ONLINE FIRST

This is a provisional PDF only. Copyedited and fully formatted version will be made available soon.

FOLIA MORPHOLOGICA

ISSN: 0015-5659

e-ISSN: 1644-3284

Unravelling the mystery of porta hepatis for surgical benefit

Authors: A. Saha, P. Srimani

DOI: 10.5603/FM.a2022.0047

Article type: Original article

Submitted: 2022-01-04

Accepted: 2022-04-07

Published online: 2022-04-28

Unravelling the mystery of porta hepatis for surgical benefit

A. Saha, P. Srimani, Hepatic portal study

A. Saha, P. Srimani

Department of Anatomy, Calcutta National Medical College, Kolkata, West Bengal, India

Address for correspondence: Dr. P. Srimani, Assistant Professor, Geetanjali Apartment, Flat No. 101, 37A, G.T. Road, P.O. Rishra, Dist. Hooghly, West Bengal, India, tel: 09830479835, 08420965190, e-mail: falgunisreemani@yahoo.co.in

Abstract

Background: Hepatobilliary surgery is nowadays growing with increasing popularity throughout the world with advent of newer liver imaging modalities. Anticipating a wide range of morphological variations of porta hepatis (PH), a precise understanding is pertinent to preoperative diagnosis, operative procedure and post-operative outcome of hepatobiliary disease.

Materials and methods: Considering recent interest, present study was undertaken.110 isolated adult cadaveric livers of unknown age and sex were dissected to explore detail morphology and morphometry of PH.

Results: Classical picture of PH was observed in 20% liver. The standard representation of structures was highest in hepatic artery (59.1%) followed by portal vein (55.5%) and hepatic duct (51.8%). On the basis of structural distribution PH was described as sixteen types. Maximum variable number was found in hepatic artery followed by portal vein and hepatic duct. In morphometric analysis, transverse diameter of PH was more than antero-posterior diameter; while mean circumference of PH indicated that PH was slightly oval in outline. Position of PH was more towards posterior and slightly right in inferior surface of liver.

Conclusions: Variations of portal anatomy regarding circulatory and biliary dynamics is worth knowing in successful planning of hepatobiliary surgeries with least complications.

Key words: liver, porta hepatis, variation, morphology, morphometry

INTRODUCTION

Despite advancement in hepatic interventions, potential vascular complications might occur in hepatobilliary surgery due to topographical alteration with structural variability of Porta hepatis (PH) or hepatic hilum resulting high degree of morbidity or even death [24]. In order to address the complications posed by variant vasculo-biliary system, detailed knowledge about portal anatomy assumes critical.Variations of biliary and hepatic arterial anatomy are reported more frequent than portal venous variants. Careful handling of such circulatory and biliary dynamics of liver is important during live donor liver transplantation (LDLT). As surgical view is limited to delineate hepatic anatomy, introduction of minimally invasive methods also remains challenging for surgeons. Moreover, presence of aberrant components might be an obstacle during operation if over-looked. Unanticipated anatomical variations may cause increase in graft ischemia time with associated risk of post-operative graft dysfunction and emphasizes need of additional anastomosis [3, 5, 11, 23].

Unfortunately, MDCT or MRCP prior to any surgical intervention often fail to recognize all anomalies with certainty. Sensitivity of MRCP is only 74% in defining bile duct anomaly. Pre-treatment CT failed to identify aberrant left hepatic artery in 31% cases [17, 27]. Therefore, accuracy and reliability of radiological analysis is still depending on anatomical references. Thus, present cadaveric study was attempted to revisit the vascular and biliary components of liver at PH updating the unusual configurations with an effort aimed at morphometry.

MATERIALS AND METHODS

110 formalin fixed adult cadaveric livers of unknown age and sex without any pathological lesion were observed. Dissection of PH was done meticulously to observe number and position of portal vein (V), hepatic artery (A) and hepatic ducts (D). Specimens deviated from 2 divisions of portal vein, hepatic artery and hepatic duct were marked as variant and noted carefully with photographs. Different types of PH were categorized on the basis of morphology (number portal vein associated with number of hepatic artery and hepatic duct). For determination of morphometric data of PH and its

exact position on inferior surface, following parameters were measured and mentioned in Figure 1 as follows:

A) Dimensions of PH: i) Transverse diameter (‘a’- from left to right end of PH) ii) Antero-posterior diameter (‘b’ – from anterior to posterior end of PH) iii) Circumference (‘c’ – along the margin of non-peritoneal area with thread and finally thread length was calculated)

B) Measurements of inferior surface of liver:

I. Distance from left end of inferior surface of liver to left margin of PH – marked as “A”

II. Distance from right end of inferior surface of liver to right margin of PH – marked as “B”

III. Distance from postero-inferior border of liver to posterior margin of PH – marked as “C”

IV. Distance from inferior border of liver to anterior margin of PH – marked as “D”

All measurements were done thrice at the level of portal vein before its division by vernier calliper, measuring scale and thread and average of three measurements were finally taken. Data were summarized by descriptive statistics and results were tabulated. All statistical calculations were performed using software SPSS version 23.

