Title: Percutaneous image-guided pancreatic duct drainage: technique, results and expected benefits

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Abstract

Purpose: The aim of this study is to provide a technical detail and feasibility of percutaneous image-guided pancreatic duct (PD) drainage and to discuss its subtleties in a series of patients with obstructed PD.

Materials and Methods: Thirty patients presenting with PD obstruction from pancreatic head tumour or pancreatitis were subjected to percutaneous image-guided PD drainage under a guidance of ultrasound or computed tomography. Following the successful puncture of PD, a locking loop drainage catheter was placed using conventional guidewire techniques under real-time fluoroscopy guidance.

Results: The percutaneous drainage of obstructed PD was completed in 29 (96.7%) patients as an independent therapeutic intent or as a bridge to further percutaneous procedures. Clinical improvement following drainage was documented by the gradual reduction in clinical symptoms, including pain, nausea and fever and improved blood test results, showing the significant decrease of amylase concentration. The amount of pancreatic fluid drained post procedure was between 300-900 mL/day. No major procedure-related complications were observed. Subsequently, 14 of 29 patients underwent further procedures, including endoluminal placement of metal stent with or without radiofrequency ablation, balloon assisted percutaneous descending litholapaxy (BAPDL), endoluminal biopsy and balloon dilatation using the same drainage tract.

Conclusion: The percutaneous PD drainage appears to be a safe and effective procedure. It should be considered in patients with obstructed PD secondary to malignancy, pancreatitis etc, where endoscopic retrograde cannulation has been failed or impracticable. The procedure can also be contemplated either as an independent treatment option or as an initial step for the subsequent therapeutic endoluminal procedures.

Keywords: pancreatic duct obstruction; pancreatic duct drainage; image guided drainage

Abbreviations:

AP Acute pancreatitis; BAPDL Balloon assisted percutaneous descending litholapaxy; CBD Common bile duct; CT Computed Tomography; ERCP Endoscopic retrograde cholangiopancreatography; EUS endoscopic ultrasound; PD Pancreatic duct; RFA radiofrequency ablation; US Ultrasound

Introduction

Pancreatic duct (PD) obstruction is a commonly encountered in patients secondarily to benign and malignant pathologies, such as pancreatitis, pancreatic duct and common bile duct (CBD) stones, benign strictures, pancreatic, duodenal or duodenal papilla neoplasms and enlarged retroperitoneal lymph node causing occlusion. An obstruction in PD results in upstream dilation which further activates digestive enzymes and induces inflammatory changes. Inflammatory mediators diffuse into the parenchyma of the pancreas through impaired pancreatic barrier and precipitate acute pancreatitis (AP) and its sequelae. Furthermore, a persistent high pressure in PD leads to acinar cells atrophy, islets aggregation and pancreatic parenchymal fibrotic changes which engender exocrine and endocrine insufficiency (1) (2) (3). The decompression of the PD helps in relieving obstruction and elimination of clinical symptoms, such as refractory pain, nausea and fever. It is achieved by variety of endoscopic approaches as placement of a stent in PD during endoscopic retrograde cholangiopancreatography (ERCP) procedure, which offers an effective minimally invasive treatment option thus obviates the need for surgery in the patients with pancreatic fistulas and pancreatic ascites (4) (5) (6) (7) (8) (9) (10). Howbeit, in cases of failure an alternative though the technically challenging technique i.e, endoscopic ultrasound guided PD drainage and stent placement is practiced (11) (12) (13) (14) (15) (16). There are two types of stents commonly used for drainage are plastic stent and self-expanding metal stents which can be covered or uncovered (17) (18).

Various studies showed the notable impact of PD stenting in the management of patients who present with symptoms secondary to pancreatic duct obstruction. Fan et al., 2015 reported a meta-analysis that PD stent placement can reduce postoperative hyperamylasemia hence it might act as an effective and safe option to prevent post-endoscopic retrograde cholangiopancreatography (ERCP) pancreatitis (19). Mazaki and Choudhary et al., published a meta-analysis of 680 and 556 patients including eight randomized, controlled trials reported a significant decrease in mild, moderate, and severe pancreatitis rates following placement of prophylactic pancreatic stents during ampullectomy, pancreatic sphincterotomy, sphincter of Oddi dysfunction, and difficult PD cannulations (7) (20). Consequently, endoscopic ultrasound-guided pancreatic duct drainage (EUS-PDD) had come to fore as an intent to drain the pancreatic ducts (PDs) when traditional drainage technique as ERCP failed.

