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Research Article

MORPHOLOGICAL VARIATIONS OF LIVER IN HUMANS AND ITS SURGICAL RELEVANCE

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ABSTRACT

Background: The knowledge of normal and variant anatomy of the liver is important during radiological investigation and surgery. Variations in the liver morphology can be either congenital or acquired. The common congenital anomalies in liver are agenesis of the lobes, absence of segments, deformed lobes, smaller lobes, atrophy of the lobes and hypoplastic lobes. It is mainly due to defective development or excessive development and sometimes these deformities are present with abnormality of diaphragm and suspensory apparatus of the liver. Though variation in the branching pattern of the hepatobiliary system has been extensively studied, the morphological variations of the liver have not been studied at length.

Methods: The study was conducted in the Department of Anatomy of our institution after obtaining the ethical clearance.100 liver specimens in the Department were used for the study. The morphological variations of the liver such as changes in size and shape, presence of pons hepatis, accessory lobes and fissures were noted. Photographs were taken to document the variations. The results obtained were then tabulated.

Results: The fissures in right lobe was 38 % and left lobe 13%, caudate lobe fissures were 6 % and quadrate lobe was 21%, pons hepatis was 10%. Grooves in the anterior surface was 9%. Conical shaped right lobes were 28% and notched border was 10%. Elongated left lobe was 17% and quadrate lobe with tongue projection was 17%, bilobed quadrate lobe was 5% and accessory lobe was 9 %.The commonest mean weight of liver ranged between 1400- 1700 gms irrespective of sex. According to Netter's classification, type 1 livers were 50% , type 2was 20%, type 3 was nil, type 4 was 5%, type 5 was 3 %, type 6 was 12% and type 7 was 10%.

Conclusions: Knowledge of such variations is also important as these do not always remain clinically latent though most often it may be clinically asymptomatic. Awareness of these variations would help both the surgeons and radiologists to avoid misdiagnosis of cases and unnecessary surgical complications.

INTRODUCTION

The knowledge of normal and variant anatomy of the liver is important during radiological investigation and surgery. Variations in the liver morphology can be either congenital or acquired. The congenital abnormalities of the liver include agenesis, atrophy or hypoplasia oflobes, accessory lobes, accessory fissures etc. It has been found out in Indian population, that accessory lobes are present in 10% of the population. The mini accessory lobe might be mistaken for a lymph node due to its small size and removed during the surgeries. The accessory fissures are the potential sources of diagnostic errors during imaging. It may be mistaken for a liver cyst, haematoma or abscess when there is a collection of fluid in these fissures. Metastatic tumour cells getting lodged into these spaces may mimic intrahepatic focal lesions. [1] Various other anomalies like pons hepatis connecting the left lobe with the quadrate lobe, hypoplasia of right lobe of the liver have been reported. Acquired variations in liver could be due to the pressure given by diaphragm, peritoneal ligaments and other organs in relation with liver so developed during lifetime of a person.[1]

Though variation in the branching pattern of the hepatobiliary system has been extensively studied, the morphological variations of the liver have not been studied at length.[1]

The modern era of liver surgery started after the intrahepatic segmentary anatomy was classified. There are wide variations in the reported prevalence of a caudate fissure, ranging from 3.7% in India.[3] The caudate lobe may also be spared from the hepatic parenchymal atrophy of cirrhosis and undergo compensatory hypertrophy.[4] Detailed studies of the macroscopic anatomy of cadaveric livers can still contribute to the identification of important anatomical variations.[6] With the advent of ultrasonography and the perfection of radiological diagnosis in the early 1980s, liver surgery progressed from

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pioneer to routine.[2] The success of liver transplantation points towards an increase in liver operations in the future. [2]In operative procedures involving the liver, a surgeon's knowledge of liver morphology is vital in determining the patient's outcome. Day to day advances in the fields of radiology like sonography and CT need to revive interest in the cadaveric study of morphological features of liver, as the accessory fissures are a potential source of diagnostic errors. Accessory fissures vary from single to multiple over different parts of the liver.[5]

Knowledge of such variations is also important as these do not always remain clinically latent though most often it may be clinically asymptomatic. Awareness of these variations would help both the surgeons and radiologists to avoid misdiagnosis of cases and unnecessary surgical complications. Although the segmental anatomy of the liver has been extensively researched, very few studies have dealt with surface variations of the liver. Hence, this study was conducted to observe the variations on the surface of the liver.

