Duodenum-Preserving Pancreatic Head Resection

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Abstract

Duodenum-preserving pancreatic head resection (DPPHR) remains a rare procedure even for high volume centers since its clinical implementation in 1979. Reports on this surgery are scattered and present mostly as sporadic systematic reviews and case reports/case series. Terminology for those procedures varies among authors. Present chapter aims to pool current knowledge and give an idea of anatomical and surgical fundamentals of DPPHR. Latter one needs meticulous knowledge of vascular anatomy of pancreatic head and adjacent organs and might become technically more challenging when compared to pancreaticoduodenectomy. Postoperative complication rate and location of the lesion are other contributing factors to limited use of DPPHR. Limited pancreatic resection is useful mostly for benign focal pancreatic lesions and chronic pancreatitis. Exposure of main pancreatic duct and/or common bile duct and their subsequent management require large experience in hepatopancreatobiliary surgery that feels to be never enough. Author is hoping to expand the knowledge of the reader on DPPHR and promote organ-sparing technique for benign lesions just like it has become in regard to liver surgery of last decade. Any further comments and suggestions will be appreciated.

Duodenum-preserving pancreatic head resection (DPPRH) has not been precisely defined or classified in the literature or existing guidelines. Roughly, it can be defined as the procedure with either total or partial resection of the pancreatic head parenchyma and with preservation of the duodenum or its segmental resection. According to the pioneer of DPPHR, Hans Beger, a total DPPHR involves resection of the pancreatic head conserving the pancreatic neck. Peripapillary segment of the duodenum and the intrapancreatic common bile duct segment might be either resected or preserved [1]. In case of the former, three anastomoses are required; i.e., end-to-end duodenum to duodenum, end-to-side common bile duct (CBD) to postpyloric duodenum and end-to-side pancreaticointestinal anastomoses, in addition to Roux-en-Y jejuno-jejunostomy.

Unlike the total one, a partial DPPHR includes limited resection of the pancreatic head parenchyma with preservation of the duodenum and common bile duct and parts of the ventral or dorsal pancreatic head tissue or resection only of the tumour bearing tissue of the uncinate process [2]. An anastomosis between the pancreatic head and an excluded jejunal loop is necessary in either case.

44.1 History of DPPHR

Role of the pioneer of DPPHR may belong to Beger. In 1972 he started his dog experiments on subtotal pancreatic head resection. First report on in-human use of this procedure has been done in 1980 by the same author [1]. Surgery was performed in 12 patients: nine of them experienced chronic pancreatitis (CP) and three underwent DPPHR for suspected malignancy and pathology showed benign lesions. Author reported no clinical lethality with 75% rate of complete recovery 3 years after surgery. A total DPPHR removing pancreatic head parenchyma completely was suggested by Imaizumi in 1990 [3]. Later on, Nakao argued that blood supply to the duodenum and common bile duct is compromised significantly during a total DPPHR to cause ischemic necrosis of them and that a segmental duodenectomy is required to avoid this complication [4]. He proposed this procedure as a pancreatic head resection with segmental duodenectomy (PHRSD) and distinguished PHRSD from DPPHR.

DPPHR for CP became a standard of care soon after its implementation into clinical practice [5]. The most likely

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reason is that surgery has been done to patients with fibrotic changes of pancreatic tissue thus mostly giving the sense of safety to the surgeon in light of postoperative pancreatic fistula. Recent systematic review and meta-analysis includes 797 patients with DPPHR for CP in 15 studies [6].

However, DPPHR for focal lesions of pancreatic head remains of limited use even in high volume centers partly because it demands meticulous technique to dissect along the mostly intact pancreatic parenchyma. Thus, further in this chapter author wants to focus specifically on DPPHR for focal lesions. To date, as of last review by Beger et al., totally 523 cases of DPPHR for benign and low-grade malignant pancreatic neoplasms within 26 cohort studies have been identified [7]. Minimally invasive or robotic-assisted approach has been used in 37 of 523 (7.1%) patients.