Nevertheless, it is one of most technically challenging intervention, and success lies in the hands of very few expert endoscopists only (11) (21) (22). To overcome these shortcomings, image-guided percutaneous drainage of PD has been developed as a novel technique. The purpose of this study is to outline the indications, technical details and outcomes of image-guided percutaneous drainage of PD as an independent procedure or as a bridge to the further interventions such as percutaneous recanalization and endoluminal biopsy.

Materials and Methods

Study Design: We conducted a single-center prospective study at "High Technology Medical Center – University Clinic" December 2010 to October 2015 following the Institutional Review Board approval. This trial was registered at the Tbilisi State Medical University and informed consent obtained from each recruited patient. The primary endpoint of study was drainage of PD whilst, the secondary endpoints were clinical improvement following the drainage procedure in terms of amelioration in fever, pain and nausea, pancreatic fluid leakage induced skin irritation and improved serum amylase.

Subjects: A total of 32 patients were considered suitable for percutaneous PD drainage. Two cases of pancreatic head tumour were excluded based on pre-procedure imaging in absence of safe puncture approach to PD. In remaining 30 patients (tumour in the pancreatic head - 18, pancreatitis - 11, cutaneous pancreatic fistula -1) endoscopic approach was not possible because of previous abdominal surgery (8 cases) or failed ERCP (16 cases) or patient refusal (6 cases) percutaneous PD drainage was attempted. All patients had dilated pancreatic duct except the one with cutaneous pancreatic fistula (Table 1). All cases were evaluated using routine investigations including WBC count, lactic dehydrogenase, aspartate aminotransferase, serum calcium, serum urea, blood glucose, amylase. Imaging such as ultrasonography, spiral three-phase computed tomography and magnetic resonance cholangiography were used to establish the clinical diagnosis. Indication for PD drainage were dilated duct in association with periampullary carcinoma and severe pancreatitis, as defined by >3 Ranson criteria (23) (24) (25) (26) (27). Patients were divided into two groups: one in whom the PD drain was positioned using combined ultrasound-fluoroscopy guidance technique (n=15); and another that underwent a combined CT-fluoroscopy guidance technique (n=14); In the case of failure both techniques were attempted (Table 2).

Procedure and Complication:

Combined Ultrasound (US) and Fluoroscopy guidance technique

The procedure performed under moderate sedation using midazolam and diprivan and local anaesthesia. The PD was approached in real-time guidance, using either the "Free-Hand" or fixed needle guide technique (28) (29) (30). The entry point over PD was selected over the proximal duct segment as per the permissible safety allowance, to ensure the antegrade placement of catheter tip. The distal segment of the PD was punctured only when a safe approach to the proximal segment was not feasible. Due to the anatomical variation, the puncture needle traversed through the various structures as an anterior abdominal wall or abdominal wall and liver or abdominal wall and stomach. The decision regarding the size of the needle was made on the basis PD diameter as 18G diameter needle preferred when PD diameter 5 mm and more whilst, a 22G needle used for PD diameter less than 5 mm in order to minimize the risk of vessel damage during the needle advancement. In cases where the coaxial application of needles was needed, first 18 G needle used to reach the pancreatic surface followed by a 22G needle inserted coaxially into the PD. The successful puncture of PD had been confirmed by the observance of pancreatic fluid in the needle cannula and procedure was switched to fluoroscopy guidance, with an injection of contrast for PD opacification. A guidewire was advanced (0.035 inch hydrophilic for 18G needles or 0.018 inch for 22G needles) in order to place a size appropriate (6 to 8.5 Fr diameter) locking loop drainage catheter. The end of the procedure was confirmed by injection of contrast agent via the drainage catheter (Fig 1a, b, c) to document the successful drainage.

