Original Article *Nepal Med Coll J 2016; 18 (1-2): 62-67*

Anatomical Variations of Hepatic Artery in Patients Undergoing Pancreaticoduodenectomy

Thapa PB,[1] Yonjen TY,[2] Maharjan DK,[2] Shrestha SK[1]

Department of Surgery, Kathmandu Medical College Teaching Hospital, Sinamangal, Kathmandu, Nepal

Corresponding Author: Dr Prabin Bikram Thapa, Associate Professor, Department of Surgery
Kathmandu Medical College Teaching Hospital, Sinamangal, Kathmandu; Email:prabinbt@gmail.com

ABSTRACT

Presence of hepatic arterial anomaly challenges the basic aim of preservation of hepatic arterial system, achievement of a R0 resection during Pancreatoduodenectomy (PD) and an uncomplicated course post-operatively.The objective of this study is to describe the anomalous arterial variations that we have observed during PD and to review the literature to reiterate the importance of identification of the anomaly. Fifty patients who underwent PD during February 2012 till July 2015 in a single surgical unit at the Department of Surgery, Kathmandu Medical College Teaching Hospital were prospectively included in our observational study. Mean and percentile value was calculated. The vascular description was based on radiological and/or intraoperative findings.The most common variation was observed with the right hepatic artery (RHA); three replaced RHA and one accessory RHA. Based on Michel classification, arterial anomaly was seen in 20% of our patients. Two rare variations; accessory left hepatic artery (LHA) from gastroduodenal artery (GDA) and trifurcation of common hepatic artery (CHA), not described in Michel's classification, have been included as "Unclassified group". Hiatt described trifurcation of CHA as subtype of the normal variant and hence, according to Hiatt classification, arterial variations were seen in 16% patients. Accessory LHA from GDA, not described in Hiatt classification either has been included as the 7th type of arterial anomaly. We did not find any technical difficulty during the PD. Thus, a variation of hepatic arterial anatomy is not uncommon. Preservation of aberrant hepatic artery is possible without any perioperative negative outcome in some cases.

Keywords: Arterial variation, Hepatic artery, Pancreatoduodenectomy

INTRODUCTION

Pancreatoduodenectomy (PD) is indicated in diseases of the pancreas, duodenum and the distal bile duct. It is a technically challenging procedure, which is complicated further by the presence of hepatic arterial anomalies. The basic aim of PD; preserving the hepatic arterial system while achieving a R0 resection is difficult to achieve in presence of hepatic arterial anomaly. Lack of knowledge and/or intention to identify the hepatic arterial anatomy, especially the variants may lead to an oncologically unsafe and a complicated postoperative course. We also observed the presence of such anomalies during PD in our surgical unit. The objective of this study is to describe the anomalous arterial variations that we have observed and to review the literature to reiterate the importance of identification of the anomaly.

METHODOLOGY

All patients who underwent PD from February 2012 till July 2015 in a single surgical unit at the Department of Surgery, Kathmandu Medical College Teaching Hospital were prospectively included in our study. This observational study only includes our first 50 patients who underwent PD during our study period. The collected data included age, gender, indications for surgery, preoperative contrast enhanced computed tomography (CECT) with or without reconstruction angiogram of celiac artery, superior mesenteric artery and inferior mesenteric artery, radiological description of hepatic arterial anomaly and intraoperative anatomy of hepatic artery. Since, this was a prospective descriptive study, only mean and percentile value were calculated using SPSS Statistics 17.0. Ethical clearance was obtained from the Institutional Review Committee and informed consent was taken from the patients. Vascular description was based on radiological and/ or intraoperative findings. The variations are described according to the classification given by Michel *et al* and Hiatt *et al*.[1,2]

RESULTS

A total of 50 PD were included during the study period. The most common variation was observed with right hepatic artery (RHA). Replaced RHA was observed in 3 patients and accessory RHA was observed in 1 patient (Figure.3). Replaced LHA was observed in 3 and accessory RHA was observed in 1. We also observed rare forms such as accessory left hepatic artery (LHA) from gastroduodenal artery