Progress in technologies for minimally invasive surgery and advanced techniques made it possible to perform a laparoscopic DPPHR as performed in 2004 and published in 2007 by Takaori [8]. In his first laparoscopic DPPHR, however, the case was converted into open for reconstruction, specifically for pancreaticojejunostomy, using a small laparotomy incision. As of nowadays, a totally laparoscopic DPPHR including laparoscopic reconstruction has been performed sporadically by several surgeons including the present author and this minimally invasive procedure has been indicated for IPMN, neuroendocrine tumors and other noninvasive neoplasms of the pancreatic head.

Robotic pancreatic surgery became notable for DPPHR in 2012 [9]. Peng et al. presented four cases of DPPHR: one for CP and three for benign pancreatic neoplasms. As of 2018, he reported 34 patients to undergo this procedure while currently it remains the largest single center experience [10].

44.2 Classification

As for now, DPPHR can be classified as total, subtotal, and partial ones. In the first scenario, the duodenum can be either totally preserved or resected segmentally. Subtotal DPPHR presumes to spare duodenum and to either spare common bile duct (CBD) or perform its resection along with resection of the pancreatic head leaving only the thin layer of pancreatic tissue along the duodenum. Partial DPPHR usually spares all the above structures.

44.3 Blood Supply to Pancreatic Head and Pertinent Adjacent Organs

It is well known that pancreatic head blood supply goes from celiac axis (CA) and superior mesenteric artery (SMA). Likewise, there is no need for expert pancreatic surgeons to recall where all the pancreaticoduodenal arteries (PDAs) arise from. Nonetheless, some aspects of blood supply to pertinent segments of the pancreas, CBD and duodenum, especially those vulnerable for ischemia, need to be mentioned.

Description of vascular anatomy of the pancreas goes back to 1748 when Haller described anterior and posterior arches (arcades between CA and SMA) [11]. Since then, not many studies have been done on this specific issue using post-mortem specimens. Falconer and Griffiths investigated 50 specimens (27 dissections and 23 injection-corrosion preparations) [12]. In all the cases, gastroduodenal artery (GDA) gave rise to the anterior vessel, the anterior superior pancreaticoduodenal artery (ASPDA), which went over the head of the pancreas inferiorly toward duodenopancreatic sulcus and then medially in the groove, and posteriorly along the gland. Anastomosis was present behind the uncinate process with an anterior inferior pancrearticoduodenal artery (AIPDA). Posterior superior pancreaticoduodenal artery (PSPDA) was present in 25 dissections. In all but two cases (when it was arising from hepatic branch of SMA) PSPDA originated 1.5 cm distally to the origin of GDA. Then PSPDA went backwards over the upper border of the pancreas in front of the CBD along the posterior pancreaticoduodenal sulcus followed by leaving the latter shortly and going medially across the posterior surface of the pancreatic head and creating an anastomosis with the posterior inferior pancreaticoduodenal artery (PIPDA).

Bertelli et al. did summarize anatomy and nomenclature of pancreas blood supply over past two centuries based on over 1000 angiographic studies [13–16]. This is the classic anatomy we use nowadays. Typically, blood supply to the head of the pancreas goes from CA (via ASPDA and PSPDA as its terminal branches) and SMA (via AIPDA and PIPDA as its terminal branches) with arcade formation anteriorly and posteriorly. Authors also emphasize on the dorsal pancreatic artery (known also as Haller's artery) as a source of blood supply to pancreatic head originating from either splenic artery (most commonly), or CHA, or CA, or SMA, or other smaller visceral artery [17]. Its right terminal branch goes behind the superior mesenteric vein and then passes along anterior surface of pancreatic head. Before supplying pancreatic head, it forms prepancreatic arch, anastomosing with branch of the GDA, AS PDA or right gastroepiploic artery.

