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KNOWLEDGE OF THE SEGMENTAL ANATOMY OF LIVER AND ITS IMPORTANCE

Anatomy

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ABSTRACT

Introduction : Liver is composed of series of segments that combine to form sectors each of which receives a portal pedicle. This portal pedicle divides into right and left which enters the respective lobes and subdivide again to form the segmental branches thus dividing the sectors into 8 segments. In the past decades, lobotomies were regularly performed, where a large amount of liver tissue was sacrificed for a small tumor present and the results were poor. With more conservative surgeries and post-operative treatment procedures, the segmental pattern of the liver becomes important.

Aim: To study the segmental anatomy of liver by using manual, radiological and ultrasonic method.

Material and methods : This study of segmental anatomy of liver was conducted in 100 specimens in the Cadaveric manual dissection method, Radiological method, and Ultrasound method

Results: In this study the three major hepatic veins, the right hepatic vein, left hepatic vein and the middle hepatic vein were observed in all the specimen. Primarily, the middle hepatic vein join with the left hepatic vein which form a common trunk before draining into the inferior vena cava. Secondly, Portal vein had bifurcation pattern of division into right and left portal vein and had segmental division to all the segments of the liver.

Discussion : Knowledge of the segmental anatomy very much used for the postoperative treatment mainly the patients posted for lobotomies of liver or segmental surgeries need an intensive nursing care to avoid post-operative complications such as pulmonary complications, deep vein thrombosis, incision hernia, post-operative incision pain and delayed healing of surgical sutures. The variations at this segmental level should be kept in mind to avoid disastrous results. So, the need for more limited resection of the liver has prompted the researchers to look closer into the segmental anatomy of the liver and find more about this organ as well as the anomalies that can spring surprises.

KEYWORDS:

portal pedicle, lobotomy, segments of liver and conservative surgery

INTRODUCTION

Liver is the largest abdominal organ[1], which lies under cover of right lower ribs and closely applied to the undersurface of the diaphragm which coincides with the costal margin[2]. It is covered by the visceral peritoneum of the Glisson's capsule[3], which thickens into three folds or ligaments connecting it to the abdominal wall. The internal architecture of the liver is composed of series of segments that combine to form sectors separated by scissura containing hepatic veins[4]. Essentially the three main hepatic veins, right hepatic vein, middle hepatic vein and the left hepatic vein within the scissurae divide the liver into four sectors each of which receives a portal pedicle. The portal pedicle which is the portal triad that contains of hepatic artery, portal vein and the hepatic duct. The portal pedicle divides into right and left pedicles which enters the respective lobes and subdivide again to form the segmental branches thus dividing the sectors into 8 segments[5]. The main portal scissura contains the middle hepatic veins and progresses from the middle of the gall bladder fossa anteriorly to the left of the inferior vena cava posteriorly[6]. This forms the right and left lobe of liver both of which are independent in terms of portal and arterial vascularization and of biliary drainage [7,8].

AIM OF THIS STUDY

To study the segmental anatomy of liver by using manual, radiological and ultrasonic method.

MATERIALS AND METHODS

This study of segmental anatomy of liver was done in the Department of Anatomy, Kasturba Medical College, Mangalore.

Venue of study

1. Department of Anatomy, Kasturba Medical College, Mangalore - 1
2. Department of Forensic Medicine, Kasturba Medical College, Mangalore -1.
3. Department of Radiology, Kasturba Medical College, Mangalore-1.

Collection of specimens

The liver specimens with which the study of segmental anatomy was studied were procured from the Department of Forensic Medicine, Kasturba Medical College, Mangalore. All the specimens studied were adult specimens. All the specimens were taken from post – mortem bodies. The cause of death was due to reasons other than liver problems. During the harvesting of the liver specimens no gross anomalies were noted. During the harvesting of the specimens the falciform ligament was retained and a long portal pedicle along with the gall bladder was taken[9]. The inferior vena cava was cut at the level little above and below the posterior surface of the liver. This was done to preserve the opening of the hepatic veins into the inferior vena cava. This study of segmental anatomy of liver was conducted in 100 specimens in the following methods.