RESULTS

Standard morphology of PH was found in 20%. Rests 80% were variants in terms of numbers of either by portal vein or hepatic artery or hepatic duct or in combinations. Numeral normalcy was highest in hepatic artery followed by portal vein and hepatic duct. In all cases, arrangements of portal structures were ducts-arteries-veins from anterior to posterior. Detailed morphology of portal structures are depicted in Table 1 as follows:

— portal vein (V): conventional two divisions were present in 55.5% specimens. In rest, vein was either single or three or four in numbers respectively;

— hepatic artery (A): usual presentation of two divisions was in 59.1% livers. In rests, artery was variable with higher incidence in cases of single followed by three, four, five or six arteries respectively;

— hepatic duct (D): classical arrangement was in 51.8% cases. In rest, PH represented with either single or with three ducts.

Figures 2 represents details about incidences of different morphological types of PH.

Sixteen types of PH were configured morphologically by numerical presence of structures in ascending order giving priority to vein, then artery and then duct. Thus, Type 1 represented the minimum number of portal vein with minimum number of hepatic artery and duct; whereas Type 16 represented maximum number of portal vein with variable number of hepatic arteries and ducts.Type 3 (1V2A2D) was found as highest incidence followed by Type 9 (2V2A2D) and Type 7 (2V1A1D) respectively. In total 13.6% cases (Type 1, 4, 6, 14) all of the three portal structures (vein, artery and ducts) were atypical in number. Maximum number of structures were noted as nine (2V6A1D) in Type 13. Absence of structure was not witnessed by present study.

Morphometry: Table 1 represents details about dimensions.

1) Dimensions of PH: Morphometric data as transverse diameter (a) larger than antero-posterior diameter (b) indicated that PH was slightly oval in outline.
2) Measurements for position of PH: In left – right plane, length of “A” varied from 5.4 to 10.5 cm. with Mean ± SD 7.55 ± 1.36, whereas “B” varied from 5.2 to 11.6 cm. with Mean ± SD 7.35 ± 1.49. In antero-posterior plane, “C” and “D” ranged from 2cm to 3.7cm with Mean ± SD 2.76 ± 0.49 and 3.2cm to 6.7cm with Mean ± SD 4.87 ± 0.99 respectively.

Schematic representation of morphometric measurements with position PH is shown in Figure 1.

Results of the present study with previous works have been compared in Table 2 and Table 3 regarding morphology and morphometry of PH respectively.

DISCUSSION

Highly variable vascular and biliary structures of the porta hepatis can impact clinical outcomes [3,5,9,13]. In present study, arrangements of portal structures were traditional in all livers as previously reported [12, 20, 23], but their number varied. Classical structures were seen in 20% cases in present study which was either missing or in a very low percentage (01.7%) in previous studies [12,20, 23]. Rather authors [12, 20, 23] reported different “non-traditional” portal anatomy in higher percentages. We also found varied combinations of portal structures as 16 types. Type 3 represented as highest number (23.6 % cases) which conflicting with previous studies. In our study, maximum number of veins was four, arteries were six and ducts were three which discrepant with others by numbers and percentages. Vascular injury along with biliary tract trauma has a mortality of 50-75% for portal vein and 40-80% for hepatic artery. The most difficult part of management encountered in abdominal trauma are associated with porta hepatis injuries which have high potential for immediate or late mortality [25]. Thus, knowledge of prevalence of morphological variation is quite often helpful for surgical planning. So, it is imperative that the clinician working on this area must be well versed with the detail of anatomical knowledge and its variations.

Table 2 represents comparison of portal structures between present & previous studies.