Furukawa et al. highlighted in their study blood supply to the pancreatic head taking into consideration its embryogenesis by computed tomography during arteriography, specifically its derivation from the ventral (smaller) and dorsal (larger) buds [18]. The former one corresponds to caudal part of pancreatic head and equals to uncinate process and gets blood supply from SMA (inferior PDAs, respectively) while the latter one is supplied by CA (superior PDAs, respectively) and equals to cephalic part of the head of the pancreas. Blood supply to CBD and ampulla of Vater is provided by CA, specifically by PSPDA, which is located along the intrapancreatic bile duct. Proximal part of the duodenum gets supply from CA, while distal part gets the one from SMA. According to the study, the boundary between those two areas was in the second part of the duodenum in 56%, in the third in 40%, and in fourth part in 4% of cases, respectively. Duodenum, mainly its first portion and proximal part of the second portion, also gets blood supply from the supraduodenal artery arising from GDA, and from retroduodenal artery arising from the PSPDA [19]. Those two are especially important to be preserved during DPPHR. Another study from Japan showed the presence of arcade formation between the ASPDA and the AIPDA in 100% of cases as well as between PSPDA and PIPDA in 88%, consequently. There was also found the membrane on the posterior aspect of the pancreas head where all of the PDAs were situated. One of the important details depicted in the study was that ASPDA eventually turns to the posterior aspect of the pancreas and joins there AIPDA [20]. Authors emphasize on the crucial role of the above membrane preservation to spare the blood supply to duodenum as well as PDAs themselves.

44.4 Technical Aspects of Total DPPHR

A total DPPHR is a procedure which requires removing all the pancreatic head tissue. In order to approach head of the pancreas, transection of gastrocolic ligament should be done along with access to lesser sac regardless of type of DPPHR.

Major pitfall of this procedure is how to preserve duodenal blood supply to avoid its ischemia. Given the description by Imaizumi, Kocher's maneuver should not be done [3, 21]. Nonetheless, author recommends ligation of GDA and right gastroepiploic artery along with sparing mesoduodenal vessels, especially when resecting uncinate process. Main pancreatic duct (MPD) and CBD are ligated extramurally followed by end-to-side pancreaticoduodenostomy and cholodochoduodenostomy, both with second part of duodenum. For the above procedure duodenum is totally preserved.

Nakao suggested 3–4 cm segmental duodenectomy along with both papilla resection for PHRSD to avoid duodenal ischemia [4]. Conservation of right gastric artery and AIPDA is required. Surgery is completed with pancreaticogastrostomy, end-to-end duodenoduodenostomy and end-to-side choledochoduodenostomy.

Takaori emphasized on preservation of PSPDA and PIPDA while ASPDA was divided at the origin of GDA. Hence, blood supply to the duodenum was preserved [8].

Hirata et al. when describing their technique of pylorus-preserving pancreaticoduodenectomy emphasize that preservation of retroduodenal artery arising from PSPDA and supplying first and proximal portion of second part of duodenum is critical, and ligation site should be after its root [18]. Likewise, Takada et al. claimed that PSPDA to be preserved while they avoided Kocher's maneuver [22].

Kim et al. demonstrated feasibility of total DPPHR with CBD preservation, however long-term outcomes as incidence of bile duct stenosis have not been reported but one during early postoperative course [23]. Authors advocate on sparing of all but ASPDA.

In general, type of anastomosis for pancreas remnant with gut as well as bile duct anastomosis is not a matter of discussion. None of the technique has been demonstrated as being safer [24]. The techniques highlighted above are preferences of each author. Aspects that matter are extent of parenchyma resection and preservation of blood supply to adjacent organs.

44.5 Technical Aspects of Subtotal DPPHR

A subtotal DPPHR, described as a typical Beger procedure, presumes preservation of thin layer of the pancreatic tissue of about 5–8 mm adjacent to the duodenum along with complete parenchyma transection followed by Roux-en-Y pancreaticojejunostomy [25]. The authors advocated that there is no need to preserve GDA. In turn, blood supply through supraduodenal vessels and dorsal duodenopancreatic arcade along with mesoduodenal vessels blood flow should be spared.