Materials

1. Cadaveric specimen -30
2. Autopsy specimen -30
3. Radiological method-20
4. Ultrasound method-20

Methods of study

Following methods were used in this study for the segmental anatomy of liver

1. Manual dissection method
2. Radiological study by contrast method
3. Ultrasound method

I. MANUAL DISSECTION METHOD

1. Cadaveric study

The liver specimens with which the study of segmental anatomy was studied in cadavers which was used in dissection hall for study purposes. The study was done on 30% formalin fixed dissecting room cadavers. The mean age of the cadavers was 60 years (Range 45- 75) with a sex distribution of 20 males and 10 females. A midline incision made in the anterior abdominal wall from the xiphi-sternum upto the umbilicus. From the lower end of the incision, a transverse incision was made till the mid axillary line. Skin flap was raised and the rectus abdominis were reflected in the same plane. Peritoneum was opened. Liver and stomach were visualized. The liver was released from its attachments. The collected liver specimens were washed thoroughly and dissected under water to see segments along its vascular planes[10].

2. Autopsy Specimen Study

In this method of study, 30 adult liver specimens were studied. The specimens taken from the Forensic Medicine Department of Kasturba Medical College and washed thoroughly with running water to remove all the blood that may ooze through the cut veins. Then they were kept in 10% formalin solution and allowed to remain in formalin for 10 days. This was done so that the soft friable liver tissue will get fixed making it easy for the dissection to be done. Then the specimens were ready for the dissection to see the structures. In this dissection, the hepatic veins and portals veins were studied. The dissection of the hepatic vein was done starting from the inferior vena cava and followed into the liver substance and the three hepatic veins were studied[11]. The portal vein was dissected from the portal pedicle from where it was separated from the hepatic artery and bile duct. It was then traced into the liver substance and the branching pattern studied.

II. RADIOLOGICAL STUDY BY CONTRAST METHOD

In this method of study of the segmental anatomy of liver, 20 specimens were studied. The liver got from the Forensic Medicine Department was washed in running water thoroughly to remove all the blood. The hepatic artery and the bile duct were flushed with syringe to remove the blood and excess bile which would help in the flow of the contrast agents. The contrast agent used was urograffin which was injected into the bile duct and the hepatic artery and x rays were taken[12].

III. ULTRASOUND METHOD – CLINICAL STUDY

This was done at the department of Radiology at Kasturba Medical College, Mangalore. This study was done on 20 patients who had referred for abdominal scan for other reasons other than liver problems. All the patients selected were adult patients. As a routine for abdominal scan the patients were asked to come in empty stomach. Some of the patients could drink sips of water to prevent excessive thirst.

The patients were made to lie in supine position for the scan for liver. Before proceeding for the scan, the abdomen was palpated to exclude any enlargement of liver or pain abdomen. The probe used for the liver scan had a transducer of 3.5 MHz[13]. This was selected because at this frequency the penetration was good. But the resolution is always low. The scanning was done in sagittal plane, transverse plane, oblique planes. Intercostals and subcostal views were also seen. In this method, the hepatic veins and its branching pattern, portal vein and its branching and bile ducts were observed.

OBSERVATIONS

The study of the segmental anatomy of liver and its clinical importance done at the Department of Anatomy, Kasturba Medical College, is based upon the hepatic veins which divided the liver into lobes and the branching of the portal vein, hepatic artery, and the hepatic duct. In this study the manual dissection method was used to observe the branching pattern of hepatic veins and portal vein. In the radiological method, the urograffin contrast agent was used to study the segmental branching pattern of hepatic artery and the hepatic duct. In the ultrasound method, which was the easiest to perform and great deal of information was available in short time. In this method, the hepatic veins, portal vein, and the hepatic duct were also observed. In the ultrasound method, the segments of the liver were studied and the findings correlated with the finding of the manual dissection and radiological methods.

