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Original Research Article

Clinically significant observations of hepatic lobe morphology in adult human cadavers

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ABSTRACT

Objectives: To determine and analyse clinically significant changes in hepatic lobe morphology.
Materials and Methods: An observational study was conducted over 42 adult human livers which were acquired during routine dissections conducted for the first MBBS students over a period of two years (2017-2019) at Dr. PSIMS & RF. Macroscopic thorough examination of the liver specimens was done through borders, surfaces and changes the in parenchymatous tissue was duly documented and photographed.
Results: The common finding was prevalence of accessory fissures(50%) followed by pons hepatis (19%) which was identified as bridging the fissure for ligamentum teres(9.5%) and encapsulating the inferior vena cava in 9.5% of liver specimens. Accessory lobes account for a total of 16.6%,with incidence of Riedel's lobe being 7.1%. Tongue like process of left lobe were encountered in 9.5% specimens. Unique finding in the present study was of a liver specimen which had multiple variations on visceral, anterior and superior surfaces.
Conclusions: Present study comprised of multiple variations in hepatic lobe morphology, which are of great clinical significance and are interest for radiologists and gastroenterologist. Studies on liver morphology would expand the knowledge for surgical inventions and help in preventing diagnostic errors in imaging techniques.

1. Introduction

Liver is the largest viscera and the second largest gland located in the right hypochondriac region of the abdominal cavity. It has myriads of functions from metabolism to detoxification. Anatomically it is divided into four lobes the right, left, caudate and quadrate lobes separated by distinct boundaries.[1] This huge gland is held in the abdominal cavity with the help of hepatic veins opening into the inferior vena cava and a small contribution by the ligaments surrounding it. Though the structure and shape of the gland are influenced by the viscera in its the vicinity, integrity of the capsule is of utmost importance to maintain the architecture of liver parenchyma.[1] With recent advances in imaging techniques with high accuracies, invention of laparoscopic and robotic surgeries, knowledge on common hepatic lobe morphology variations is a must for clinical reasoning to avoid diagnostic errors. While Couinaud's segmental liver anatomy research receives the greatest attention for surgical resections of hepatic segments, there are also studies that focus on common and rare morphological variants.[2] Literature on variations in hepatic lobe morphology has reported accessory fissures, accessory lobes and pons hepatis as the common findings. Knowledge of such variations is important as these do not always remain clinically latent though most often it may be clinically asymptomatic. Netter classified the morphological variations into seven different types.[3] Present study aims to determine and analyze clinically significant changes in the hepatic lobe morphology.

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2. Materials and Methods

An observational study was conducted on 42 human adult livers which were acquired during routine dissections conducted for 1st MBBS students over a period of two years (2017-2019) from the department of Anatomy at Dr. Pinnamaneni Siddhartha Institute of Medical Sciences & Research Foundation. Macroscopic examination was thoroughly done which included borders, surfaces and parenchymal changes in hepatic lobes. The observations were duly documented and analyzed for clinical significance.

3. Results

Out of 42 liver specimens 21 were normal without any gross variations in the morphology of hepatic lobes. An array of variations were found in the remaining 21 specimens with 8 specimens having more than two v and remaining having either single or two variations. The most common finding was accessory fissures 21(50%) which were found a maximum of 8(19%) in the right lobe with two livers showing a prominent and deep fissure referred to as Rouviere's sulcus or Gantz fissure (Figure 1), 4 (9.5%) were seen in the left lobe, 2(4.76%) in the quadrate lobe and 3 (7.14%) in caudate lobe out which two were vertical fissures (Figure 3). Diaphragmatic fissures (Figure 2) were identified in 4(9.5%) livers with two livers having single fissure each and 2 having multiple grooves (Figure 9). Second common finding was the presence of pons hepatis (hepatic bridge or pont hepatique) in 8 livers, with 4(9.5%) bridging the ligamentum teres (Figure 4) and 4 (9.5%) bridging or encapsulating the inferior vena cava partially (Figures 5 and 6).

Accessory lobes were the third common variations found in 7 (16.6%) specimens, out which 3 had Riedel's lobe (Figure 12) and one mini accessory lobe (Figure 11) was found above the porta hepatis on right side. Two were found each on the visceral surface of left lobe and right lobe.

