

Surgical Anatomy of The Hepatic Arteries: A Prelude to Living Donor Liver Transplantation

H.J. Majid[§], N. Raza^ā, M. Shafi[§], M.A. Javed[§], U. Ali[†], M. Alam[§], M. Khan[§], H.M. Dar[§] and M. Tufail^{†§}

[§]Department of General Surgery, Shaikh Zayed Hospital and Federal Postgraduate Medical Institute, Lahore, Pakistan

[†]Hepatopancreaticobiliary & Liver Transplantation (HPB-LT) Unit, Shaikh Zayed Hospital and Federal Postgraduate Medical Institute, Lahore, Pakistan

^āDepartment of Anatomy, Sharif Medical and Dental College, Sharif Medical City, Raiwind, Lahore, Pakistan

ABSTRACT

In the setting of Liver Transplantation as a new and emerging specialty in Pakistan the need has arisen for exact descriptions of the hepatic vascularization to avoid iatrogenic vascular damage. Exact knowledge of the arterial anatomy is required to plan the best resection as well as to minimize the risks of donor morbidity. We studied variations of extrahepatic arterial anatomy in forty six patients who underwent major hepatobiliary or pancreatic resections with complete exposure and/or skeletonization of the extrahepatic arterial anatomy. The extrahepatic arterial anatomy in twelve cadaveric dissections was also studied. The commonest arterial variant seen in our series was Type 1 i.e. 91.37%. The prevalence of anatomical variants was 8.63%. Knowledge of the variation in the hepatic arterial anatomy will help us in planning and performing the safe procurement of grafts from living donors with less risk of serious ischemic complications.

Key Words: Surgical anatomy of the Hepatic Artery, Liver Transplantation.

INTRODUCTION

Shaikh Zayed Hospital and Federal Postgraduate Medical Institute, Lahore, Pakistan was approved and nominated as the first official Liver Transplant Center of the Federal Government on a national level. The extensive experience of our surgeons over the last three decades in Major Hepatobiliary and Pancreatic Resections and Shunt Surgery serves as a good foundation for a Liver Transplantation Program in Shaikh Zayed Hospital. The longstanding tradition of harmonious teamwork and the existing infrastructure in Shaikh Zayed Hospital make our hospital the ideal setting for Liver Transplantation in Pakistan.

With a background of being a tertiary referral center for complicated Hepatobiliary and Pancreatic cases for the last thirty years, Shaikh Zayed Hospital receives case referral from all over the country. Major Hepatobiliary and Pancreatic Resections are

carried out on a regular basis as we stand at the brink of performing our first indigenous Living Donor Liver Transplant (LDLT).

In the setting of Liver Transplantation as a new and emerging specialty in Pakistan the need has arisen for exact descriptions of the hepatic vascularization to avoid iatrogenic vascular damage. Living Donor Liver Transplantation is an extremely complex technique in which the exact knowledge of the arterial anatomy is required to plan the best resection as well as to minimize the risks of morbidity. There are great variations in the pattern of hepatic arterial supply. The usual anatomy of the hepatic arterial vascularization is a common hepatic artery arising from the celiac axis, accounting for 25 to 75% of the cases¹. In the variant patterns, the hepatic lobes receive arterial flow through branches coming from the superior mesenteric artery, left gastric artery, or, rarely, from the aorta or other visceral arterial trunks².

Major hepatobiliary resections and pancreaticoduodenectomies represent a good opportunity to study the surgical anatomy of the hepatic arteries. The extrahepatic arteries must be identified with precision to avoid injuries that might compromise complete arterialization of portions of the liver. Thus, the presence of all arteries that are accessory or replaced must be demonstrated. We studied variations of extrahepatic arterial anatomy in forty six patients who underwent major hepatobiliary or pancreatic resections with complete exposure and/or skeletonization of the extrahepatic arterial anatomy. The extrahepatic arterial anatomy in twelve cadaveric dissections was also studied.

AIMS AND OBJECTIVES

The objective of this study was to review the anatomy of the extra-hepatic arterial system so as to maximize the knowledge of our surgeons performing procedures in and around the porta hepatis, to avoid injury to vascular and ductal structures and with a view to start safe Living Donor Liver Transplantation in our own institute.