The findings observed are given below

Hepatic Veins

S. No.	Various pattern observed	Number of specimens	Percentage %
1	Right hepatic vein is larger than the middle & left hepatic veins	80	100%
2	Middle hepatic vein observed to join the left hepatic vein	70	87%
3	A single vein was seen draining the caudate lobe of the liver	80	100%

Portal vein

S. No.	Various pattern observed	Number of specimens	Percentage %
1	Bifurcation pattern	71	88%
2	Trifurcation pattern	7	8%
3	Accessory portal vein	2	4%

Hepatic artery

S. No.	Various pattern observed	Number of specimens	Percentage %
1	Arising from the coeliac axis	20	100%
2	Hepatic artery divides into right & left hepatic artery	20	100%
3	Right hepatic artery divides into superior & inferior	20	100%

Bile duct pattern

S. No.	Various pattern observed	Number of specimens	Percentage %
1	Triple confluence	2	10%

DISCUSSION

SEGMENTS OF LIVER

The importance of more conservative surgery and need for limited resection of liver lead to establish the segmental anatomy of liver where the liver is divided into still smaller functional segments than just lobes.

After the establishment of the major vascular territories of arteries and hepatic venous supply [16], the traditional method of division of the hepatic segments based on the topographical relation of the liver was dropped and classification based on the vasculature of liver started. In the American system, the liver was divided into four lobes and the importance of the caudate lobe was not considered here but this formed the basis of the four classical types of hepatic resection. In the French system, there are 8 segments and the caudate lobe is considered as independent lobe and this gained popularity and it is now globally accepted by surgeon of the two system of classification of segmental anatomy of liver that are present[17].

Claude de Couinaud a French surgeon and anatomist proposed the new segmental anatomy of liver. He divided the liver into 8 segments. He described that the right lobe is divided into two sectors namely anteromedial and posterolateral. The anteromedial sector was divided into segment V anterior and segment VIII posterior[14]. The posterolateral sector was divided into segment VI anterior and segment VII posterior. He divided the left lobe into three segments and named them segment II posterior and segment III anterior and

segment IV medial to umbilical fissure. The Spigelian lobe or the caudate lobe or the segment I is considered as an autonomous segment.In this study, all the specimens studied were found to have 8 segments that corresponded to the Couinaud segments.

HEPATIC VEINS

With the establishment of relationships between the portal venous system and hepatic venous systems[17], **(Glisson 1659)** the nomenclature for major branching of intrahepatic portal vein and for major hepatic veins.

Couinaud description of the segments was based upon the division of liver into eight segments following the distribution of the portal pedicles and the location of three hepatic veins. He had put forward that the middle hepatic vein separates the whole liver into right and left lobe. The right hepatic vein further separates the right liver into right posterior sector and right anterior sector and left hepatic vein separates the left liver into the left anterior sector and left posterior sector. In the drainage of hepatic veins observed, in 75% of specimens the left hepatic vein joining with the middle hepatic vein to empty into the inferior vena cava [18]**.**

L. H. Blumgart in his description says that the hepatic veins drain directly from the upper part of the posterior surface of the liver at somewhat oblique angle directly into the inferior vena cava[19]. The right hepatic vein somewhat larger than the left vein. The middle hepatic veins have short extra hepatic course. The left and middle hepatic veins may drain separately into the inferior vena cava but frequently joined after a short extra hepatic course to form a common venous channel. He also describes that there are also other short hepatic veins that drain into the inferior vana cava.

Peter I Williams (38th edition) Grays anatomy states that there are three hepatic veins drain into inferior vena cava. The most commonly the middle hepatic vein joining with the left hepatic vein.[20] In a majority of cases, the diameters of the right and left hepatic veins were between 7 mm and 13 mm. No gender differences were found in the study by **Sharma D Deshmukh A, Rains VK (2001)** and they have observed that in 96 % of cases the middle and left hepatic veins form a common trunk[21]. Variations in the drainage pattern of hepatic veins have been reported from time to time.[22]These include accessory right hepatic veins, **(Van Leewwen et al., 1994**, **De Cecchis et al, 2000)** significant accessory hepatic veins **(Marcos et al., 2000)** and accessory suprahepatic veins **(Bach et al 1994-95).** The knowledge of this accessory vein is important for the operating surgeon.

In the present study, the right hepatic vein, left hepatic vein and the middle hepatic vein were seen in all the specimens, and in 51 0f 58 specimens studied the middle hepatic vein was seen joining with the left hepatic vein. This coincides with the observations of **(H. Bismuth and Peter I Williams)** there were no accessory veins observed

PORTAL VEIN

Supplying almost two third of the blood to the liver, this portal vein was important not only for the digestive purpose by bringing all the splanchnic blood, it was also important for the segmentation of liver. It was **Looten (1908)** who claimed vascular independence of right and left lobes based on the portal vein branching. Then it was **Segell (1923)** studied by injecting radio opaque gelatin into vessels of human liver obtained by autopsy. He gave general information of the 4 systems – portal vein, hepatic Artery, hepatic vein and hepatic duct.