Papillary and caudate processes were identified in 4 and 6 liver specimens each (Figure 10) and hypoplastic caudate lobe was encountered in 7(16.6%) specimens. Large gall bladder covering the small quadrate lobe was found in 2 livers. Other significant observations were presence of hypoplastic left lobes in 5 specimens (Figures 9 and 12), hypertrophied left lobe with lateral extension referred to as Beaver's lobe or lingual (Figure 13) was identified in 4 livers. Hypertrophied projections of superior surface of right lobes forming a dome shape was characteristic in almost 10 livers out of which 4 had hypoplastic left lobes and one of them showed up with shape of tortoise (Figure 12).

Unique finding in the present study was of a liver specimen showing rare entities on visceral as well as on the superior surfaces. The specimen showed developing Riedel's lobe separated by a prominent fissure from the anterior border of right lobe, an accessory lobe attached to anterior border of left lobe and extension of left lobe as lingula, pons hepatis encapsulating the inferior vena cava, a prominent papillary and caudate processes and distorted anterior border with upturned fundus of gall bladder (Figures 7 and 8).

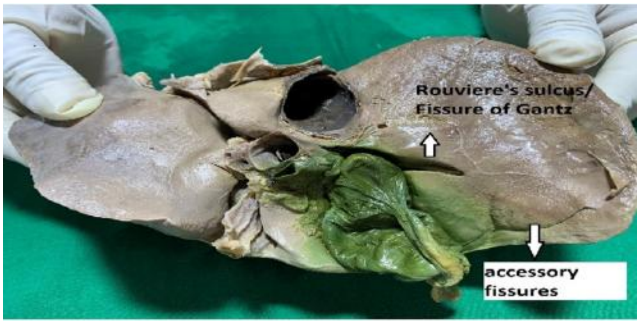

Fig. 1: Liver showing Rouviere's sulcus

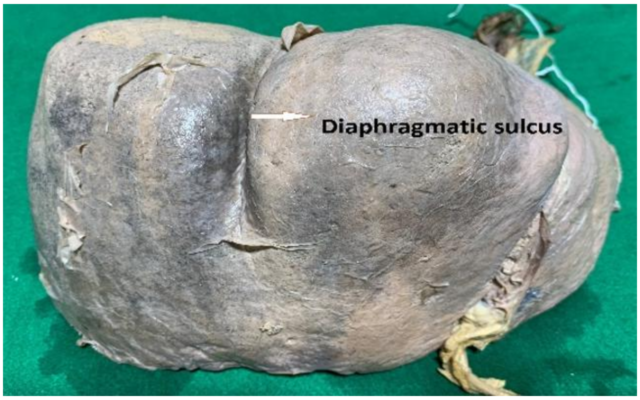

Fig. 2: Diaphragmatic sulcus

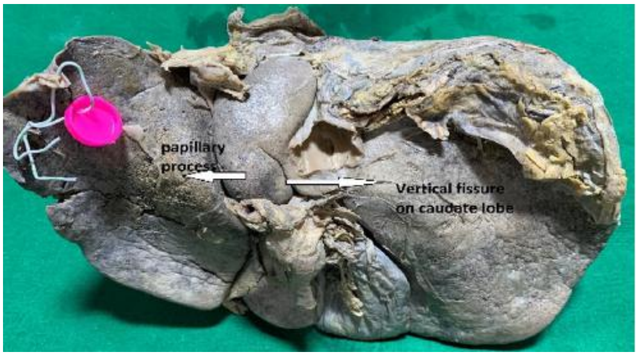

Fig. 3: Vertical fissure of caudate lobe and a prominent papillary process

Table 1: Showinga summary of clinically significant observations in the present study

Accessory Fissures	**21(50%)**
Right lobe	8 (19%)
Left lobe	4(9.5%)
Caudate lobe	3(7.1%)
Quadrate lobe	2(4.7%)
Diaphragmatic fissures	4(9.5%)
Pons hepatis	**8(19%)**
Bridging fissure for ligamentum teres	4(9.5%)
Bridging /encapsulating IVC	4(9.5%)
Accessory lobes	**7(16.6%)**
Riedel's lobe	3(7.1%)
Beaver's lobe/lingula	4(9.5%)
Hypoplastic left lobe	5(11.9%)
Papillary process	4 (9.5%)
Caudate process	6(14.2%)
Hypoplastic caudate lobe	7 (16.6%)

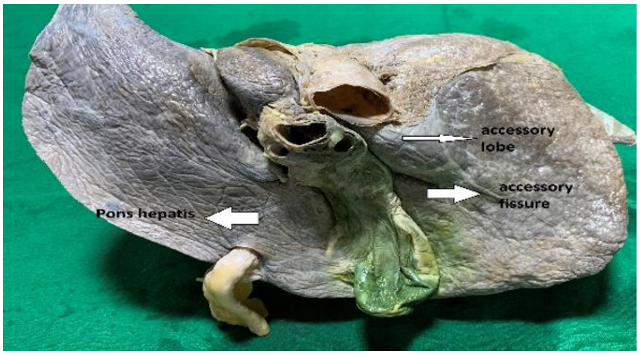

Fig. 4: Pons hepatis bridging the quadrate lobe with left lobe over fissure for ligamentum teres