Combined CT and Fluoroscopy guidance technique

The computed tomography (CT)-fluoroscopy guided technique of PD drainage were employed in a situation where safe approach using ultrasound guidance was not possible, or CT provided a better delineation of PD anatomy thus provided easy access to the proximal segment. That being so the pre-procedure evaluation with contrast CT allowed the selection of the most appropriate access route. The procedure performed under moderate sedation, with a patient in prone or supine position. In a posterior approach, i.e., a prone positioned patient the needle passed through the posterior abdominal wall and retroperitoneal fat. Hydro-dissection of retroperitoneal fat was performed with saline injection using 18G puncture needle and a safe passage created between the spleen, large bowel and kidney if they came into the path towards PD. In an anterior approach, i.e., a supine positioned patient the anterior abdominal wall or abdominal wall and stomach were pierced by 18G or 22G needles whilst, coaxially applied combination of 18 and 22 G diameter needles used in five cases for PD puncture. The guidewire (of 0.035 inch or 0.018 inch diameter) was placed through the cannula into the PD and later confirmed by CT. Then patients were transferred to the angiography suite where an appropriate (6 to 8.5 Fr) locking loop drainage catheter was positioned over the guidewire using real-time fluoroscopy guidance. Later the 0.018 inch guidewire had been exchanged with 0.035 inch guidewire in cases where 22G needle was used to approach PD (Fig 2 a, b, c, d, e, f). Day care patients were discharged following the post procedure observation of 3 to 6 hours and daily outpatient's clinics follow up visits were made for next three days to take a note for any post procedure complications. In patients who were referred to us for the procedure were kept admitted in their respective primary admission units for next three days to check for any post procedure complications. Subsequently, 14 patients underwent a second-line percutaneous procedure using the mature drainage tract to access the PD. All the subsequent procedures (metal stent placement with or without radio-frequency ablation based endoluminal RFA, balloon assisted percutaneous descending litholapaxy (BAPDL), endoluminal biopsy, balloon dilatation, external-internal drainage) were performed under fluoroscopy guidance using the PD mature drainage tract following few days of the clinical improvement. The presence of functioning mature PD drainage tract was marked as the key for the safe and successful undertaking of the next line of interventions. A soft hydrophilic guidewire and a 5 Fr guide catheter were used to traverse the obstructed PD segment. When guidewire reached the duodenum, the soft wire was exchanged for a stiff wire in order to position an introducer sheath. The balloon dilatation and metal stent placement performed using conventional techniques while in cases of PD obstruction caused by tumour a novel 5 Fr RF endoluminal RFA device introduced in a similar fashion to recanalize the PD.

Further interventions as BAPDL was performed by pushing the stones into the duodenum by a balloon over a guidewire following the entry into the PD. Likewise, an endoluminal biopsy was carried out by using a forceps device over the guidewire introduced through the obstructed segment of PD. PD drainage catheters were kept clamped for a few days to observe any return of clinical symptoms while imaging had been performed before removal to confirm the radiological evidence of non-dilated PD.

Results:

In the given study period, a total of 30 patients underwent percutaneous PD drainage in whom either endoscopic approach was not possible because of previous abdominal surgery (8 cases) or failed ERCP (16 cases) or patients' refusal (6 cases). All patients had dilated pancreatic duct on imaging except the one with cutaneous pancreatic fistula (Table 1). There were 16 men (53.3%) and 14 women (46.4%), with a mean age of 57.9 years (range: 32-90 years). The main symptoms were abdominal pain, fever and nausea. The percutaneous PD drainage was attempted in all patients with success of 96.7% (29/30 cases) as an independent therapeutic intent or as a bridge to further percutaneous procedures. The patients were divided into two groups based on the type of procedure completed: one in whom the PD drain positioned using combined ultrasound-fluoroscopy guided technique (n=15) and another where a combined CT-fluoroscopy guided technique was performed (n=14) (including the non-dilated PD case with pancreatic fistula). In the case of the failure both techniques were attempted (Table 2).