(GDA) (Figure 4) (n=1). We did not observe rare variations such as CHA from the aorta or LGA. Trifurcation of the common hepatic artery (CHA) was observed in two patients (Figure 6). Michel *et al* and Hiatt *et al* classified hepatic arterial anomalies into 10 types and 6 types respectively as has been shown in table 1.[1,2] The arterial variations that we observed have been classified according to both the Michel and the Hiatt classification. According to Michel classification, arterial anomaly was seen in 10 patients (20%) (Table 1). The remaining 40 patients (80%) had normal variation (Type 1) (Figure 1). The commonest variation was Type 3 wherein, a replaced RHA arose from Superior mesenteric artery (SMA) (Figure 3) in 30 % (n=3) patients. An accessory RHA (type 6) was seen in 1 patient (10%). The second most common variation was a replaced LHA arising from LGA in 2 patients (20%). We saw two rare variations; accessory LHA from GDA (n=1) and trifurcation of CHA (n=2) which has not been described in Michel's classification.[1] We have included them in the "Unclassified group of Michel – Type 11".

Table 1: Spectrum of arterial anomaly in our series

Michel Type	Description		Number	Percent of variation (%)
1	Normal		40	
2	Replaced LHA from LGA		2	20
3	Replaced RHA from SMA		3	30
4	Replaced RHA and LHA		0	0
5	Accessory LHA		1	10
6	Accessory RHA		1	10
7	Accessory RHA and LHA		0	0
8	Replaced RHA + Accessory LHA or Replaced LHA + Accessory RHA		0	0
9	CHA from SMA		0	0
10	CHA from LGA		0	0
	Unclassified	(aLHA from GDA)	1	10
		Trifurcation of CHA	2	20

Hiatt classifi cation is more concise as compared to Michel classifi cation with only 6 types. According to Hiatt, trifurcation of CHA is described as subtype of the normal variant (Type 1) and hence, according to this classifi cation, there were 42 normal arterial anomaly and 8 arterial variations in our study (Table 2).[2] There were 4 patients with RHA anomaly (n=4, 50%) and 3 with LHA anomaly ((37.5%). Accessory LHA from GDA has not been described in Hiatt classification either. We have included it as the 7th type of arterial anomaly.

Table 2: Spectrum of arterial anomaly in our series

Hiatt Type	Description	Number	Percent of variation (%)
1	Normal	40 + 2	
2	Replaced or accessory LHA	3	37.5
3	Replaced or accessory RHA	4	50
4	Replaced or accessory RHA + Replaced or accessory LHA	0	0
5	CHA from SMA	0	0
6	CHA from Aorta	0	0

In our series, we did not encounter any technical difficulty during the PD. Vigilant preoperative determination of the anomaly and meticulous dissection may have awarded this result. CT angiography was important in diagnosing the presence of anomalies preoperatively. It was done in 20 patients undergoing PD (40%), which included 3 patients with hepatic arterial anomaly. However, the remaining 30 patients were patients referred from other centers and thus were received with an existing CT scan of the abdomen and pelvis. Hence, the CT angiogram were deferred in them. In these patients with no CT angiogram, arterial anomaly was identified in 7 patients intraoperatively.

