Some interesting observations on the surface features of the liver and their clinical implications

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ABSTRACT

Introduction: A sound knowledge of the normal and variant liver anatomy is a prerequisite to having a favourable surgical outcome. Knowledge of the commonly-occurring variations assumes even more significance in the era of diagnostic imaging and minimally-invasive surgical approaches. Although the segmental anatomy of the liver has been extensively researched, very few studies have dealt with the surface variations of the liver.

Methods: 90 formalin-fixed livers were utilised for the study. Variations regarding the shapes of the caudate and the quadrate lobes as well as the normal fissures were observed. The presence of the accessory fissures and any other variations on the surface of the livers were noted.

Results: Varied shapes of the caudate and the quadrate lobes were encountered. Notching along the inferior border of the caudate lobe was seen in 18 percent of livers, a vertical fissure was observed in 30 percent, and prominent papillary process was seen in 32 percent. Accessory fissures and grooves were more common in the right lobe. Multiple prominent vertical grooves were observed on the anterosuperior surface of the liver in six percent of livers. Quadrate lobe was absent in four percent, and in two cases, it was found to be deeply buried. Presence of a pons hepatis, bridging the left and the quadrate lobes, was observed in 30 percent of the livers examined.

Conclusion: Our study is expected to serve as a guide for proper interpretations of liver images using various imaging modalities. It will also be useful to the operating surgeons to be aware of the frequently-occurring morphological variations on the liver surface.

Keywords: accessory fissures, caudate lobe, liver anatomy, papillary process, pons hepatis, quadrate lobe

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INTRODUCTION

The liver is the largest abdominal viscera, occupying a substantial portion of the upper abdominal cavity. The liver has four lobes or eight segments, depending on whether it is defined by its gross anatomical appearance or by its internal architecture. Historically, the gross anatomical appearance of the liver has been divided into the right, left, caudate and quadrate lobes by the surface peritoneal and ligamentous attachments. Demarcation of the right and left lobes anteriorly, is along the line of attachment of the falciform ligament. Posteriorly, it is along the fissure for ligamentum venosum, and inferiorly, along the fissure for ligamentum teres. The caudate lobe on the posterior surface and the quadrate lobe on the inferior surface lie to the right of these two fissures, separated from each other by the porta hepatis. Towards the left, the caudate and quadrate lobes are bounded by the groove for the inferior vena cava and the gall bladder fossa, respectively.[1]

The classification of the liver, depending on the internal architecture, differs from the above description. The most widely-accepted nomenclature is that described by Couinaud (1957) and Healy and Schroy (1953). According to these classifications, an imaginary "principal parasagittal plane" passing through the gall bladder fossa, divides the liver into functional right and left lobes. Segments I, II, III and IV make up the functional left lobe, and segments V, VI, VII and VIII make up the functional right lobe. This classification is also accepted by the Federative Committee on Anatomical Terminology.[1,2]

The modern era of liver surgery started after the intrahepatic segmentary anatomy was classified. With the advent of ultrasonography and the perfection of radiological diagnosis in the early 1980s, liver surgery progressed from pioneer to routine.[3] The success of liver transplantation points towards an increase in liver operations in the future.[4] Procedures like laparoscopic hepatectomy and laparoscopic thermal ablation for patients with hepatic tumour, have been increasing recently.[5] In