Fig. 6: Partial encapsulation of inferior vena cava by pons hepatis, deep fossa for gall bladder is identified

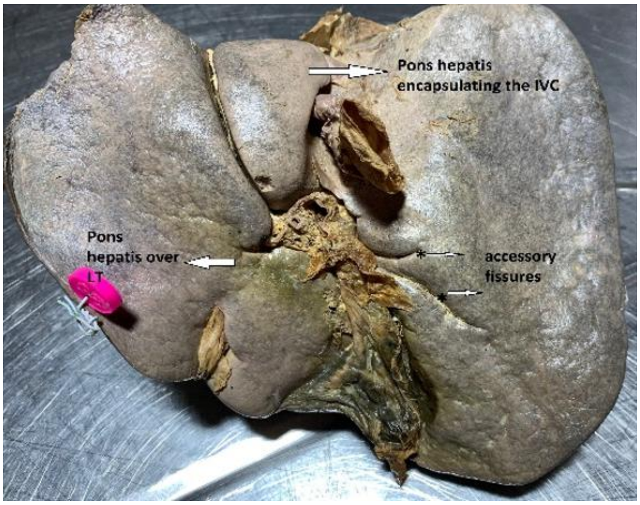

Fig. 5: Pons hepatis bridging fissure for ligamentum teres and encapsulating inferior vena cava

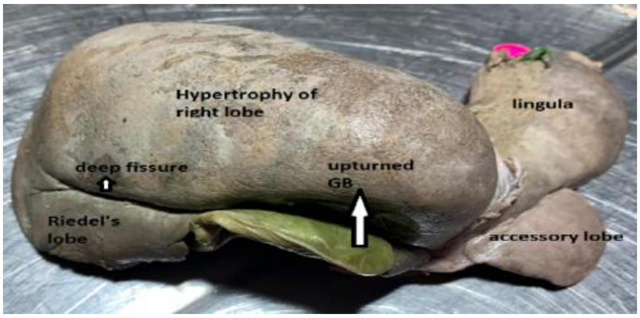

Fig. 7: Liver showing multiple variations Riedel's lobe with deep fissure separating it from right lobe accessory lobe attached to inferior border of lift lobe expansion of left lobe as tongue shaped process called lingula

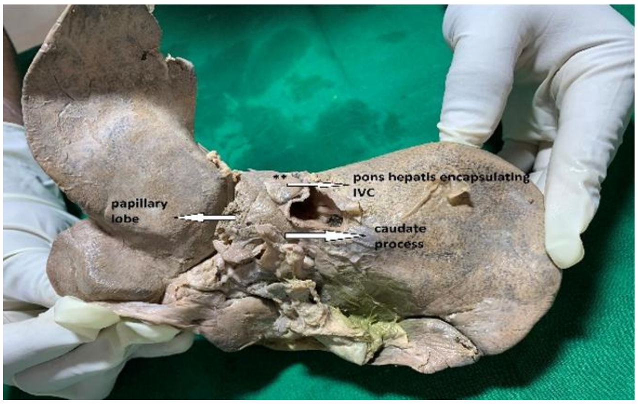

Fig. 8: Visceral surface of liver, prominent papillary and caudate prodess, pons hepatis encapsulating inferior vena cava

Fig. 9: Liver showing hypoplstic left lobe and multiple diaphragmatic grooves

Fig. 10: Showing prominent papillary process and deep foss for gall bladder

Fig. 11: Mini accessory lobe over porta hepatis

Fig. 12: Liver showing Riedel's lobe with hypoplastic left lobe, hypertrophy of right lobe "tortoise like appearance"

Fig. 13: Lingula, tongue like projection of left lobe also referred to as Beaver's lobe

4. Discussion

Hepatic lobe morphology variations may exhibit an array of presentations when physical examination and imaging techniques are performed and lead to diagnostic errors. It is important to make clear cut distinction between congenital anomalies and anatomic variations of liver lobes. Congenital anomalies of liver lobes are very rare compared to pronounced biliary apparatus anomalies. Many studies have provided evidence that anatomical variations of hepatic lobes are subjected to individual variance. A comparative tabulation of similar studies on clinically significant observations has been done at the end of discussion.