In combined ultrasound-fluoroscopy guidance technique, the PD was punctured in real-time using either the "Free-Hand" (1 patient 6.7%) or the fixed needle guide technique (14 patients 93.3%). The body segment of the PD punctured in 13 cases (86.7%) was not accessible the neck segment was punctured (2 cases 13.3%). In 8 cases (50%) the needle trajectory went through the anterior abdominal wall, transhepatic route in 5 cases (28.6%) and transgastric path in 3 cases (21.4%). An 18G trocar needle was used for puncture of the PD in 6 cases (40.0%), 22G puncture needle set in 8 cases (57.1%) and the combination of 18G and 22G needle in 1 case (7.1 %). After successfully puncturing of the PD the procedures were completed with placement of a locking loop drainage catheter.

The combined CT-fluoroscopy guided technique was performed in 14 cases where the tailed segment of PD was accessed in 5 (35.7%), the body segment in 8 (57.1%) and the neck segment in 1 case (7.4%). In 5 (35.7%) cases where PD tail segment was accessed through the posterior approach, only abdominal wall and retroperitoneal fat were traversed before reaching the pancreas. In 4 cases (28.6%) hydro-dissection of retroperitoneal fat was performed to create a safe passage track for the needle. The anterior approach was used in 9 cases (64.3. %); among them, only abdominal wall was traversed in 6 (66.7%) patients, a transgastric route was used in 2 cases (22.2%) and a transhepatic route in 1 case (11.1%). An 18G needle was used in 3 cases

(21.4%), a 22G in 6 cases (42.9%) and a combination of 18 G with 22 G needles (co-axial technique when the pancreatic surface was accessed by 18 G, the stylet removed and PD was approached by 22G needle, which was introduced via 18 G needle cannula) in 5 cases (35.7%). The PD drainage procedure was confirmed by CT and a locking loop drainage catheter placed.

The percutaneous drainage procedure was completed in all 29 patients either as an independent therapeutic intent or as a bridge to further percutaneous procedures. Further ongoing procedures involved endoluminal RFA with metal stent placement in six patients, four underwent BAPDL, one each had metal stent placement, an endoluminal biopsy, balloon dilatation and external-internal drainage. Thus in all 29 cases approach to the dilated PD was attempted to minimize or alleviate the consequences of PD obstruction. Clinical sequelae of PD obstruction extends from dilation of proximal PD to pancreatitis with or without fluid collection, pancreatic abscess, pseudocyst and onset of hyperglycemia. In the case of the pancreatic fistula the PD was not dilated and thus non-dilated PD was accessed and drained.

In 22 cases (75.8%) drainage was achieved in single schedule procedure while in 7 cases (24.2.0%) further schedulings were needed. In one case the first schedule procedure was unsuccessful due to the failure to create a safe route using retroperitoneal hydro-dissection through CT-guided posterior approach; at this stance puncture not attempted. In remaining 6 cases (2 cases of a posterior approach and 4 cases of an anterior approach using a transgastric route) the first procedure was terminated following three unsuccessful attempts. The total number trials attempted to approach pancreatic tissue by puncture needle was 63 (average of 2.1 per patient). The success rate of first trial attempt to puncture PD was 43.3% (13 cases), i.e., eight cases (77.8%) with an 18 G needle and five cases (35.7%) with a 22 G needle.

The post procedure pancreatic fluid drainage varied from 300 to 900 mL/day, which progressively increased over a period of 6–7 days. Clinical improvement documented through a gradual reduction of clinical symptoms (fever, pain and nausea, pancreatic fluid leakage induced skin irritation) and improved blood test results in all the cases. The significant decrease of serum amylase concentration was noted in all cases (from 287.41 ± 160.60 to 37.41 ± 11.62U/L; p=0.0001). The PD drainage performed in seven patients with diabetes mellitus, of these five had pancreatic cancer, and two had PD obstruction secondary to stones. Three pancreatic cancer patients and one patient with calculus induced pancreatitis with recent onset diabetes showed a dramatic improvement in the hyperglycaemic control. The complete cessation of medication was attained in 2 cases whilst, significant dose reduction achieved in the rest two (blood glucose before PD drainage 10.46 ± 0.65 mmol/L, four weeks after drainage 4.05±1.13 mmol/L; p=0.038). The remaining three patients with long history of diabetes mellitus showed no significant change in hyperglycaemic control following PD drainage. The procedure was well tolerated in all patients with no 30 day or in-hospital mortality. The drainage catheter kept in situ for two weeks in case of PD obstruction where post-drainage recanalization by RFA with stenting was performed while a maximum of 10.5 months in the case where PD stricture managed by balloon dilation with external-internal drainage.