METHODS

The study was conducted in the Department of Anatomy of our institution after obtaining the ethical clearance.100 liver specimens in the Department were used for the study. The liver specimens were removed during routine dissection for medical undergraduate teaching and were be preserved in 10% formalin. The morphological variations of the liver such as changes in size and shape, presence of pons hepatis, accessory lobesand fissures were noted. Photographs were taken to document the variations. The results obtained were then tabulated. Descriptive statistics was used to analyse the data and extract important information using SPSS.

RESULTS

Gross variations of liver like presence of fissures in right lobe, left lobe, anterior surface, superior surface, diaphragmatic surface, grooves on surfaces of the liver, lobulations, conical shaped right lobe, elongated left lobe, notched border, underdeveloped caudate process, hypertrophied caudate process, abnormal papillary process with fissure, fissure in the caudate lobe, bilobed caudate lobe, fissure in the quadrate lobe, quadrate lobe with tongue like projection, pons hepatis and presence of accessory lobe were observed in the study (Figure 1-Figure 18). The frequency of variations in morphology of liver has been tabulated (Table 1 and Table 2).

Table 1 Morphological Variations of the Liver

Sl.No	Morphology of Liver	Percentage
1.	Fissures in right lobe	38
2.	Fissures in left lobe	18
3.	Fissures in caudate lobe	6
4.	Fissures in quadrate lobe	21
5.	Pons hepatis	10
6.	Absent quadrate lobe	15
7.	Groove in the anterior surface	9
8.	Lobulations on the anterior surface	0
9.	Conical shaped right lobe	28
10.	Notched border	10
11.	Elongated left lobe/Beaver's lobe	17
12.	Quadrate lobe with tongue like projection	15
13.	Bilobed quadrate lobe	5
14.	Accessory lobe	9
15.	Appendix of liver	0
16.	Normal Liver	50

Table 2 Morphology of Liver According To Netters Classification

Netters type	Percentage
Type 1:Normal	50
Type 2: Very small left lobe, deep costal impression	20
Type 3: Complete atrophy of left lobe	-
Type 4: Transverse saddle like liver, large left lobe	5
Type 5: Tongue like process of left lobe	3
Type 6: Very deep renal impression and corset constriction	12
Type 7: Diaphragmatic grooves	10

Out of the 100 livers studied, fissures of various size were encountered in 83 specimens (83%). The accessory fissure was present on the right lobe in 38 % on the right lobe and 18 % of left lobe in the caudate lobe in 6 % and in quadrate lobe in 21 %.Most often the fissures were present on thevisceral surface and in few cases, deep fissures were seen on the anterior and superior surfaces.

Figure 1-18 Showing variousmorphological Variations of Liver

These fissures on the anterior and superior surfaces were either single or multiple (Figure 8, Figure 12, Figure 14) and ranged

from 1- 7 maximum being 7 fissures in one of the liver (Figure 14). In 3 livers, the superior surface was irregular due to visceral impression. Other than the fissures, 28 specimens (28%) showed conical shaped right lobe (Fig. 3). Elongated left lobe or Beaver's lobe (Netter's type 4) was observed in 17 specimens (12.86%) (Fig. 7). Netter type 2 liver was seen in 20% , which was characterized by a small left lobe with deep costalimpressions. Hypertrophied caudate process was observed in 15 % (Figure 16, Figure 18). Quadrate lobe was bilobed in 5 specimens (Figure 11, Figure 17). Pons hepatis was seen in 10 specimens (10 %) (Figure 9). Notched border was encountered in 10 specimens (10%). Accessory lobe was seen in 9 specimen (9 %) either in caudate lobe or in quadrate lobe or adjacent to these lobes (Figure 13).

DISCUSSION

Haobam Rajajee Singh *et al* studied 70 specimens and observed fissures of various size and orientations in 57 specimens (81.4%). The accessory fissure was present on the right lobe in 51.43%, on the left lobe in 11.43%, in the caudate lobe in 27.1% and in quadrate lobe in 32.86%. In four livers, the fissure was present on the right lobe, caudate lobe and quadrate lobe. Most often the fissures were present on the visceral surface and in a few cases, deep fissures were seen on the anterosuperior surface. These fissures on the anterosuperior surface were either single (10%) or multiple (4.3%). In 2 livers, the superior surface was irregular due to visceral impression. Other than the fissures, 13 specimens (18.57%) showed conical shaped right lobe. Elongated left lobe or Beaver's lobe (Netter's type 4) was observed in 9 specimens (12.86%). Netter type 2 liver was seen in one specimen, which was characterized by a small left lobe with deep costal impressions. In addition to the presence of fissure, the morphological variations observed in caudate lobe included underdeveloped caudate process in 4.29%, hypertrophied caudate process in 2.86%, enlarged papillary process in 4.29% or underdeveloped papillary process in 1.43%. Caudate lobe was bilobed in 2 specimens. Twenty three liver specimens (32.86%) showed the presence of fissure in quadrate lobe. Tongue like projection was seen in 5 (7.14%) specimens and bilobed quadrate lobe 5 specimens (7.14%). Pons hepat is was seen in 16 specimens (22.9%). Notched border was encountered in 7 specimens (10%). Accessorylobe was seen in 9 specimen (12.86%) either in caudate lobe or in quadrate lobe or adjacent to these lobes. Accessory fissures were noted in the right, left, caudate and quadrate lobes of the liver by various authors. The number of fissures ranged from 1 to 5 in each liver. Accessory fissures in the right lobe, left lobe, fissure extending over postero-superior surface and between caudate process and duodenal impression have been reported.[1]