Unlike Beger procedure, its Bern modification leaves bridge of pancreatic tissue in front of superior mesenteric vein as well as opened both MPD and CBD followed by end-to-side anastomosis of pancreatic head with the jejunum including both ducts [26]. Kocher's maneuver and preservation of the entire duodenum is performed in both cases. Both procedures have become useful for CP with occasional use for benign or low-grade focal pancreatic lesions.

44.6 Technical Aspects of Partial DPPHR

A partial DPPHR is a procedure designed for benign and low-grade focal pancreatic lesions [27]. However, due to numerous technical aspects and sometimes being unsure about malignant potential of the lesion, surgeons tend to prefer Whipple procedure over DPPHR. In young patients with benign/low-grade pancreatic head lesions Whipple procedure seems to be excessive while removing organs not pertinent to the disease itself.

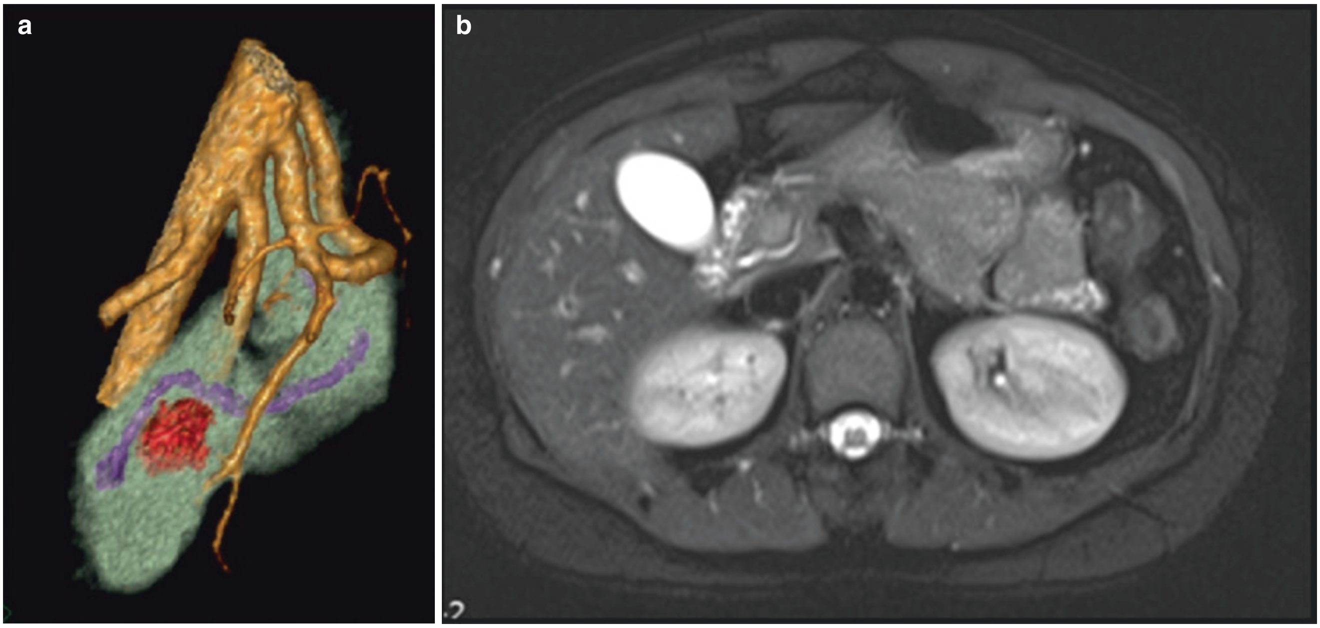

Fig. 44.1 (**a**) Abdominal 3D CT measured a 3 mm distance of pancreatic head mass (red) to MPD (purple) as well as demonstrated aberrant vascular anatomy of CA (yellow) giving rise to right hepatic artery, left hepatic artery, splenic artery, left gastric artery, and transverse pancreatic artery. (**b**) Abdominal MRI. Hyperintense pancreatic head mass in close proximity to MPD on its posterior surface

Extent of pancreatic head parenchyma resection can be defined as partial by extrapolating extent of pancreatic parenchyma resection for other types of surgery when comparing pancreatic function during long-term follow-up [28]. In order to get satisfactory endocrine and exocrine function in most cases resection of no more than 50% of pancreatic head parenchyma is recommended. Enucleation cannot be included into partial DPPHR as it doesn't presume resection of pancreatic tissue. In contrast, uncinatectomy represents a typical partial DPPHR. We recommend to avoid MPD exposure when possible during partial DPPHR. This is usually feasible with tumor distance to MPD of more than 2 mm.