Couinauds in 1953 described the division of liver into sectors by the hepatic veins. The anteromedial sector is divided into segment V anterior and segment VIII posterior. The posterolateral sector is divided into segment VI anterior and segment VII posterior. Left lobe of liver divided into segment III anterior, segment II posterior and segment IV medial to the umbilical fissure. The Spegelian lobe or segment I considered as an autonomous segment since it receives vascularization both form right and left branch of portal vein and its venous drainage directly into inferior vena cava.

There are 3 patterns of portal vein branching described by **Couinauds**

Pattern I: Immediate trifurcation of main portal trunk into right anterior right posterior and left portal branches was observed in 8/103 specimens studied.

Pattern II: Right posterior segmental branch arises directly from the main portal trunk and seen in 6/103 specimens (5.8%) studied

Pattern III: The origin of the right anterior segmental branch form left portal vein was seen in 3/103 specimens (2.9%)

Studying the left branch of portal vein, it was described that the left branch of the portal vein curved laterally at the root of the ligamentum teres and along with the hepatic artery it gave feedback vessels to the medial segment IV i.e., the quadrate lobe **(Goldsmith and Woodburne 1957).** In anatomical record **(Hans Ekuas 1952)** stated that the intrahepatic portal venous system presente a constant "skeleton" for the liver. It was represented as "Trellis". With the non- invasive method of investigation like the ultrasound and computerised tomography it became easy to study the vascular pattern which also threw light on variations in pattern of branching. In ultrasound examination, the portal branches to the four segments of each lobe are letter "H" as was described by **Lafortune**. **Margeret et al (1990)** reported in colour Doppler study a large aberrant branch from the anterior segmental branch to the medial segment of the left lobe. **Osamu matsui et al., (1997)** reported a branch from right portal vein distributed to posterior aspect of segment IV.

In the present study, the portal vein was seen to have a normal bifurcation pattern and division into the segmental branches correlating with the **Couinauds** observation that the trifurcation pattern was observed in less than 8% of cases. The segmental branching of portal vein was observed in the typical H pattern in all the specimens studied correlating with the **Lafortune** description. In 2 specimens, accessory vein were given to the segment IV i.e., the quadrate lobe from the anterior segmental branch of the right branch of the portal vein.

This correlates with the observations made by **Margaret et al and Osamu Matsui et al.**

HEPATIC ARTERY

The importance of good knowledge of the hepatic artery not only helps in the hepatobiliary surgeries, but is also useful in selective embolization for the control of tumor growth.

Michels (1966) stated that despite variations in origin and occurrence of accessory vessels, the hepatic arterial system consists of end arteries.

Variations of the arterial anatomy are common (Bismuth) and among the most frequent are

1. The presence of supplementary hepatic artery to the right lobe or of a replaced hepatic artery.
2. Left hepatic artery originated from the left gastric artery may be found in the lesser omentum.

In the study of the arterial supply of left hemi liver done by **Mlakar B et al** the observed that the left hemi liver was supplied by one artery in 53 % of cases, by two arteries in 40 % and by three arteries in 7%.[23] The left hepatic artery, which originated from the proper hepatic artery, supplied all three left segments in 39% of specimens. The replacing left hepatic artery, which originated from the left gastric artery supplied the whole left hemi liver in 30 % of cases.

In this present study, hepatic artery was seen arising from the coeliac

axis correlating with the observation by **Decker & Du Plessis 1986.**[24] The hepatic artery was seen dividing into right and left hepatic arteries. No variations in origin or branching was noted. The right hepatic artery divided into right anterior segmental branch which divided into superior and inferior branches to supply the segment VIII and segment V. Left posterior segmental branch dividing into the superior and inferior branches to supply the segment VI and segment VII.