We didn't encounter any technique specific complications, such as haemorrhage, vessel injury, visceral injury or infection, even in the cases where the transgastric route sought. The post procedure pain in the puncture area was reported in seven cases and managed successfully with non-steroidal anti-inflammatory drugs.

Discussion

Non-surgical PD drainage and/or stenting is mostly performed by an ERCP, but sometimes it can be technically challenging and arduous if not impossible, to perform in a significant number of patients, particularly following gastroduodenal surgery. EUS guided PD drainage has emanated as a therapeutic option in cases of unsuccessful endoscopic intervention though its efficacy lies in the hands of experienced endoscopists with very inconsistent success rates (25% to 100% (11) (12). Barkley et al., 2010 in a study over 20 patients has demonstrated the success rate of EUS guided PD drainage of about 48% (31).

The first case of successful treatment of calculous induced chronic pancreatitis was reported in literature existing from 1911 by pancreatostomy, i.e., surgical pancreatic duct external drainage. In addition the benefit and utility of percutaneous drainage as therapeutic methodology was supported by few more landmark papers (Table 3) (32). Many decades later a prospective randomized trial organized by Poon et al. 2002 demonstrated the positive impact of intraoperative external drainage of pancreatic duct with a stent to reduce the leakage rate of pancreaticojejunostomy following pancreaticoduodenectomy (33). Percutaneous trans-fistulous pancreatic duct drainage was shown to be effective in the management of intractable fistulae communicating with the main pancreatic duct and this approach, combined with endoscopy (Rendezvous technique), has been reported to be successful in three cases of pancreatic fistulae associated with disconnected pancreatic duct syndrome, avoiding a need complex operation in all patients (34) (35) (36) (37) (38). Gobien et al., 1983 provided the first report on image guided external percutaneous PD drainage and described successful management of recurrent acute pancreatitis in a high risk surgical patient (39). The duct accessed, the guidewire placed in the PD under CT guidance and the procedure was completed by placement of 8Fr diameter drainage catheter under fluoroscopy guidance. The site of placed catheter was confirmed and documented by contrast injection. The success was followed by few more sporadic reports of using various methods to drain the obstructed PD (Table 3) (40) (41).

Compared to the endoscopic retrograde or EUS guided procedures the percutaneous approach seems more feasible because of the less physical distance from the skin to the site of interest i.e., PD. This enables easy manipulation of guide wires, probes and drainage catheters during the procedure once the PD is accessed. Subsequently, the mature PD drainage tract can be utilized for the further interventions and monitoring of the draining pancreatic fluid (42) (43).

The choice of imaging depends on the site of PD segment selected as the "target" on pre-procedure imaging. According to the literature the best reported site is the tail segment because of the following reasons: it's theoretically safer due to the retroperitoneal access although we haven't found such difference in the present study. Along with that tail puncture, provides more proximal access thus gives feasibility for positioning of longer shaft in the PD and add safety values i.e., "Pig-Tail" condition of the drainage catheter tip. Furthermore, tail puncture also provides an ease with second-line procedures owing to the longer sheath shaft into the PD.

As the tail segment of PD is barely visible in the US, CT-based imaging should be preferred in cases, where it is a "target of choice". Along with that, CT imaging is especially helpful in the creation of safe puncture route through hydro dissection in the posterior approach. Another important feature of CT guidance lies in its ability to characterize the position of introduced wire without contrast in contrary to the US imaging. Nevertheless, few other considerations should be made before hand regarding patient selection following formal MDT discussion and thorough evaluation including ultrasound, MRI and contrast-enhanced CT.