METHODS

The medical records of all patients who underwent major hepatobiliary resections with complete exposure of the extrahepatic arteries and pancreaticoduodenectomies with extensive lymphadenectomies and skeletonization of the vessels within a two years period were reviewed (Group A). All cases with deficient operative data or patients who underwent minor or non-anatomical hepatic resections without a complete or formal exposure of the hepatic arteries were excluded from this study. Hepatic arterial anatomy was recorded as it was described in operative notes.

During the same time period, the extrahepatic arterial anatomy was also studied in twelve cadaveric dissections in the Dissection Hall of a Medical College in Lahore (Group B).

A modification of Michels³ classification scheme was used for recording the arterial anatomy in both the groups (Box 1).

- **Type 1:** In this normal pattern, the common hepatic artery arises from the celiac axis to form the gastroduodenal and proper hepatic arteries; the proper hepatic artery divides distally into right and left branches.
- **Type 2:** A replaced or accessory left hepatic artery arises from the left gastric artery.
- **Type 3:** A replaced or accessory right hepatic artery originates from the superior mesenteric artery.
- **Type 4:** In this double-replaced pattern, the right hepatic artery arises from the superior mesenteric artery, and the left hepatic artery is a branch of the left gastric artery.
- **Type 5:** The entire common hepatic artery originates as a branch of the superior mesenteric artery.
- **Type 6:** The common hepatic artery takes direct origin from the aorta.

Box 1. Modified Michel's Classification.

RESULTS

A detailed review of the complete medical records of 46 patients (Group A) who underwent major hepatobiliary resections with complete exposure of the extrahepatic arteries and pancreaticoduodenectomies with extensive lymphadenectomies and skeletonization of the vessels in our unit within the last two years (February 2008 to February 2010) was carried out. The extrahepatic arterial anatomy was also studied in 12 cadaveric dissections in the Dissection Hall of a Medical College in Lahore (Group B).

Arterial variations in both the groups could be classified as one of the many types described in Michel's Classification. The results for Group A are summarized in Table 1.

Types 4, 5 and 6 and other more rare types described by other authors in larger series were not seen in any of the patients in our study.

Table1: Arterial variations in Group A (n = 46)

Type	Number	Percent
Type 1	41	89.13
Type 2	02	4.34
Type 3	03	6.52
Total	46	100.00

In Group B, the only variant seen was Type 1 (Fig. 1) and none of the other types was seen in any of the 12 cadaver dissections.

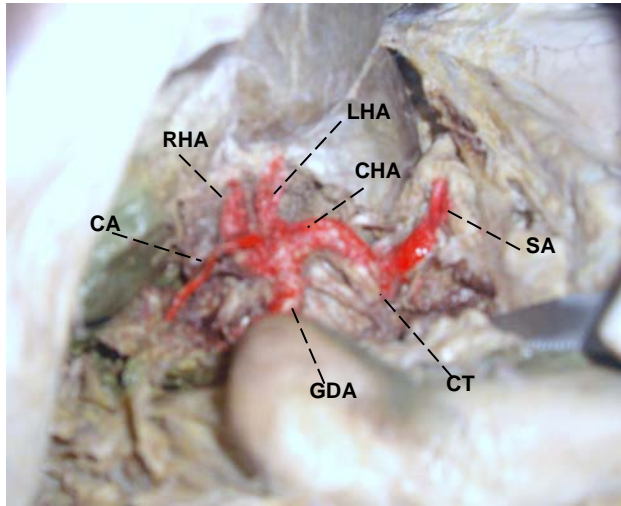


Fig. 1. Cadaveric dissection showing Type 1, the “normal” pattern. RHA: Right Hepatic Artery, LHA: Left Hepatic Artery, CHA: Common Hepatic Artery, CA: Celiac Trunk, GDA: Gastrooduodenal Artery, SA: Splenic Artery, CA: Cystic Artery.