BILE DUCTS

The aberrant hepatic biliary segmental anatomy was studied using Magnetic Resonance cholangiographic method by **Koenraad J. Mortele et al (2001)** the most common anatomic variants in the branching of the biliary tree involved the right posterior duct and its fusion with the right anterior or left hepatic duct[25]. Another common variant (11%) of the main hepatic biliary branching is the so called triple confluence. The branching pattern of intra hepatic ducts was atypical in 37% of cases was observed by Jin **Woo Choie in 2003[26].** The two most common variations were drainage of the right posterior segmental duct into the left hepatic duct (11%) and triple confluence of the right anterior segmental duct, right posterior segmental duct and left hepatic duct (10%).

Blumgart (1988) has studied the hepatic duct confluence and concluded that the most common variations was drainage of the right anterior or right posterior segment into common hepatic duct in 16 % and the triple confluence in 12 % of the cases. In the present study two specimens out of 20 studied by radiological method showed the triple confluence of the hepatic duct thus correlating with the previous studies **(Blumgart / Choi / Koenraad J. Mortele)** which showed it as one of the common variations[27].

SUMMARY

In this study the hepatic vasculature was studied first, as this forms the basis of the segmental pattern of the liver and the functional anatomy. In this study the three major hepatic veins, the right hepatic vein, left hepatic vein and the middle hepatic vein were observed in all the specimen. In 87 % of observation the middle hepatic vein joined with the left hepatic vein and formed a common trunk before draining into the inferior vena cava. A single vein was seen draining the caudate lobe the liver. In all the 80 specimens studied the portal vein had bifurcation pattern of division into right and left portal vein and had segmental division to all the segments of the liver. The caudate lobe was seen to receive portal blood from both the right and left portal vein. A single variation was observed in one specimen where an accessory portal vein was seen from the right anterior division of portal vein to the quadrate lobe.

No variations were seen in the hepatic artery pattern of segmental branching. Triple confluence of the hepatic ducts was seen in one specimen. All the segments were seen in all the 80 liver specimens observed. This observation on the segmental anatomy of the liver and its variations has great importance to the opening surgeon because a neat surgery is the gateway to successful results. In the past decades, lobotomies were regularly performed, where a large amount of liver tissue was sacrificed for a small tumor present and the results were poor. With more conservative surgeries the segmental pattern of the liver becomes important. The variations at this segmental level should be kept in mind to avoid disastrous results.

So, knowledge of the segmental anatomy very much used for the postoperative treatment mainly the patients posted for lobotomies of liver or segmental surgeries need an intensive nursing care to avoid post-operative complications such as pulmonary complications, deep vein thrombosis, incision hernia, post-operative incision pain and delayed healing of surgical sutures. Physical therapy exercises advised to patients after the surgery reduces these complications and minimizes losses in lung function and improves the strength of respiratory muscles and shortens the period of hospital stay[28]. The more recent studies document that the use of elasticized abdominal binders will improve walk performance, controlling pain and distress, and improving patients' experience[29, 30].