DISCUSSION

Pancreatoduodenectomy (PD) is indicated in various diseases of the pancreas, distal biliary tree or the duodenum. The aim to perform a R0 resection with preservation of hepatic arterial supply is challenged by the presence of variations of the hepatic arterial anomaly. Hepatic artery remains an important blood supply to the liver and the biliary system. Any inadvertent damage to the hepatic artery may lead to hepatic arterial thrombosis, liver failure, infarction, abscess formation, biliary fistula or pseudoaneurysm.[3] The most common variant of the hepatic artery is the RHA arising from the SMA.[1,2] Such RHA runs lateral to the portal vein (PV) in the hepatoduodenal ligament, and courses under the head of the pancreas and under the CBD toward the liver.[3] The RHA from SMA may course behind, within or along the ventral side of the pancreas.[4] Michel *et al* found that half of the RHA actually coursed through the pancreatic parenchyma, whereas the other half passed posterior to the pancreas.[1] Such anatomical location poses difficulty in PD especially during the en bloc lymph node dissection and risks injury to the variant artery. However, it is important to identify the variations in hepatic artery and attempt preservation. Variations in the anatomy of hepatic artery are common. It is said to occur because of the persistence of vitelline arteries during the embryologic development.[3] In the most common pattern (25-75% of cases Hiatt *et al*), the common hepatic artery (CHA) arises from the coeliac axis to divide into the gastroduodenal artery (GDA) and the hepatic artery proper (HAP).[2] The latter divides further into the left (LHA) and right hepatic arteries (RHA). However, the liver may receive its blood supply from the superior mesenteric artery (SMA), left gastric artery (LGA), aorta or other visceral branches. These anomalous arteries are termed as "Accessory" if they occur in addition to the normal arterial supply or as "Replaced" if they are the primary arterial supply to the liver. "Trifurcation" where the LHA, RHA and GDA originate simultaneously from CHA is thought to be a subtype of the normal by Hiatt *et al*.[2]

Classification of variations of hepatic artery

The variation in the hepatic arterial anatomy was initially described by Michel *et al* in 1966 based on 200 cadaveric dissection.[1] It has since formed the basis of further development. Michel *et al* described 10 types of variations and the normal variation was observed in 55% of the patients only. The remaining patients had anatomical variations. The most common variation was type 3 (11%).

Based on Michel classification, we observed normal arterial anatomy in 80% patients in our study. The commonest variation that we observed was also Type 3 (30% (n=3) patients) wherein, a replaced RHA arose from superior mesenteric artery (SMA). We encountered two variations that has not been described by Michel; an accessory LHA arising from GDA (n=1) and trifurcation of CHA (n=2). We have included them in the "Unclassified group of Michel – Type 11".

Classification of hepatic arterial types

Michel Type	Description		Number	Percent of variation (%)
1	Normal		55	
2	Replaced LHA from LGA		10	20
3	Replaced RHA from SMA		11	30
4	Replaced RHA and LHA		1	0
5	Accessory LHA		8	10
6	Accessory RHA		7	10
7	Accessory RHA and LHA		1	0
8	Replaced RHA + Accessory LHA or Replaced LHA + Accessory RHA		2	0
9	CHA from SMA (Hepatomesenteric trunk type CHA)		2.5	0
10	CHA from LGA		0.5	0
	Unclassified	(aLHA from GDA)	0	10
		Trifurcation of CHA	0	20
	Total (%)		98	100

In 1993, Hiatt *et al* published their observation of arterial variations of 1000 patients who underwent orthotopic liver transplantation by the UCLA liver transplant services between 1984 and 1993.[2] They reduced the types of variations to 5 along with a 6th type which is very rare. Again, the most common variation was observed with the RHA. Hiatt type 1 (normal variant) has been observed in 51-76% cases, type 2 in 4.6-18%, type 3 in 10.6-21% cases, type 4 in 1.9-4% cases, type 5 in 1.5-5% cases and others in 0.2-6% cases in various series.[5-9] However, unlike studies based on cadaveric dissections or arteriographic anatomy, the information on intrahepatic branches is missing and it may have lead to the difficulty of affirmatively determining the accessory or replaced nature of the arteries.[2,6,8]

According to Hiatt, trifurcation of CHA is described as subtype of the normal variant (Type 1) and hence, according to this classification, we observed 42 normal arterial anomalies and 8 arterial variations. RHA anomaly (n=4, 50%) was the commonest in our study also and 3 had LHA anomaly (37.5%).[2]Accessory LHA from GDA has not been described in Hiatt classification either. We have included it as the 7th type of arterial anomaly.