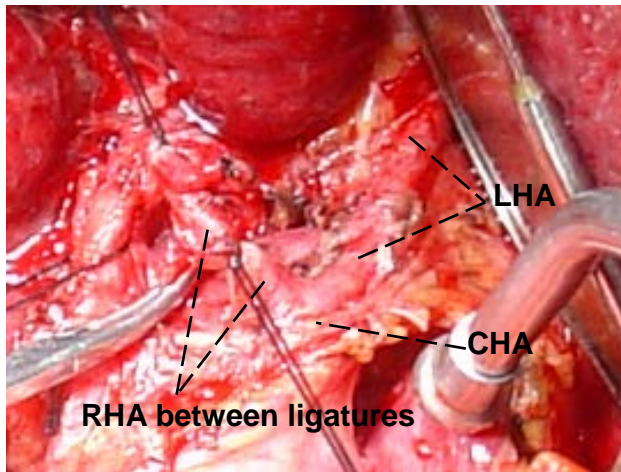


Fig. 2: Type 1 pattern exposed during the course of a Right Hepatectomy for HCC. The Right Hepatic Artery (RHA) is visible between ligatures prior to division. CHA: Common Hepatic Artery, LHA: Left Hepatic Artery.

The overall results are summarized in Table 2. Thus the commonest arterial pattern seen in

our series was Type 1 *i.e.* 91.37% (Fig. 2). The prevalence of anatomical variants was 8.63%.

Table 2: Overall results (n=58).

Type	Number of dissections (patients and cadavers)	Percentage
Type 1	53	91.37%
Type 2	02	3.44%
Type 3	03	5.17%
Total	58	100.00

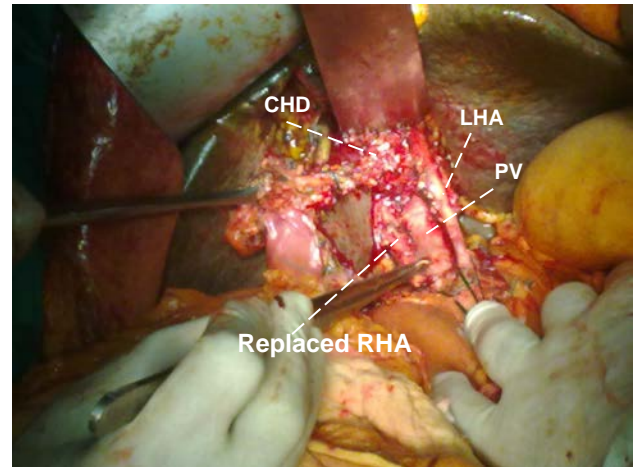


Fig. 3: Replaced right hepatic artery arising from the superior mesenteric artery (Type 3) exposed during resection for a hilar Cholangiocarcinoma. PV: Portal Vein, RHA: Right Hepatic Artery, LHA: Left Hepatic Artery, CHD: Common Bile Duct.

DISCUSSION

Hepatic arterial anatomy in our series was classified according to the modified Michels’ classification^{3,4}. If two hepatic arteries supply the same hepatic lobe, one originating in the common hepatic trunk and the other arising from a different arterial trunk, the last one is called an “accessory.” On the other hand, if there is only one hepatic artery for the hepatic lobe, that does not arise from the common hepatic artery, it is called a “replaced” artery. In our study, whether an individual vessel is accessory or replaced was not always determined, because the intrahepatic branches were not dissected⁴.

In our study the prevalence of anatomical variations of the hepatic artery was 8.63%, a percentage far less than that reported in other series based on surgical dissections for hepatic procurement in donors (20-30%)^{4,5-7} and the 39 to 46% reported in series based on autopsy/cadaveric dissections or radiological studies^{4,8-10}. The variants observed by us fit into Michel's classification³. The only anatomical variants seen in our series were a replaced left hepatic artery arising from the left gastric artery (9.7%) and a replaced right hepatic artery arising from the superior mesenteric artery (7.8%) (Fig. 3). This is in agreement with previous studies^{3-7,10,11}. However, these were the only variants that we saw in our series. None of the other variants reported by other authors were seen by us. All these differences noted between our observations and those of the authors of other major series may be attributed to the small sample size of our series.

This study of hepatic arterial anatomy represents an important lesson for us that has emerged from our long experience in Hepatobiliary and Pancreatic Surgery. Accidental injury of any of the arteries that supply the hepatic parenchyma might cause ischemia and biliary tract complications. These arterial patterns are of importance in the planning and performance of safe Living Donor Liver Transplantation and the development of this new and emerging specialty in Pakistan. Awareness and knowledge of this high degree of variation in the hepatic arterial anatomy will likely help in planning and performing the safe procurement of grafts from living donors with less risks of serious ischemic complications.