References

1. W.P. Longmire, R.K. Tompkins (2012) "Manual of Liver Surgery" Springer Science & Business Media. P. 154.
2. William R. Jarnagin (2012) "Blumgart's Surgery of the Liver, Pancreas and Biliary Tract."(5th edition). Elsevier, Saunders.
3. Ronald S. Chamberlain, L. H. Blumgart (2000) "Hepatobiliary Surgery" Landes Bioscience, the University of Michigan.
4. Ronald S. Chamberla in (2013) "Essential Functional Hepatic and Biliary Anatomy for the Surgeon" Chapter (2). Hepatic Surgery", Hesham Abdeldayem.
5. Pietro Majno et.al (2013) "Anatomy of the liver: An outline with three levels of complexity – A further step towards tailored territorial liver resections." European Association for the Study of the Liver, Elsevier B.V. March 2014 ,Volume 60, Issue 3, Pages 654–662.
6. F. Charles Brunicardi, Dana K. Andersen, Timothy R. Billiar, David L. Dunn, John G. Hunter, Jeffrey B. Matthews, Raphael E. Pollock (2015)." Schwartz's Principles of Surgery", 10e.
7. Sjaak Pouwels.et.al "Preoperative exercise therapy for elective major abdominal surgery: A systematic review". International Journal of Surgery,Volume 12, Issue 2, February 2014, Pages 134–140.
8. Roberta Munhoz Manzano," Chest physiotherapy during immediate postoperative period among patients undergoing upper abdominal surgery: randomized clinical trial".Sao Paulo Med J. 2008;126(5):269-73.
9. Margaret Farquharson, James Hollingshead, Brendan Moran (2014).Farquharson's Textbook of Operative General Surgery, 10th Edition.CRC press,Taylor and Francis Group.
10. Camran Nezhat.(2000),Operative Gynecologic Laparoscopy: Principles and Techniques,2edition.Mc Graw Hill.
11. Edward R. Howard (1991)." Surgery of liver disease in children", Butterworth-Heinemann.
12. Henrik Thomsen, Robert N. Muller, Robert F. Mattrey (2012). "Trends in Contrast Media ".Springer.
13. Ellen J. Hagopian, Junji Machi (2014). "Abdominal Ultrasound for Surgeons" .Springer.
14. Angela D. Levy, Koenraad J. Mortele, Benjamin M. Yeh – 2015." Gastrointestinal Imaging.Oxford publications.
15. Robin Smithuis and Eduard E. de Lange. (2006) "Anatomy of the liver segments".
16. C.Couinaud (1999). " Liver Anatomy: Portal (and Suprahepatic) or Biliary Segmentation". Dig Surg 1999;16:459–467.
17. Mavrides E1.et al. (2001)"'The anatomy of the umbilical, portal and hepatic venous systems in the human fetus at 14-19 weeks of gestation." Ultrasound Obstet Gynecol. Dec; 18(6):598-604.
18. H Bismuth. Surgical anatomy and anatomical surgery of the liver. World J surg. 1982;6:3–9.
19. Blumgart LH, Belghiti J. Surgery of the liver, biliary tract, and pancreas. 3rd edition. Philadelphia: Saunders Elsevier; 2007. pp. 3–30.
20. Peter L. Williams - Gray's Anatomy: Churchill Livingstone; 38 edition (January 8, 1995).
21. Sharma D.et.al "Surgical anatomy of retrohepatic inferior vena cava and hepatic veins: a quantitative assessment. Indian J Gastroenterol. 2001 Jul-Aug;20(4):136-9.
22. Van Leeuwen .et.al(1994) : Variations in venous and segmental anatomy of the liver : two and three dimensional MR imaging in healthy volunteers. American Journal of Roentgenology 162 (6): 1337-45
23. Mlakar B.et.al " Anatomical variations of the cystic artery". Eur J Morphol. 2003 Feb;41(1):31-4.
24. Decker,G.A.G and du Plessis, D.J. Lee McGregor's Synopsis of Surgical Anatomy: The liver and biliary system. 12th Edn. John Wright & Sons Ltd. Bristol. pp 86-87 (1986)
25. Mortele KJ, Wiesner W, Ji H, Ros PR. Scientific Teaching Exhibit: Usual and Unusual Causes of Extrahepatic Cholestasis: Assessment with Magnetic Resonance Cholangiography (MRC) and ultrafast MR imaging. 2001.
26. Jin Woo Choi, et.al.Anatomic Variation in Intrahepatic Bile Ducts: an Analysis of Intraoperative Cholangiograms in 300 Consecutive Donors for Living Donor Liver Transplantation. Korean J Radiol. 2003 Apr-Jun; 4(2): 85–90.
27. Koenraad J. Mortelé .et.al. "Anatomic variants of biliary tree MR cholangiographic finding and clinical applications.American Journal of Roentgenology ,Volume 177, Issue 2 ,Anatomic Variants Of The Biliary Tree. August 2001, Volume 177,
28. Dronkers J. et.al "Prevention of pulmonary complications after upper abdominal surgery by preoperative intensive inspiratory muscle training: a randomized controlled pilot study. Clin Rehabil. 2008;22(2):134-42).
29. Thomas J. Hoogeboom.et.al. "Merits of exercise therapy before and after major surgery".,a Curr Opin Anaesthesiol. 2014 Apr; 27(2): 161–166
30. Oren Cheifetz.et.al "The Effect of Abdominal Support on Functional Outcomes in Patients Following Major Abdominal Surgery: A Randomized Controlled Trial" Physiother Can. 2010 Summer; 62.