Classification of hepatic arterial types

Hiatt Type	Description	Percent (Hiatt et al)	Comparison with Michel	Our observation (%)
1	Normal	75.7	Type 1 (55 %)	
2	Replaced or accessory LHA	9.7	Type 2 and 5 (18%)	37.5
3	Replaced or accessory RHA	10.6	Type 3 and 6 (18%)	50
4	Replaced or accessory RHA + Replaced or accessory LHA	2.3	Type 4, 7 and 8 (4%)	0
5	CHA from SMA	1.5	Type 9 (2.5%)	0
6	CHA from Aorta	0.2	Type 10 (0.5%)	0
	Unclassified			12.5
		100		100

Importance of the identification of the hepatic arterial anatomy during PD

The liver has a dual blood supply; hepatic artery and the portal vein. Effect of inadvertent damage to the hepatic artery on the liver may be minimized by compensatory increase in the portal venous blood flow and the intrahepatic collateral flow. However, the biliary system is dependent on its arterial supply alone. Most blood supply is derived from the retroduodenal artery,

a branch of the GDA.[3,10,11] The proximal blood supply is from the RHA. In PD, where GDA is routinely sacrificed, further damage to the hepatic artery can compromise blood supply to the biliary system leading to fistulation at the bilioenteric anastomosis.[3]
Injury to the hepatic artery has been associated with hepatic arterial thrombosis, hepatic necrosis, liver failure, infarction and abscess formation.[3,11,12]
Though associated, occurrence of surgical complications (such as pancreatojejunostomy

leakage, delayedgastric emptying, postpancreatectomy, hemorrhage, hepaticojejunostomy leakage, primary intra-abdominal abscess, wound infection, re-laparatomy, hospital mortality or median hospital stay) were no different between whether the anomalous RHA was present or not and may even be higher in patients with normal arterial variation in some studies.[13,14] Presence of hepatic arterial variation has been thought to affect resectability. However, studies indicate that it may not affect the resectability of pancreatic tumor but may alter the surgical plan.[15] In a series of 289 patients with pancreatic adenoacarcinoma of whom 249 underwent PD; the resection rate was 92.5% for patients with anomalous RHA and 85.1% for those with standard anatomy.[14] In the same series, Kim *et al* found no difference (p-value 0.2) in the incidence of anomalous RHA between patients who underwent PD (14.9%) versus those who did not (7.5%). The resectability was instead associated with the presence of metastasis or locally advanced disease involving major arterial structures (i.e. SMA). The need to preserve the anomalous artery (as much as possible) and yet achieve a R0 resection is the reason for complicated PD and alteration in the surgical plan. The extent of difficulty may differ according to the variations. Though this effect has been negated by Jah *et al*; most other authors including Perwaiz *et al* had a different experience.[16,17] Perwaiz *et al* observed that the anomalous artery may be coursing away from the field of transection and may not affect the performance of PD in some.[17] However, they observed difficulty in removing the uncinate process and division of the CBD in 66% cases and these were mainly related to RHA arising from SMA. Also, they found difficulty in ligation of GDA, creating a retropancreatic tunnel from the supraduodenal side and transecting the neck of the pancreas in 11.3% patients. These included patients with anomalous arteries from GDA or when CHA was originating from SMA. In some cases, performance of PD is not possible in the presence of anomalies. Perwaiz *et al* [17] abandoned PD in two cases. One patient had an anomalous RHA arising from SMA encased by a 5.5 cm tumor. The risk of positive resection margin led to abandoning the procedure. The other patient was a 71-year-old patient with celiac artery stenosis. The test clamp of the GDA led to the cessation of the fl ow in RHA and LHA. A prominent pancreaticoduodenal arterial arcade from the SMA was found coursing across the tumor and supplied the hepatic arteries through the supraduodenal artery. The procedure was abandoned as the feasibility of PD with negative margins was remote and the patient was elderly with coronary artery diseases and extensive atherosclerosis of the major abdominal arteries.