Knowledge about portal vein variation is important in identifying the location of liver lesion as portal vein along with hepatic veins are used as landmarks in determining segmental anatomy of liver [11]. Transhepatic embolization of portal vein is gaining acceptance as a method to induce contralateral liver hypertrophy in patients with small future remnant livers [16]. Absence of the right portal vein occurs in 16.5% of patients and is associated with trifurcation of the main vein to right anterior, posterior segmental veins and left portal vein. Absence of left portal vein occurs in 1% of patients. Portal vein trifurcation is a relative contraindication to liver transplantation using living donors as multiple anastomoses needed for right lobe graft transplantation [18]. In another study, incidence of overall variations of portal vein was as high as 27.4%; main portal vein branching variation was 21.5% and right portal vein variation was 3.9% [14]. In 51% of the liver, portal vein did not bifurcate before entering the liver [23]. We also found the same in 37.3% cases. On the other hand, portal vein bifurcation and trifurcation were in 83.3% and 15.2% cases [4]. We too noted three veins in 5.5% liver. Though most abdominal venous variations are asymptomatic, awareness about existence of these variations decreases the complication rates in surgical procedures [5, 9].

While liver transplantation is often the best treatment option for end-stage acute or chronic hepatic disease, vascular complications following transplantation may hamper long-term success with an incidence rate as high as 9% [2,7]. Furthermore donor selection is influence by arterial anatomy as liver grafts with multiple arteries are usually avoided [18]. Standard hepatic artery persists in 50–75% patients as previously reported [10,13, 22, 26] but we found in 59.1% cases. Contrarily, variant anatomy has important implications in planning liver resections or placement of hepatic artery infusion catheters or pumps [10,22, 26]. Multiple arteries (three-five) were reported in varied percentages by previous authors (12, 20, 23]. We also observed multiple arteries (maximum six) in 21.8% liver.

Risk of bile duct variation is increased by presence of variant portal vein [26]. Normal biliary anatomy is thought to be present in 58% of the population [3, 19]. MRCP study shows an aberrant right hepatic duct in 4.8%; a right posterior hepatic duct in 5.7% and trifurcation of the duct in 0.8% of patients [8]. Kostov and Kobakov [15] have found variation of hepatic ducts in 27.8% cases. Other authors have reported the absence of right hepatic duct in 26% and absence of left hepatic duct in 2% of cases (Ohkubo et al., 2004). Single hepatic duct was observed in 100% cases by Neginhal and Kulkarni [20], 79.7% by Sapna et al. [23] and 76% cases by Gupta et al [12]. But our study found only 46.4% porta hepatis with single duct. Three ducts were seen in 3.4% and 4% by Sapna et al. [23] and Gupta et al. [12] respectively. Our study documented only 1.8% cases with 3 ducts. Accurate knowledge about such accessory hepatic ducts and also their position is important, especially during laparoscopic cholecystectomies, as incidence of bile duct injuries is as twice as high when compared with open cholecystectomies [6].

As majority of interventional procedures are made at the porta hepatis, which has a different location on the visceral surface of the liver, meticulous surgical technique and expertise are necessary to approach in a systematic way to obtain complete removal of tumor in peritoneal carcinomatosis. The centripetal approach from right side, left side and from anterior side is recommended to achieve a complete circumferential dissection [1]. Thus, a thorough assessment porta hepatis before initiation of dissection is needed. To describe the location of the porta hepatis in respect of the borders of the visceral surface we have done detail morphometric measurements which have not been reported yet. Regarding dimensions of porta (antero-posterior diameter, transverse diameter and circumference) our study is very close to Neginhal and Kulkarni [20] report, but quite different from others [12,23]. Table 3 represents comparison of morphometry of porta hepatis between previous and present study.

CONCLUSIONS

Literature on anatomical knowledge on PH has not proved to be adequate to reduce the incidence of iatrogenic complications. Thus our main focus was study of portal anatomy as it guides surgical decision-making and impacts outcomes. Variable portal structures were noted in 80% cases in this study. High incidence of variations helped us to come into a conclusion on anatomical classification of 16 types of PH depending on the number of structural pattern which may contribute additional benefit particularly in the field of portal surgery. Present study also found maximum six arteries in PH which differ from previous studies. Till now no anatomical study regarding morphometry of position of PH has been reported as per our knowledge which needs to be highlighted to achieve best possible results in surgical techniques in this challenging area of the abdomen.