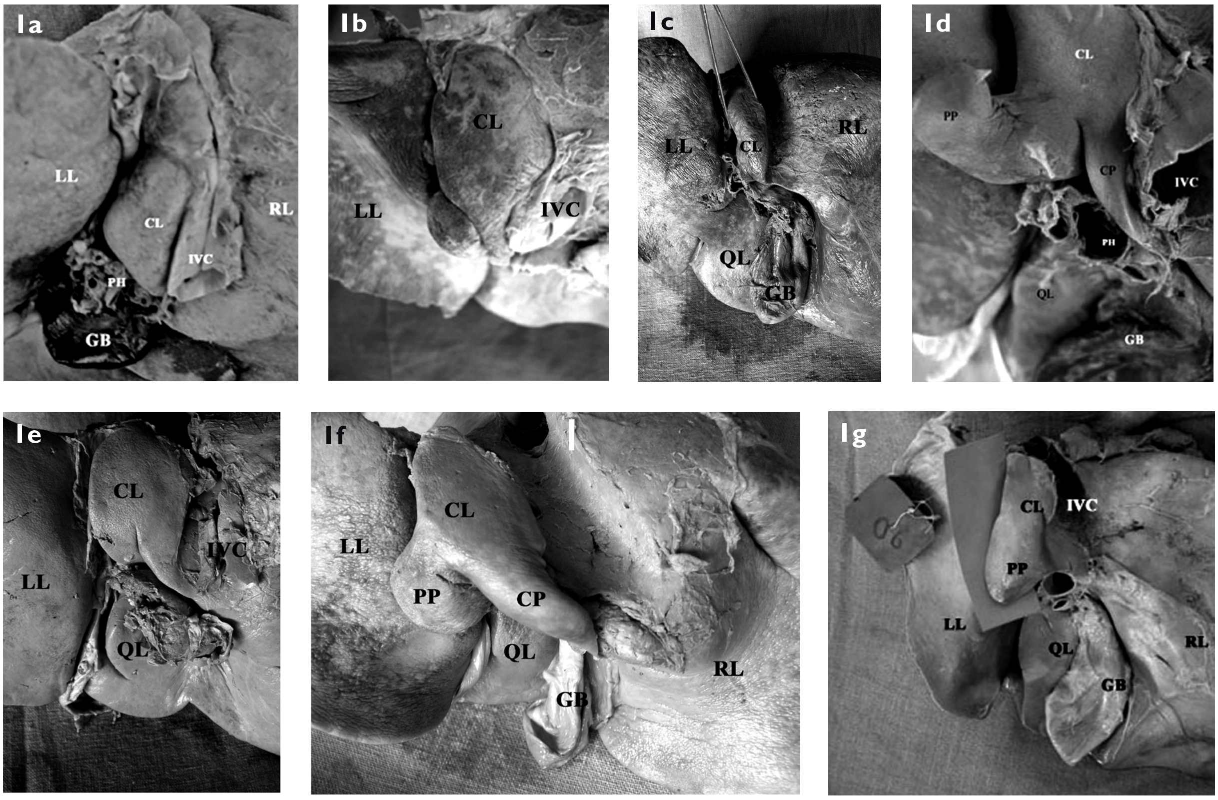

Fig. 1 Photographs show (a) a small caudate lobe. The superior margin of the lobe does not reach the superior surface of the liver. The inferior vena cava inclines to the left superior to the caudate lobe; (b) the papillary process separated from the caudate lobe by a fissure; (c) a narrow rectangular caudate lobe (held between the prongs of the forceps). A pons is seen bridging the fissure for ligamentum teres; (d) a bicornuate caudate lobe with a large curved papillary process; a notch and a fissure separate the papillary process and the caudate process; (e) an inverted pear-shaped caudate lobe with a vertical fissure along the inferior border; a transverse fissure in the quadrate lobe is also seen; (f) a bicornuate caudate lobe with a notch along the inferior border separating prominent papillary and caudate processes; and (g) a triangular papillary process extending from the caudate lobe.
RL: right lobe; LL: left lobe; CL: caudate lobe; QL: quadrate lobe; IVC: inferior vena cava; PH: porta hepatis; GB: gallbladder; PP: papillary process; CP: caudate process.

any operative procedure involving the liver, a surgeon's knowledge of hepatic anatomy is vital in determining the patient's outcome.