Furthermore, these procedures should be performed only in tertiary centres with well-established services as ultrasound, CT and fluoroscopy-guided interventional radiology. In our experience, the best approach to the PD in body or neck of the pancreas is through an anterior abdominal wall whereas posterior abdominal wall approach has been adapted to target the PD in the tail of the pancreas. In anterior approach one may encounter stomach and liver in their trajectory toward the PD. Though the liver is a relatively easy tissue for the needle to pass through while the elasticity of the gastric wall can cause the needle to deviation from the desired route. In addition, there are chances of associated theoretical complications such as bleeding risk, gastric perforation and peritonitis, though we haven't encountered any of such complication.

In cases where both CT and US can image the PD, the CT guided technique should be preferred as it provides better access to PD than the US. However, in cases where both modalities provide adequate imaging particularly in cases where “target” is PD in body or neck of the pancreas, US guided access should be used as it shows real-time needle movement with simultaneous imaging of vessels on Color Doppler. Here, the target can be aimed at the advancement of needle, along with that there are certain other properties which make it a better modality as it is non-invasive (no radiation), can be done in single setting i.e., no need for transfer of a patient to fluoroscopy room and it is more cost-effective. The “Free Hand” ultrasound guidance technique allows easier adjustment of needle position albeit it's insertion has been already initiated. It could be manipulated without adjusting the transducer position even though the needle has already penetrated the tissue by depth of 2-4cm. In contrast, fixed needle guidance provides a more direct route to the PD and better anticipated view of the trajectory before the insertion of a needle.

Moreover, the needle size was carefully considered and evaluated based on the patients’ characteristics and procedure type. The 18 or 22 G puncture needle was used to create a path to access the PD. The 18G needle showed higher first puncture success rates that might be because of largely dilated PD (5-11mm) which provides an easier entrance. In contrast, the success rate with 22 G needle was less because it can easily bend while manipulating through the tissue, especially in the transgastric approach. However, this problem can be overcome by the use of a combination of 18 and 22 G diameter needles, using an 18G needle to access the pancreas then switching to a 22 G to access the PD, as it can fit inside the 18G needle cannula. The advantage of using a 22 G puncture needle was its better safety profile as it has a smaller diameter and sharper tip (40).

We would like emphasize that there is no need to inject the contrast through the puncture needle cannula as the position of the needle tip is confirmed by visualization of pancreatic fluid at a hub of the needle which is a colourless liquid with viscosity equivalent to water. The wire is introduced through the needle and its position is confirmed by CT imaging without any introduction of intraductal contrast. One of the key issues towards the successful management of percutaneous PD drainage is the use of the locking loop catheter configuration as it prevents any inadvertent dislodgement due to patient's breathing and peristaltic movement in the abdomen. The PD tail puncture provides longer access to PD by this mean, a longer shaft could be placed in the duct and tract. This leads to enhanced safety and ease in locking the loop of the drain (to get the “Pig-Tail” condition of the drainage catheter tip) (44) (45). In addition, PD tail puncture also facilitates easier inception of the longer introduction sheath, which mollifies the technical demands of the second line procedures, performed using different type 4 or 5 Fr advancement catheters. The wire conduction down, into duodenum is the obligatory step for second-line procedures thus, the pathway provided through the PD tail approach opens the doors of easiness. Meanwhile, a time elapse of one week or longer between the first and next procedure is much needed as this not only helps in quantification of the clinical improvement in patients but also makes patient fit enough to stand the further interventions. Furthermore, this facilitates the maturation of the drainage tract which gives an easy access during the subsequent procedures.

In our experience, percutaneous PD drainage is a safe and effective procedure which can be used as an independent treatment option for PD decompression or as a bridge to the subsequent procedures especially in cases, where endoscopic retrograde PD cannulation fails or not feasible. Percutaneous imaging-guided PD drainage reduces the clinical manifestations of PD obstruction such as pancreatitis and hyperglycaemia prior to the definitive treatment. It should be routinely considered in cases of PD obstruction and/or integrity-related pathologies (pancreatitis, recently revealed diabetes, pancreatic fistula). Moreover, it should be contemplated as a possible treatment option alongside the endoscopic retrograde stent placement, and EUS guided antegrade drainage and stenting. The present study has certain limitations, as non-randomized design, unintended biases of patient selection which might influence the analysis. However, in spite of all these limitations, the present study has outlined the image guided percutaneous PD drainage technique as a safe and effective procedure in the PD obstruction secondary to the malignant or benign pathologies of the pancreas. Nevertheless, further randomized studies are warranted in order to confirm these findings.