Conflict of interest: None declared

REFERENCES

1. Aydin N, Sardi AV, Milovanov V. Approach to the Porta Hepatis During Cytoreductive Surgery: Technical Considerations. Ann Surg Oncol. 2015; DOI: 10.1245/s10434-015-4872-x.
2. Caiado AH, Blasbalg R, Marcelino AS, et al. Complications of liver transplantation: multimodality imaging approach. Radiographics. 2007; 27 (5): 1401-1417.
3. Catalano OA, Singh AH, Uppot RN, et al. Vascular and biliary variants in the liver: implications for liver surgery. Radiographics. 2008; 28 (2): 359-378.
4. Chaib E. Absence of bifurcation of the portal vein. Surg Radiol Anat. 2009; 31(5): 389-392.
5. Covey AM, Brody LA, Getrajdman GI, et al. Incidence, patterns, and clinical relevance of variant portal vein anatomy. Am J Roentgenol. 2004; 183 (4): 1055-1064.
6. Devi KP. The study of variations of extra hepatic biliary apparatus. IOSR Journal of Dental and Medical Sciences 2013; 5(5): 25-31.
7. Duffy JP, Hong JC, Farmer DG, et al. Vascular complications of orthotopic liver transplantation: experience in more than 4,200 patients. J Am Coll Surg. 2009; 208 (5): 896-903.
8. Düsünceli E, Erden A, Erden I. Anatomic variations of the bile ducts: MRCP findings. Tani Girisim Radyol. 2004; 10(4): 296- 303.
9. Erbay N, Raptopoulos V, Pomfret EA, et al. Living donor liver transplantation in adults: vascular variants important in surgical planning for donors and recipients. Am J Roentgenol. 2003; 181(1); 109 –114.
10. Fasel JH, Muster M, Gailloud P, et al. Duplicated hepatic artery: radiologic and surgical implications. Acta Anat (Basel). 1996; 157 (2): 164-168.
11. Garg S, Kumar KH, Sahni D, et al. Surgical anatomy of the vasculo biliary apparatus at the hepatic hilum as applied to liver transplantations and major liver resections. J AnatSoc India. 2018; 67: 61-69.

12. Gupta D, Sharma P, Gandotra A. Porta hepatis in normal liver. International Journal of Biomedical and Advance Research 2017; 8(3): 121–125.
13. Hiatt JR, Gabbay J, Busuttil RW. Surgical anatomy of the hepatic arteries in 1000 cases. Ann Surg. 1994; 220 (1): 50–52.
14. Koc Z, Oguzkurt L, Ulusan S. Portal vein variations: clinical implications and frequencies in routine abdominal multidetector CT. Diagn Interv Radiol. 2007; 13(2): 75-80.
15. Kostov DV, Kobakov GL Six rare biliary tract anatomic variations: implications for liver surgery. Eurasian J Med. 2011; 43(2): 67-72.
16. Madoff DC, Hicks ME, Vauthey JN, et al. Transhepatic portal vein embolization: anatomy, indications, and technical considerations. RadioGraphics 2002; 22 (5): 1063–1076.
17. McSweeney SE, Kim TK, Jang HJ, et al. Biliary anatomy in potential right hepatic lobe living donor liver transplantation (LDLT): The utility of CT cholangiography in the setting of inconclusive MRCP. Eur J Radiol. 2012; 81(1): 6-12.
18. Mortele´ KJ, Cantisani V, Troisi R, et al. Preoperative Liver Donor Evaluation: Imaging and Pitfalls. Liver Transpl. 2003; 9: S6-S14.
19. Mortele´ KJ, Ros PR. Anatomic variants of the biliary tree: MR cholangiographic findings and clinical applications. Am J Roentgenol. 2001; 177 (2): 389-394.
20. Neginhal DD, Kulkarni UK. Normal Anatomy of Porta Hepatis –A Cadaveric Study. Natl J Clin Anat. 2019; 8: 22–26.
21. Ohkubo M, Nagino M, Kamiya J, et al. Surgical anatomy of the bile ducts at the hepatic hilum as applied to living donor liver transplantation. Ann Surg. 2004; 239(1): 82-86.
22. Redman HC, Reuter SR. Angiographic demonstration of surgically important vascular variations. Surg Gynecol Obstet. 1979; 129 (1): 33-39.
23. Sapna M, Shetty SD, Nayak S. A study on the number and arrangement of the structures passing through the porta hepatis in South Indian population. Int J Morphol. 2015; 33(1): 164-168.
24. Seco M, Donato P, Costa J, et al. Vascular liver anatomy and main variants: what the radiologist must know. JBR-BTR. 2010; 93 (4): 215– 223.
25. Sheldon GF, Lim RC, Yee ES, et al. Management of Injuries to the Porta Hepatis. Ann Surg. 1985; 202(5): 539-545.
26. Suzuki T, Nakayasu A, Kawabe K, et al. Surgical significance of anatomic variations of the hepatic artery. Am J Surg. 1971; 122 (4): 505-512.
27. Van den Hoven AF, J Smits ML, de Keizer B, et al. Identifying aberrant hepatic arteries prior to intra-arterial radio embolization. Cardiovasc Intervent Radiol. 2014; 37 (6): 1482–1493.

