case (No.20) the pancreatic injury was underestimated due to unrecognizing of rupture of the proximal pancreatic duct, which initially lead to lower grading in Lucas scale. Though the proper grading was eventually established at surgery.

Associated splenic injury – which usually focuses the attention, particularly when associated with massive haemoperitoneum – should not be misleading. The possibility of a pancreatic contusion should always be considered when the mechanism of injury was a direct frontal upper abdominal impact [9].

In most cases of pancreatic injuries, the attention is focused on the injury of the main pancreatic duct [12]. The presence of retroperitoneal fluid suggests pancreatic duct rupture, which may require emergent ERCP [11]. A patient with post-traumatic pseudocyst is considered to have ductal leak until proven otherwise [4].

Preoperative or intraoperative pancreatography to diagnose ductal damage remains controversial [20,21]. ERCP is even thought to be inappropriate in acute post-traumatic cases, because of its invasive nature [21]. On the other hand, CT is not adequate in demonstrating pancreatic duct rupture, a point also shown in our study. On the contrary, ERCP is credited with 100% sensitivity [9,22]. In our series the sensitivity of ERCP was 88%. However, ERCP could be undertaken only in stable patients. It also requires an experienced endoscopist, generally not rapidly available in emergency settings [22]. This technique is currently useful in preoperative delineation of ductal anatomy in patients with missed injuries [15]. Magnetic resonance pancreatography (MRP) may be used to asses the pancreatic ductal system non-invasively, possibly an alternative to ERCP in assessing delayed complications secondary to pancreatic duct injury [4].

Regarding complications, most of the literature reported that the formation of pancreatic fistula is the most common complication of pancreatic injury with an incidence ranging from 7 to 20% [23,24]. In our study pancreatic fistula and pseudocyst occurred with the similar rate of 14.3% and 9.5% respectively. The literature reports a variable mortality rate from 3-40%, which increases when associated injuries are present [21,24]. In our study we had two deaths from brain injury, 7 patients (33,3%) had delayed complications, whilst a majority of the patients (66.6%) survived without sequel.

Conclusions

Pancreatic trauma is an uncommon and frequently overlooked sequel of major blunt abdominal trauma. CT is the most effective modality for diagnosis of blunt abdominal trauma, however the CT diagnosis of pancreatic injury may be missed at admission. Sensitivity of CT diagnosis is noticeably increased by repeated and sequential studies. Multislice CT technology with multiplanar image reconstruction will further improve diagnostic power of CT. However, the proper examination technique is mandatory. Accurate reading of images, preferably on workstation, should pick up indirect sign of pancreatic injury, particularly when associated with other organ injury. A patient with pancreatic injury and associated collections or post-traumatic pseudocyst should be considered to have a ductal leak until proven otherwise. Also ductal disruption is likely present if the pancreas appeared to have transsection or deep laceration on CT. In doubtful cases or when the patient sustained blunt abdominal trauma with persistent unexplained abdominal pain or elevated serum amylase level, repeating CT examination within 24–48 hours is highly recommended.

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