Accessory fissures have been notified as the commonest variations of hepatic lobe morphology by various authors in different studies on cadavers. Justin chin et al., in their study on 33 specimens have identified 27% of variations to be accessory fissures as the most common observation, 12% of diaphragmatic fissures and have notified the Rouviere's sulcus/Fissure of Gantz.[2] In present study the percentage of accessory fissures was 50 and the Rouviere's sulcus was identified in 2 liver specimens. Other studies have not identified and mentioned the above fissure of Gantz/Rouviere's sulcus(fig 1). In particular, identification of Rouviere's sulcus can be used as a signpost to avoid bile duct injury during laparoscopic cholecystectomy, but is typically not relied upon due to its reported inconstancy.[2] On ultrasound and computed tomography any collection of fluid in the fissures may be mistaken for liver cysts, intrahepatic hematomas or liver abscess, which would require radiological work up.Implantation of peritoneal-disseminated tumour cells into these spaces may also imitate intrahepatic focal lesion. In cases of abdominal trauma, imaging or direct palpation of sulcus prior to laparotomy may give a false impression of a liver laceration. The diaphragmatic fissures or sulci are a result of uneven growth of the hepatic parenchyma caused by variable resistance offered by the different bundles of the diaphragm muscle. Macchi et al. suggested that the diaphragmatic sulci could represent a useful landmark for surface projection of the portal fissures and of the hepatic veins and their tributaries running through them.[9] In a study conducted on caudate lobe morphology by Sarala et al. in 100 formalin fixed liver specimens 30% of caudate lobes were identified for bearing vertical fissures dividing the caudate process from the caudate lobe.[10] Joshi et al. reported presence of vertical fissure in 30% of their liver specimens. In present study 4(10%) livers showed up vertical fissures on caudate lobe which is attributable to small sample size compared to the other studies.[11] Kogure et al. performed corrosion cast studies and confirmed the presence of a portal fissure between the spiegel's lobe and the paracaval portions and they also proposed that the external notch can be used as an index to separate both the parts of caudate lobe.[12] Couinaud reported that in 34 of 96 cases, hepatic vein lie in the plane of the vertical fissure.[2]

Von Haller in 1743, described pons hepatis as a segment of hepatic tissue connecting the quadrate lobe to left lobe over the fissure for ligamentum teres.[2] In the same study mentioned earlier Justin Chin et al. identified and referred pons hepatis to hepatic tissue that surrounds the inferior vena cava, showing various stages of encapsulation,[2] In the present study pons hepatis surrounding the inferior vena cava partially and completely over its posterior surface has been identified in 4 livers which was not done in any other studies. The prevalence of pons hepatis encapsulating inferior vena cava is reported to range from 4-30% according to Reddy N et al. reflecting on the benign nature of the condition.[13] Clinically metastatic hepatomas have been found originating from the pons hepatis as well as harboring site of peritoneal disseminated tumor cells. It is also important site and landmark for cryoreductive surgeries of the liver.[2]

Accessory lobes are defined as supernumerary in number, composed of normal liver parenchyma in continuity directly with the original liver, by mesentery or by a pedicle in contrast with ectopic liver lobes which do not have this continuity. Chaudhari H et al. reported 3.7% mini accessory lobes,[6] a mini accessory lobe was reported at the posterior part of fissure for ligamentum teres by Nayak S B et al.[14] In present study a pedunculated mini accessory lobe was identified in one specimen which was located to the right upper part of porta hepatis attached to the right lobe(Figure 11). One of the complications of accessory lobes is torsion especially in pedunculated form which requires surgical intervention. Small accessory lobes can be mistaken for lymph node and or may be accidently removed leading to severe intra-abdominal bleeding.[13] An accessory lobe could be formed by the displacement of the primitive rudiment of the organ or by persistence of the mesodermal septa during its proliferation. Another presentation of accessory lobes is Riedel's lobe with an incidence ranging from 3.3-31% (Figures 7, 8 and 12). Riedel's lobe was described by Corbin in 1830 and defined by Reidel in 1888 as a round tumor on the anterior side of the liver, the gall bladder to the right.[2,15,16] Gillard et al. defined Riedel's lobe as being present where ever the liver extended caudal to the most inferior part of the costal margin on cross-sectional computed tomography image. As a result they reported Riedel's lobe is much more commonly found than previously reported.[17] It is of clinical importance since it could be a prime cause of palpable right abdominal mass as an extreme case of elongation of mass secondary to intraperitoneal or intrapelvic inflammation or secondary to surgical interventions. Liver tumors including metastasis or hepatocellular carcinomas may sometimes arise only in the lowest part of Riedel's lobe, occasionally it is attached to liver by a wide fibrous sulcus-regarded as pedunculated lobe which can undergo torsion. Usually this lobe is separated from the rest of the liver by a transverse narrowing of hepatic parenchyma.[15,16] Justin Chin et al. identified a unique liver with pronounced Riedel's lobe and left lobe projection.[2]Present study also reported a unique liver having multiple variations with Riedel's lobe separated from the right anterior surface by a deep fissure which is a rare finding, distorted anterior border, an upturned fundus of gall bladder and an accessory lobe attached at the anterior