Presence of anomalous artery may question the oncological safety. Deviation of the pancreatic transection line to the right side risks a positive pancreatic margin and coring of the anomalous artery out of the pancreatic capsule may risk tumor cell spillage.[17] However, this risk of breach of oncological safety has been negated by many studies. Perwaiz *et al* found that 5.6% of patients with normal pattern but no patient with arterial anomaly had positive resection margin.[17] Lee *et al* observed that R status, locoregional recurrence, (20.5 vs 13.3%, p value 0.202), distant metastasis (19.3 vs 40.1%) or median survival (28.7 +3.3 months vs 29.8 +15.4 months p value 0.763) were comparable between those with normal HA and variant HA.[12] Similar results were observed by Eshuis *et al* and Kim *et al*.[13, 14] Kim *et al* observed that the rate of lymphovascular invasion was significantly higher (p value 0.009) in the normal variant (65.6%) as compared to anomalous variants (48.7%).[14]

Methods of identification

Preoperative identification of the variation of the hepatic artery is possible with various imaging modalities. CECT or Magnetic Resonance Imaging (MRI) of the abdomen provides detail information of the arterial anatomy of the liver as well as the relation of the tumor with the adjacent structures.[3] However, vascular anatomy is not routinely mentioned in all radiological reports.[13,18] Such identification is dependent on the attention to details given by the surgeon and radiologist. Stauffer *et al* realized that only 9/24 anomalies, which were identified intraoperatively had been noted in preoperative imaging.[3] However, retrospective review of these images identified anomalies in 24/25 of these patients. Selective mesenteric angiography has been used by various studies and recommended for routine use for potential radical resection for malignant neoplasm of the pancreas by Rong and Sindelar.[5,11,19] However, improvements in the quality of the aforementioned investigations have reduced the need for such invasive procedures.Variations of the hepatic artery may be identified intraoperatively. Palpation and meticulous dissection are the cornerstones. However, efficacy of palpation is limited by the presence of large tumors or when associated with pancreatitis.[10,20].

Recently, the use of intraoperative Ultrasound (IOUS) has improved identification.[14,17] IOUS may even help in deciding whether the anomalous artery can be sacrificed or requires preservation. Perwaiz *et al* divided an accessory LHA encased by tumor after the IOUS revealed preserved LHA from HAP following test clamp of the accessory LHA.[17]

Fate of the anomalous artery during surgery

Identifi cation of the arterial variation is of paramount importance. It is possible to meticulously dissect and preserve the variant artery in most cases. Stauffer *et al* was able to preserve the variant artery in 24/31 patients (77%).[3] However, it may be transected, accidentally or deliberately. Deliberate transection has been done in cases of tumor involvement and thrombosis.[3]Such transected arteries have been reconstructed by primary anastomosis or by interposition grafts with the gonadal vein or PTFE jump grafts.[3] It may be directly re-implanted to the GDA. However, in such repair, there is a risk of potentially fatal postoperative bleeding if a pancreatic fistula and/or a pseudoaneurysm develops.[20-23]

Ligation or sacrifice of the variant artery may be done for an accessory RHA of small caliber, if it affects resection and is unlikely to have clinical significance.[3,4]

Test occlusion of the GDA and pulsation of the hepatic artery as described by Bull *et al* has been used to guide ligation or preservation of the GDA during PD.[24] It has been observed that ligation of the replaced RHA does not always lead to hepatic necrosis and the postoperative liver dysfunction may be transient.[15] This has been attributed to the reversed flow through spontaneous intrahepatic anastomosis between arteries in different segments.