Hepatic imaging is usually performed to search for primary or metastatic liver diseases.[6] The major fissures are important landmarks for interpreting the lobar anatomy and locating the liver lesions. In the era of imaging and minimally-invasive approaches, it is imperative on the part of both the radiologists and operating surgeons to have a thorough knowledge of the anatomy and the commonly-occurring variations of this organ. The variations in the surface morphology of this organ were observed very frequently during the routine dissections in this department. Although the segmental anatomy of the liver has been extensively researched, very few studies have dealt with surface variations of the liver. Hence, this comprehensive study was conducted to observe and note the variations on the surface of the liver.

METHODS

90 formalin-fixed livers were utilised for the study. All the livers belonged to adults of unknown age and gender. The livers were apparently normal and free from any disease. Various shapes of caudate and quadrate lobes were observed. The presence of accessory fissures on the liver surface was observed. Any other variations on the surface of the livers were noted.

RESULTS

Various shapes of the caudate lobe were observed. It was rectangular in 58%, bicornuate in 20%, and had different shapes (i.e. pear-shaped, quadrate, triangular, elongated, heart-shaped, square and inverted pear-shaped) in the remaining 22% (Figs. 1a–g). Notching of the lower border of the caudate lobe was present in 18% (Figs. 1d & f). A vertical fissure extending upwards from the lower border was seen in 30% (Figs. 1e & 2d). Prominent papillary process was observed in 32% (Figs. 1d, f & g).

In two cases, the quadrate lobe was absent (Fig. 2b). In two other cases, the quadrate lobe was not seen on the inferior surface, but after retracting the two lips of the fissure for ligamentum teres, it was seen lying deeply