In the present study, fissures on various surfaces were encountered in 83 specimens (83%). The accessory fissure was present on the right lobe in 38 % on the right lobe and 18 % of left lobe in the caudate lobe in 6 % and in quadrate lobe in 21 %.Most often the fissures were present on the visceral surface and in few cases, deep fissures were seen on the anterior and superior surfaces. These fissures on the anterior and superior surfaces were either single or multiple maximum being 7 in one of the specimen. In 3 livers, the superior surface was irregular due to visceral impression. 28 specimens (28%) showed conical shaped right lobe. Elongated left lobe or Beaver's lobe was observed in 17 specimens. Netter type 2 liver was seen in 20%. Hypertrophied caudate process was observed in 15 %. Quadrate lobe was bilobed in 5 specimens. Pons hepatis was seen in 10 specimens (10 %) (Figure 9). Notched border was encountered in 10 specimens (10%).

Sangeeta *et al*. observed more fissures on the right lobe of the liver. Accessory fissures were observed more on the visceral surface in previous studies.[1]

Costal impressions of the liver were noted in previous studies. Liver with diaphragmatic impression (Netter's Type 7), deep renalimpressions with corset constrictions were reported. Prominent vertical groove on anterosuperior surface were found in 6% of the liver.[1]

The sulci were localized in the anterior and superior surface of the right lobe and also on the left lobe. They were narrow with variable depths ranging from 1 to 2 cm; variable in number (1–6 sulci. Extra lobes separated completely except a small portion in relation to inferior border of liver were present in 2 (2.5%) specimens. Presence of Riedels lobe might be mistaken as an unidentified abdominal mass on various no- invasive imaging techniques.[2]

Morphologic anomalies of the caudate lobewere present in 64% of unselected persons in this Caribbean population. These included the presence of a linguiform process (64.3%), absence of a caudate process (28.6%), presence of an inferior caudate notch (21.4%), the presence of a vertical caudate fissure (19.6%) and the presence of a papillary process (10.7%).[3]

The caudate lobe is subdivided into Spiegel's lobe (the caudate lobe proper and the papillary process), the caudate process and the paracaval portion, which is anterior to the inferior vena cava. The caudate lobe is connected to the right lobe of the liver by the caudate process, which passes laterally between the portal vein and the inferior vena cava at the portahepatis. The caudate process is sometimes elevated. The medial inferior part of the caudate lobe sometimes forms a papillary process, which passes left (and also sometimes anteriorly) into the region of the superior recess of the omental bursa. The caudate and papillary processes are sometimes separated from the remainder of the liver by grooves or fissures.[4]

SunithaVinnakota *et al* studied 58 specimens and 31 (53.44%) specimens had accessory fissures on the left lobe, right lobe, caudate lobe, and quadrate lobe, which resulted in the formation of accessory lobes. Hypoplastic left lobes were noted in 2 (3.44%) specimens.[5]

Sangeeta *et al* observed small left lobe with deep costal impressions (Netters Type 1 classification) in 5 livers,3 livers showed atrophy of left lobe(Netters Type 2 classification) 5 livers were transverse saddle like with relatively large left lobe (Netters Type 3),6 livers showed tongue like projection of left lobe (Netters Type 4). 4 livers showed deep renal impression and corset constriction(Netter Type classification)5 livers showed deep diaphragmatic grooves (Netters Type 6).[6]

In the present study, according to Netter's classification, type 1 livers were observed in 50%, type 2 was 20%, type 3 was nil, type 4 was 5%, type 5 was 3 %, type 6 was 12% and type 7 was 10% (Table 2).

Emue E B *et al* in nigerian population demonstrated that most adult cadaveric liver of Nigerians was darkish-brown, wedge

shaped, and firm and friable. The commonest mean weight for male was 1516±0.1g and that of female 1333±0.1g.