REFERENCES

1. Nelson TM, Pollak R, Jonasson O, Abcarian H. Anatomic variants of the celiac, superior mesenteric, and inferior mesenteric arteries and their clinical relevance. *Clin Anat* 1988; 1:75-91.
2. Braun MA, Collins MB, Wright P. An aberrant right hepatic artery from the right renal artery: anatomical vignette. *Cardiovasc Intervent Radiol* 1991;14:349-51.
3. Michels NA. Newer anatomy of the liver and its variant blood supply and collateral circulation. *Am J Surg* 1962; 112:337-47.
4. Hiatt JR, Gabbay J, Busuttil RW. Surgical Anatomy of the Hepatic Arteries in 1000 Cases. *Annals of Surgery*. Vol. 220, No. 1, 50-52, 1994 J. B. Lippincott Company.
5. Merion RM, Burtch GD, Ham JM, Turcotte JG, Campbell DA. The hepatic artery in liver transplantation. *Transplantation* 1989;48:438-43.
6. Vicente E, Turrión VS, Nun˜o J, Mora NP, Pereira F. Cirugı́a del trasplante hepático. In: Cuervas-Mons V, ed. *Trasplante Hepático*. Barcelona, Spain: Editorial Mayo SA Barcelona, 1993:37-54.
7. Makisalo H, Chaib E, Krokos N, Calne R. Hepatic arterial variations and liver related diseases of 100 consecutive donors. *Transpl Int* 1993; 6:325-29.
8. Suzuki T, Nakayasu A, Kawabe K, Takeda H, Honjo. Surgical significance of anatomic variations of the hepatic artery. *Am J Surg* 1971; 122:505-12.
9. Covey AM, Brody LA, Maluccio MA, Getrajdman GI, Brown KT. Variant hepatic artery anatomy revisited: digital subtraction angiography performed in 600 patients. *Radiology* 2002;224: 542-47.
10. De Santis M, Ariosi P, Calo GF, Romagnoli R. Hepatic arterial anatomy and its variants. *Radiol Med (Torino)* 2000;100:145-51.
11. Gruttadauria S, Foglieni CS, Doria C, Luca A, Lauro A, Marino IR. The hepatic artery in liver transplantation and surgery: vascular anomalies in 701 cases. *Clin Transplant* 2001; 15:359-363.

The Authors:

Dr. Haroon Javaid Majid FRCSEd
Assistant Professor
Department of Surgery
Shaikh Zayed Federal Postgraduate Medical Institute,
Lahore, Pakistan

Nausheen Raza
Professor & Head of Department of Anatomy
Sharif Medical and Dental College
Sharif Medical City, Raiwind, Lahore

Surgical Anatomy of The Hepatic Arteries

Dr. Muhammad Shafi MS
Senior Registrar
Department of Surgery
Shaikh Zayed Federal Postgraduate Medical Institute,
Lahore, Pakistan

Dr. Muhammad Arif Javed FCPS
Senior Registrar
Department of Surgery
Shaikh Zayed Federal Postgraduate Medical Institute,
Lahore, Pakistan

Dr. Umer Ali
Liver Transplant Surgeon
Shaikh Zayed Hospital,
Lahore, Pakistan

Dr. Mehboob Alam
Trainee Registrar
Department of Surgery
Shaikh Zayed Federal Postgraduate Medical Institute,
Lahore, Pakistan

Dr. Misbah Khan
Trainee Registrar
Department of Surgery (HPB-LT)
Shaikh Zayed Federal Postgraduate Medical Institute,
Lahore, Pakistan

Dr. Harun Majeed Dar FCPS
Associate Professor
Department of Surgery
Shaikh Zayed Federal Postgraduate Medical Institute,
Lahore, Pakistan

Professor Muhammad Tufail FCPS
Head of Department of Surgery and HPB-LT
Shaikh Zayed Hospital & Federal Postgraduate Medical
Institute, Lahore, Pakistan

Corresponding Author:

Dr. Haroon Javaid Majid FRCSEd
Assistant Professor
Department of Surgery
Shaikh Zayed Federal Postgraduate Medical Institute,
Lahore, Pakistan
Consultant Surgeon
Shaikh Zayed Hospital, Lahore, Pakistan
Email: hjmajid@gmail.com