Conclusion: Image guided percutaneous PD drainage appears to be a safe and effective procedure and should be considered for patients with obstructed PD, where endoscopic retrograde cannulation fails or infeasible. Furthermore, this minimally invasive techniques represent a valuable therapeutic option as a primary step or adjunct in cases where subsequent manipulation are needed in future.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Legends:

Figure 1. Pancreatic duct (PD) percutaneous drainage has been performed in patient of recurrent idiopathic pancreatitis, to facilitate drainage and create a platform for percutaneous dilatation. Patient's anatomy (pancreatic body was located immediately behind abdominal wall) enabled to perform the drainage avoiding the liver or stomach.

01 a. US - Dilated pancreatic duct (arrow); pancreatic body touches the anterior abdominal wall - no other visceral structures as liver or stomach seen between pancreatic surface and parietal peritoneum

01 b. Percutaneous US guided (transabdominal wall only) pancreatic duct approach - needle and guidewire (arrow) seen in pancreatic duct body segment

01 c. Status of pancreatic duct following the drainage procedure

Figure 2. A safe route to PD via its tail segment created by retroperitoneal hydro-dissection in in a patient with gall stone induced pancreatitis.

02 a. CT image. In prone position imaging stones seen in distal PD (arrow)

02 b. CT image. Hydro-dissection performed by saline

02 c. CT image. The spleen pushed out by hydrodissection as part of the approach towards dilated PD (arrow)

02 d. CT image. The puncture needle tip in the PD

02 e. CT image. The guidewire introduced into the PD

02 f. Fluoroscopy image showing injected contrast in drained PD with two filling defects (stones, identified by arrows)

Table 1: Details of clinical diagnosis and type of percutaneous interventions done

Diagnosis		Number	PD Drainage	Endoluminal RFA&Metal Stent Placement	BAPDL	Metal Stent Placement	Enodluminal Biopsy	Balloon Dilatation	External-Internal Drainage
Head of pancreas tumor		18	17	6		1	1		
Pancreatitis 11	Wirsungoliathiasis	6	6		4				
	Pancreas divisum	1	1					1	
	Wirsung duct stricture	1	1						
	Acute pancreatitis	1	1						
Pancreatic fistula		1	1						1

Table 2: Characteristics of Imaging guidance techniques involving percutaneous drainage of pancreatic duct

Parameters	Ultrasound & Fluorosocopy Guided Technique	CT & Fluoroscopy Guided Technique	Total
Number of cases	15	14	29
Free hand technique	1	14	15
Needle guide technique	14	0	14
Transabdominal-wall-only route	8	6	14
Transhepatic route	5	1	6
Transgastric route	3	2	4
Trans retroperitoneal fat route	0	5	5
18G Needle	6	3	9
22G Needle	8	6	14
Combination of 18 and 22G needles	1	5	6
Neck segment	2	1	3
Body segment	13	8	21
Tail segment	0	5	5
Hydrodissection with saline injection	0	4	4

Table 3: Review of literature for the external drainage, performed by different techniques

Authors	Intraoperative Drainage	Imaging guided drainage		
		Through existed pancreatic fistula under fluoroscopy	Through intact skin surface	
			Combined (CT and Fluoroscopy) guidance	Combined (US and fluoroscopy) guidance
Link et. al. (1911)	1			
Poon et. al. (2007)	120			
Hirota et. al. (2008)		2		
Irani et. al. (2012)		3		
Gobien et. al. (1983)			1	
Mathieson et. al. (1992)				2
Cope et. al. (2001)		2		3
Akhan et. al. (2006)				1
Arya et. al. (2010)				1

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