Table 2: Showing comparison of present study with other studies on hepatic lobe morphology

Similar studies	Sample size (number)	Accessory fissures (%)	Diaphragmatic fissures/grooves	Accessory lobes	Pons hepatis (FLT/IVC)	Beaver's lobe/lingula
Present study	42	50	10	17	19	10
Justin Chin et al[2]	33	27	12	24	36(IVC)	-
Haobam et al[4]	70	81.4	10	12.8	22.8	12.8
Tsegaye et al[5]	33	27.7	12.1	6	9	6
Chaudhari et al[6]	80	23.7	-	3.7	1.2	12.5
Sachin et al[7]	50	10	2	10	10	10
Saritha et al[8]	50	30	4	16	4	4

border of left lobe (Figures 7 and 8). Chaudhari H et al. showed a prevalence of 1.25% of Riedel's lobe[6] Saritha S[8] et al. in a study of 50 liver specimens identified 2% of Riedel's lobe. Present study showed 7% prevalence of Riedel's lobe, comparatively higher than other studies but in normal range of reference.

Hypertrophy and hypotrophy of hepatic lobes are some of the regular findings in studies conducted by other authors. Hypoplastic (small) left lobes were reported by Sachin[7] et al. (2%), Sunitha[18] et al. (3.4%) and Saritha S[8] et al. (2%). In the present study 5 (11.9%) specimens showed hypotrophy of left lobes. Hypertrophy and lateral extension of left lobe leading to formation of tongue like process called lingula was the common observation in most of the studies. Hypertrophy of papillary process and caudate process of caudate lobe were identified in 7.14% each in 70 specimens in a study conducted by Haobam[4] et al. Chaudhari H[6] et al. identified 1.25% of hypertrophied papillary process. Sarala et al.[10] reported 21% of prominent papillary process in their study on 100 caudate lobes and 9% of prominent caudate process. Joshi et al.[11] reported 32% of papillary process and did not mention caudate process in a study conducted on 90 caudate lobes. In present study the percentage of hypertrophied caudate and papillary process were 14% and 10%. The probability of computed tomography imaging increases if the papillary process is involved in diseases or when papillary process is enlarged. The normal anatomy of the caudate lobe can create several pitfalls that may lead mistakenly to a diagnosis of disease. Auh et al. observed that on computed tomography, a normal or small papillary process may be mistaken for enlarged porta hepatis lymph nodes. It is known that the enlarged papillary process can displace the gastric antrum and duodenum anteriorly, thus mimicking a right sided retroperitoneal mass. When enlarged papillary process extends on to left side it can mimic pancreatic body mass, such an enlargement is common in cirrhosis of liver.[19]

Hypoplastic quadrate lobes were identified in 2% of specimens by a study conducted by Saritha S et al.[8] In present study 2.3% hypoplastic quadrate lobes were identified. Liver projections of superior surface of right lobe were identified by Justin Chin et al.[2] in 3 specimens, which was also observed in present study in almost 7 specimens. Growth of liver parenchymal tissue depends upon the surrounding structures in relation to the organ, perfusion of the lobes, its metabolic activity and pronounced function of detoxification subject liver parenchyma to under go morphological changes. Liver capsule plays an important part in maintaining the integrity of its shape. Once the capsule is lacerated, the liver tissue is easily parted and provides only limited support for surgical interventions. As a whole hyper and hypotrophy demonstrate individual variation normally and most often are quiescent clinically, until it is associated with clinical conditions like cirrhosis leading to portal hypertension and others conditions leading to parenchymal tissue damage.

5. Conclusion

The present study focuses on the clinically significant variations in hepatic lobe morphology. Sound knowledge of variations of external hepatic morphology is pre-requisite for surgical interventions and to avoid radiological diagnostic errors. Advancement in the field of imaging and invention of robotic surgeries has now become mandate for expanding knowledge on anatomical variations of the liver.

6. Source of Funding

None.

7. Conflict of Interest

None.

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