In the present study, the commonest mean weight of liver ranged between 1400- 1700 gms irrespective of sex

The common congenital anomalies in liver are agenesis of the lobes, absence of segments, deformed lobes, smaller lobes, atrophy of the lobes and hypoplastic lobes. It is mainly due to defective development or excessive development and sometimes these deformities are present with abnormality of diaphragm and suspensory apparatus of the liver. The other rarest abnormalities are seen in lobar and segmental part of liver.[8]

Ten (12.5%) specimens had accessory fissures on the different lobes, which resulted in the formation of accessory lobes. A complete transverse fissure dividing quadrate lobe into a superior and an inferior lobe were seen in 6(7.5%) specimens.[8] In the present study, accessory lobe was observed in in 9 specimen (9 %) either in caudate lobe or in quadrate lobe or adjacent to these lobes (Figure 13).

A complete transverse fissure dividing caudate lobe into a superior and an inferior lobe were seen in 3(3.7%) specimens. Variable size and shape of pons hepatis joining the left lobe with quadrate lobe was seen in 1(1.25%) specimen. Absence of fissure for ligamentumteres was seen in 9(11.2%) specimens. The Riedel's lobe was present in 1(1.25%) specimen. Elongated left lobe present in 10(12.5%) specimen while a mini accessory lobe above quadrate lobe was seen in 3(3.7%) specimens. Large papillary process was present in 1(1.25%) specimen. Type 1 (Very small left lobe, deep costal impressions) was present in 14 (17.5 %) specimens. Type 4 (Tongue like process of right lobe) was present in 1 (1.25 %) specimen.[8]Type 5 Very deep renal impression and corset constriction) was present in 1 (1.25%) specimen. Type 6 (Diaphragmatic grooves) was present in 6 (7.5%) specimens. Type 2 (Complete atrophy of left lobe) and Type 3 (Transverse saddle like liver, relatively large left lobe) were not found in any of the livers.[8]

In the present study, elongated left lobe was observed in 10% of the specimens.

Demarcation of right and left lobes anteriorly is along the line of attachment of the falciform ligament, posteriorly it is along the line of attachment of the ligamentumvenosum and inferiorly along the fissure for the ligamentumteres, so these demarcations are important for division of right and left lobe of liver.[8] Similar finding was seen only in one liver specimen. Absence of fissure for ligamentumteres was present in 11.2% specimens and in 9.7% cases out of 41 livers by Muktyaz H and Nema U.[8]

Major fissures like accessory hepatic fissure can be single or multiple and do not extend beyond the upper part of liver. It is mainly due to invagination of musculature of diaphragm into the upper part of right lobe of liver and commonly seen in elderly patients. Diaphragmatic sulci develop from irregular growth of liver parenchyma caused due to resistance by different bundles of the diaphragm muscle. Diaphragmatic sulci was present in 7.5% specimens. Prominent papillary process and long caudate process were seen in 1.25% specimen.[8]

In the present study, majority of the fissures were present on the visceral surface and in few cases, deep fissures were seen on the anterior and superior surfaces. These fissures on the anterior and superior surfaces were either single or multiple maximum being 7 in one of the specimen which was unique and not observed in any of the studies.

Sachin Patilobserved normal type in 28 livers (56 %) without any accessory fissures or lobes .Out of the remaining 22 specimens, 5 (10%) specimens, even though they appear normal, they had accessory fissures on the different lobes, which resulted in the formation of accessory lobes. Pons hepatis of variable size and shape joining the left lobe with quadrate lobe was seen in 5 (10 %) specimens.[9]

In the present study, pons hepatis was observed in 10 % of the specimens.

Mansur DI *et al* observed normal morphology of liver was in 54.28% and anomalies in 45.71% of liver. The most common anomalies were accessory fissures which were found in 32.86% of livers. Then the enlarged papillary process was found in 11.43%, short gall bladder was in 10% and elongated left lobe was in 7.14%.

In the present study, normal morphology was observed in 50% of the specimens and elongated left lobe in 17% of the specimens.

CONCLUSIONS

The knowledge about the morphological variations of liver will be helpful for radiologists in diagnosis of liver diseases and surgeons for planning biliary or Porto-systemic anastomotic surgeries & also during segmental resection of liver. Knowledge of such variations is also important as these do not always remain clinically latent though most often it may be clinically asymptomatic. Awareness of these variations would help both the surgeons and radiologists to avoid misdiagnosis of cases and unnecessary surgical complications.

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