Here is an example of partial DPPHR. Approach to pancreatic head was the same as described above. Surgery became a challenge due to intraparenchymal location of the tumor and its close proximity to MPD (Fig. 44.1a, b). Pancreatic lesion had been additionally visualized using intraoperative US (Fig. 44.2). Kocherization of duodenum has been done given that PDA arcades (between both anterior and both posterior PDAs) were preserved. Patient underwent partial DPPHR with preservation of MPD integrity. Lesion was excised with small portion of pancreatic parenchyma followed by Roux-en-Y pancreaticojejunostomy using simple interrupted suture (Fig. 44.3a, b). Pathology revealed proinsulin-only secreting tumor.

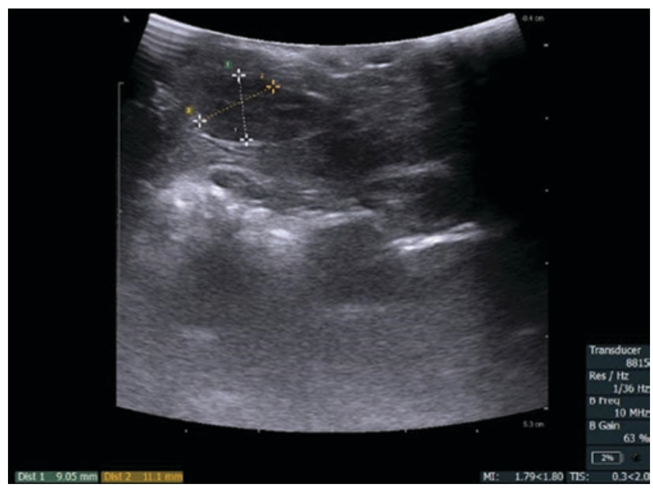

Fig. 44.2 Intraoperative US revealed hypovascular pancreatic head lesion close to MPD

44.7 Outcomes of DPPHR

For CP there is a sufficient number of studies highlighting short- and long-term outcomes. First randomized trial has been published by authors from Ulm and Bern [29]. The authors compared patients randomly assigned to either pylorus-preserving Whipple group or DPPHR group.