Preoperative embolizations have been done for large aberrant artery that is involved by tumor. It facilitates adequate collateralization to the right lobe and bile ducts before PD thus improving the resectability with adequate oncologic outcome.[25]

Approaches to the variants of hepatic artery

A variant hepatic artery may be approached by various methods. However, such approach depends on whether it was identfiedbypreoperativeinvestigationandthe relationship of the tumor to the artery. The arteries may be approached dorsally after a Kocher maneuver as is generally done during a traditional PD.[12]A ventral approach has been described by Noie *et al*.[26] It is performed without a Kocher's maneuver. It involves skeletonizing the LHA, HAP, CHA and PV; dissecting replaced RHA from the ventromedial aspect of the hepatoduodenal ligament by dividing the thin connective tissue behind the PV and isolating the HA and PV without Kocher's maneuver. This approach leaves the cancer and bile duct untouched en bloc with the surrounding LN and pancreas head. This facilitates a complete en bloc resection of the hepatoduodenal and para-aortic lymph nodes along with the main lesion. A modified technique for PD has been also described by Varty *et al*, wherein an early retropancreatic dissection is done to expose the variant artery.[27] A RHA coursing through the pancreatic parenchyma, can be preserved by dividing the pancreatic parenchyma. A RHA coursing posterior to the pancreas can be dissected from the pancreatic parenchyma. In all approaches, excessive traction on the dorsum of the pancreatic head must be avoided to prevent thrombosis/pseudoaneurysm of the variant artery.[3]

Thus, a variation of hepatic arterial anatomy is not uncommon. Presence of variations in the anatomy of hepatic artery should be taken into account to prevent accidental injury. Preservation of aberrant hepatic artery is possible without any perioperative negative outcome in some cases. Our study requires, large patient population and longer follow up required to obtain oncological or statistical significance

REFERENCES

1. Michels NA. Newer anatomy of the liver and its variant blood supply and collateral circulation. *Am J Surg* 1962; 112:337-347
2. Hiatt JR, Gabbay J, Busuttil RW. Surgical Anatomy of the Hepatic Arteries in 1000 Cases. *Annals of Surgery* 1994; 220;1:50-52
3. Stauffer JA, Bridges MD, Turan N, Nguyen JH, Martin KJ. Aberrant right hepatic arterial anatomy and pancreatoduodenectomy: recognition, prevalence and management. *HPB* 2009;11:161-165
4. Yamamoto S, Kubota K, Rokkaku K, Nemoto T, Sakuma A. Disposal of replaced common hepatic artery coursing within the pancreas during pancreatoduodenectomy: report of a case. *Surg Today* 2005;35:984–987.
5. Rong Gh, Sindelar WF. Aberrant peripancreatic arterial anatomy: considerations in performing pancreatectomy for malignant neoplasms. *Am Surg* 1987;53:726-729.
6. Kemeny MM, Hogan JM, Goldberg DA, Goldberg DA, Lieu C, Beatty JD, Kokal WA, Riihimaki DU, Terz JJ. Continuous hepatic artery infusion with an implantable pump: problems with hepatic arterial anomalies. *Surgery* 1986; 99:501-504.
7. Rygaard H, Forrest M, Mygind T, Baden H. Anatomic variants of the hepatic arteries. *Acta Radiol Diagn* 1986; 27:425-427.
8. Daly JM, Kemeny N, Botet J. Long-term hepatic arterial infusion chemotherapy. *Arch Surg* 1984; 119:936-941.
9. Niederhuber JE, Ensminger WD. Surgical considerations in the management of hepatic neoplasia. *Semin Oncol* 1983; 10:135-147.
10. Woods MS, Traverso LW. Sparing a replaced common hepatic artery during pancreaticoduodenectomy. *Am Surg* 1993;59:719–721
11. Traverso LW, Freeny PC. Pancreaticoduodenectomy, the importance of preserving hepatic blood flow to prevent biliary fistula. *Am Surg* 1989;55:421–426