Table 1. Morphology and morphometry of portal structures

Portal structures n [%]			**Dimensions of PH [cm.]**	
Vein [V]	One	41 (37.3)	Transverse diameter	
	Two	61 (55.5)	Range	2.0 – 4.0
	Three	6 (5.5)	Mean ± SD	2.93 ± 0.51
	Four	2 (1.8)	95% CI	
			LL	2.83
			UL	3.03
Artery [A]	One	21 (19.1)	Antero-posterior diameter	
	Two	65 (59.1)	Range	1.2 – 2.8
	Three	14 (12.7)	Mean ± SD	1.82 ± 0.38
	Four	6 (5.5)	95% CI	
			LL	1.75
			UL	1.89
	Five	2 (1.8)	Circumference	
	Six	2 (1.8)	Range	4.8 – 11.5
Hepatic Duct [D]	One	51 (46.4)	Mean ± SD	8.33 ± 1.63
	Two	57 (51.8)	95% CI	
	Three	2 (1.8)	LL	8.02
			UL	8.64

Table 2. Comparison of portal structures between previous and present study

		Present study [%]	Sapna et al. [23] [%]	Gupta et al. [12] [%]	Neginhal and Kulkarni [20] [%]
Vein	One	37.3	50.8	84	26
	Two	55.5	44.1	12	72
	Three	5.5	5.1	4	-
	Four	1.8	-	-	2
Artery	One	19.1	20.3	4	8
	Two	59.1	55.9	32	56
	Three	12.7	15.3	36	26
	Four	5.5	8.5	25	8
	Five	1.8	-	4	2
	Six	1.8	-	-	-
Duct	One	46.4	79.7	76	100
	Two	51.8	16.9	20	-
	Three	1.8	3.4	4	-
Classical portal structures		20%	1.7%	0%	0%
Highest combination of portal structures		1V2A2D [23.6%]	1V2A1D [25.4%]	2A1V1D [32%]	2V2A1D [36%]

Table 3. Comparison of morphometry of porta hepatis between previous and present study

Studies	**Transverse diameter [cm] [Mean ± SD]**	**Antero-Posterior diameter [cm] [Mean ± SD]**	**Circumference [cm] [Mean ± SD]**
Sapna M et al. [23]	4.825	2.433	-
Gupta D et al. [12]	3.80 ± 1.03	1.79 ± 0.43	13.61 ± 1.92
Neginhal and Kulkarni [20]	3.17 ± 0.50	1.68 ± 0.36	10.46 ± 1.415
Present study	2.93 ± 0.51	1.82 ± 0.38	8.33 ± 1.63

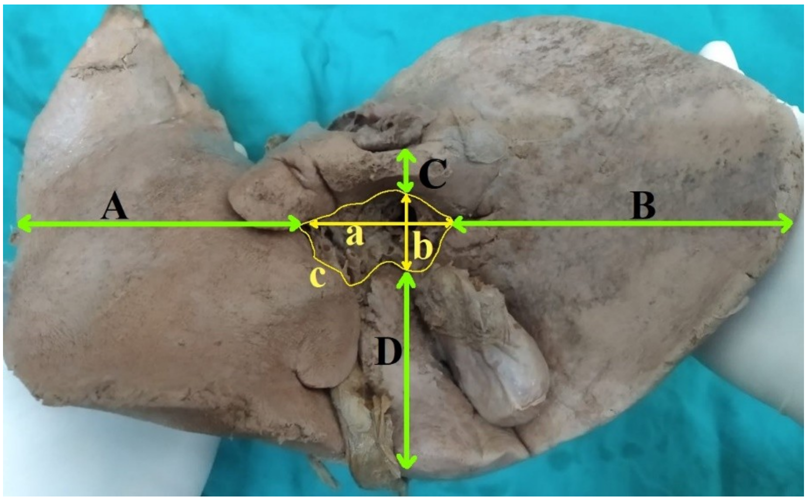

Figure 1. Morphometric measurements: a – transverse diameter of PH, b – antero-posterior diameter of PH, c – circumference of PH, A – distance between left end of inferior surface and PH, B – distance between right end of inferior surface and PH, C – Distance from postero-inferior border of liver to posterior margin of PH, D – distance from inferior border of liver to anterior margin of PH

Figure 2. Types 1-16 PH with incidences (V= Portal vein, A= Hepatic artery, D = Hepatic duct)