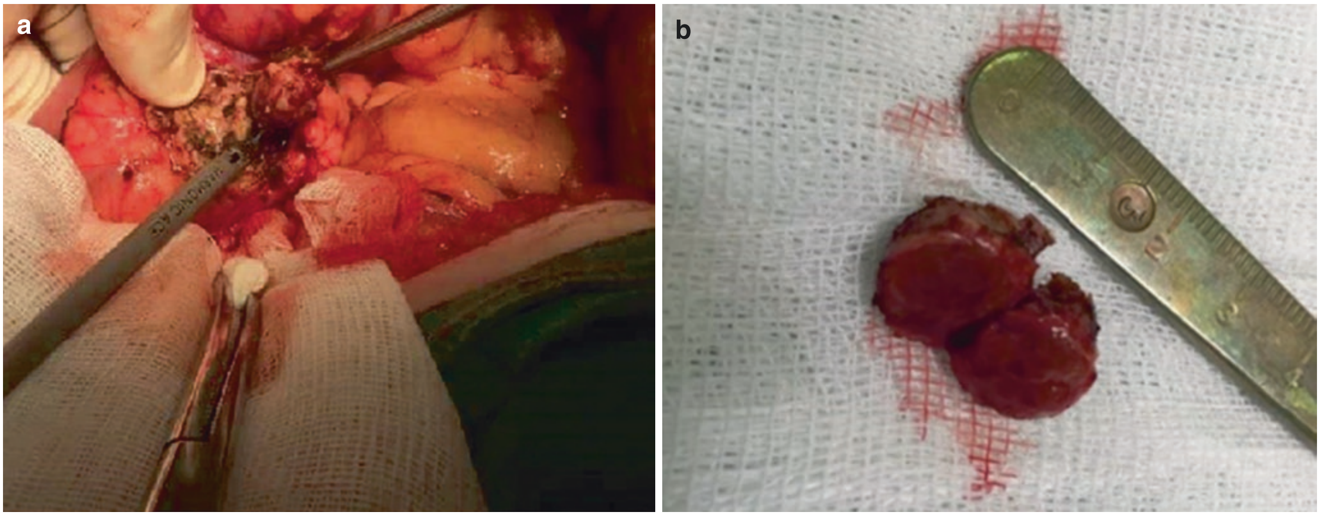

Fig. 44.3 (**a**) Pancreatic head bed after resection. (**b**) Macroscopic specimen of pancreatic head lesion

There was no postoperative mortality in both groups. Postoperative complication rate was 20% and 15%, respectively. However, patients who underwent DPPHR showed favourable long-term outcomes as less pain, greater weight gain, a better glucose tolerance, and a higher insulin secretion capacity. Authors also emphasize on preservation of duodenum as crucial factor for further intact glucose metabolism.

About two decades later, the same authors published multicentre, randomised, controlled, double-blind trial focusing mostly on long-term outcomes of surgery for CP comparing DPPHR vs partial pancreatectomy [30]. There was no difference in morbidity, mortality, and quality of life 24 months after surgery in DPPHR vs partial pancreaticoduodenectomy group. However, being a more definitive treatment, a partial pancreaticoduodenectomy was associated with fewer readmissions due to ongoing or recurrent pancreatitis.

Another meta-analysis on CP demonstrated that DPPHR has been shown to have more benefits over conventional pancreaticoduodenectomy/pylorus-preserving pancreaticoduodenectomy in reducing prevalence of endocrine insufficiency, delayed gastric emptying, and duration of postoperative stay, as well as increasing quality of life for patients, consequently. However, there was no significant differences between two groups in prevalence of pain relief, development of pancreatic fistula, wound infection, or exocrine insufficiency, as well as mortality rate [6].

As for DPPHR for focal premalignant and low-grade malignant neoplasms with IPMN as being the most frequent, according to meta-analysis, severe complication rate has been reported as 8.9% for total DPPHR and 13.9% for subtotal DPPHR. Overall in-hospital and late mortality with mean follow-up over 47 months were 0.6% and 1.5%, respectively [7].

As for long-term outcomes, single center study on functional results after various types of pancreas resection for neuroendocrine neoplasms found body mass index (BMI) to be the strongest predictor of postoperative diabetes mellitus (DM) with greater BMI being the greater risk for development of DM [28]. In addition, patients with advanced age, male gender, and non-functioning tumor were more prone to develop postoperative DM. Multivariate logistic regression analysis of predictors of postoperative pancreatic exocrine insufficiency showed that the extent of pancreatic parenchyma resection was the only independent predictor of postoperative pancreatic exocrine insufficiency.

Sporadic single center studies done before ChroPac presumed that quality of life and some other long-term variables after DPPHR for CP are above those after pancreaticoduodenectomy [30, 31]. However, non-randomized nature and other disadvantages like possible experimenter expectancy bias do not allow to support this hypothesis.

ChroPac study showing the outcomes of DPPHR for CP made it clear that most of those patients present with latent or prominent impairment of pancreatic function before surgery. In contrast, there are no similar studies yet for focal pancreatic lesions with intact parenchyma surrounding the tumors. This might cause a major argument over the organ-preserving surgery, especially in young patients. Our experience of DPPHR favors this procedure for specific patients as mentioned above.

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