12. Lee JM, Lee YJ, Kim CW, Moon KM, Kim MW. Clinical implications of an aberrant right hepatic artery in patients undergoing pancreaticoduodenectomy. *World journal of surgery* 2009;DOI:10.1007/s00268-009-0063-x
13. Eshius WJ, Loohius MO, Busch RC, Gulk TM, Gouma DJ. Influence of aberrant right hepatic artery on perioperative course and long term survival after pancreatoduodenectomy. *HPB* 2011;13:161-167
14. Kim PT, Temple S, Atenafu EG, Cleary SP, Mouton CA, McGilvary ID, Gallinger S, Greig PD, Wei AC. Aberrant righ hepatic artery in pancreaticoduodenectomy for adenocarcinoma: impact on resectability and postoperative outcomes. *HPB* 2014, 16, 204-211.
15. Domenico SD, Santacroce W, Rossi AM, Giannone A, Valente U. Reversed arterial flow in the paramedical segments of the liver after pancreatoduodenectomy. *J Clin Ultrasound* 2011;Feb:39:2:99-103.
16. Jah A, Jamieson N, Huguet E, Praseedom R. The implications of the presence of an aberrant right hepatic artery in patients undergoing a pancreaticoduodenectomy *Surg Today* 2009; 39:669-74. [PMID 19639433]
17. Perwaiz A, Singh A, Singh T, Chaudhary A. Incidence and management of arterial anomalies in patients undergoing pancreaticoduodenectomy. *J Pancreas* (Online) 2010. Jan 8;11(1):25-30.
18. Turrini O, Wiebke EA, Delpero JR, Viret F, Lillemoe KD, Schmidt CM. Preservation of replaced or accessory right hepatic artery during pancreaticoduodenectomy for adenocarcinoma: impact on margin status and survival. *J Gastrointest Surg* 2010;14:1813–1819.
19. Volpe PP, Peterson S, Hoover EL, Doerr RJ, Justification for visceral angiography prior to pancreaticoduodenectomy. *Am Surg* 1998;64:758-761.
20. Bold RJ, Charnsangavej C, Cleary KR, Jennings M, Madray A, Leach SD, et al. Major vascular resection as part of pancreaticoduodenectomy for cancer: radiologic, intraoperative, and pathologic analysis. *J Gastrointest Surg* 1999; 3:233-43. [PMID 10481116]
21. Li B, Chen FZ, Ge XH, Cai MZ, Jiang JS, Li JP, Lu SH. Pancreatoduodenectomy with vascular reconstruction in treating carcinoma of the pancreatic head. *Hepatobiliary Pancreat Dis Int* 2004; 3:612-5. [PMID 15567757]
22. Nakano H, Bachellier P, Weber JC, Oussoultzoglou E, Dieng M, Shimura H, Boudjema K, Wolf P, Jaeck D. Arterial and vena caval resections combined with pancreaticoduodenectomy in highly selected patients with periampullary malignancies. Hepatogastroenterology 2002; 49:258- 62.PMID 11941970
23. Kondo S, Katoh H, Hirano S, Ambo Y, Tanaka E, Okushiba S, Morikawa T. Results of radical distal pancreatectomy with en bloc resection of the celiac artery for locally advanced cancer of the pancreatic body. *Langenbecks Arch Surg* 2003; 388:101-6. [PMID 12684805]
24. Bull DA, Hunter GC, Crabtree TG, Bernhard VM, Putnam CW. Hepatic ischemia, caused by celiac axis compression, complicating pancreaticoduodenectomy. *Ann Surg* 1993; 217:244-7. [PMID 8095781]
25. Miyamoto N, Kodama Y, Endo H, Shimizu T, Miyasaka K, Tanaka E. Embolization of the replaced common hepatic artery before surgery for pancreatic head cancer: report of a case. *Surg Today* 2004;34:619-622
26. Noie T, Harihara Y, Inoue K, Kubota K, Takayama T, Makuuchi M. Ventral dissection of replaced right hepatic artery during pancreatoduodenectomy. *Hepatogastroenterology* 2001;48:999-1000.
27. Varty PP, Yamamoto H, Farges O, Belghiti J, Sauvanet A. Early retropancreatic dissection during pancreaticoduodenectomy. *Am J surg* 2005;189:488-491