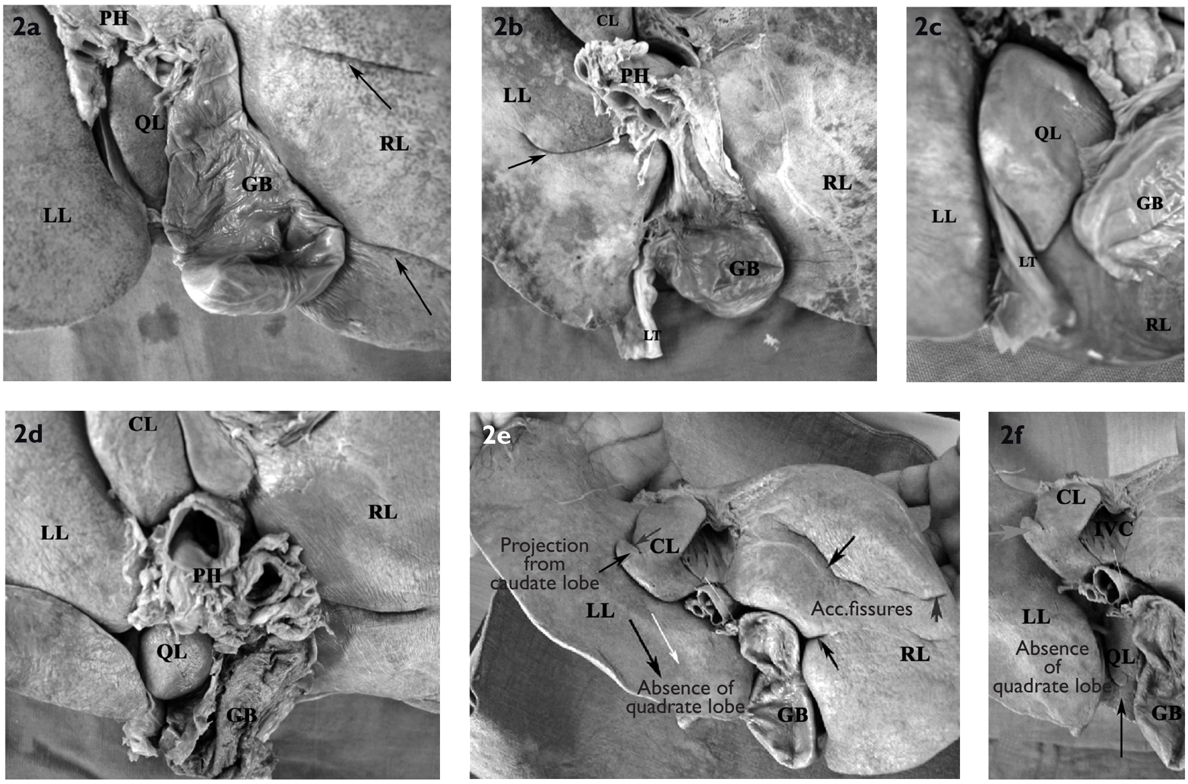

Fig. 2 Photographs show (a) a narrow inverted pear-shaped quadrate lobe; two accessory fissures in the right lobe are also seen (arrows); (b) the absence of the quadrate lobe; fissure for ligamentum teres is seen adjacent to the left margin of the gall bladder fossa; an accessory fissure in the left lobe is also seen; (c) an inferiorly-pointed quadrate lobe (not reaching the inferior border); (d) a small, globular quadrate lobe is surrounded by the gall bladder, porta hepatis and the left lobe; a vertical fissure in the caudate lobe is also seen; (e) the absence of the quadrate lobe on the inferior surface; a lingular projection is seen on the left margin of the caudate lobe and accessory fissures are seen in the right lobe; and (f) the same specimen as 2e, after retracting the lips of the fissure for ligamentum teres, the quadrate lobe is seen buried deep (arrow).
RL: right lobe; LL: left lobe; CL: caudate lobe; QL: quadrate lobe; IVC: inferior vena cava; PH: porta hepatis; GB: gallbladder; LT: ligamentum teres.

buried (Figs. 2e & f). Different shapes of the quadrate lobe were encountered (Figs. 2a–f). The shape was rectangular in 66%. In 6% of the cases, the quadrate lobe was very narrow. In these cases, the fissure for ligamentum teres was in close proximity to the left margin of the gall bladder fossa (Fig. 2a). In another 20% of the livers, various other shapes were observed, viz. pear-shaped, triangular with the apex up, and presence of tongue-like processes pointed inferiorly. In 12% of the livers, the quadrate lobe was continuous with the right lobe, below the fossa for the gall bladder. Fissures in the quadrate lobe were found in 20% of the livers (Fig. 1e).

The presence of the pons hepatis of variable dimensions, joining the quadrate and the left lobes, was present in 30% (Fig. 1c). In the majority of these cases, the pons was bridging the upper third of the fissure for ligamentum teres. In one case, the pons was present in the depth of the fissure for ligamentum teres. In two cases, the pons completely bridged the fissure on the inferior surface, resulting in the merging of the left and the quadrate lobes. In 80% of the livers, the fissure was not just limited to the inferior surface, but continued for a variable distance after cutting the inferior border onto the anterior surface, where the fissure was vertical, oblique or T-shaped (Figs. 3a–c).

Variations were also observed in the contour of the inferior border (Figs. 4a–d). The appendix of the liver was present in 10% of the cases. Accessory fissures were more common on the inferior surface of the right lobe. In all the cases, veins were observed in the depth of these fissures. Table I shows the distribution and occurrence of the accessory fissures on the surface of the liver (Figs. 2a & e). Prominent parallel vertical grooves, on the anterosuperior surface of the right lobe, were observed in 6% of livers. In all the cases, these grooves were multiple, ranging from two to five in number (Fig. 5).

DISCUSSION

Various shapes of the caudate lobe were encountered in the present study. Sahni et al also reported a variety of shapes of the caudate lobe.[7] The caudate lobe has been described to comprise two portions, joined by a narrow parenchymal bridge – the caudate isthmus. One is situated to the left of the inferior vena cava, corresponding to the

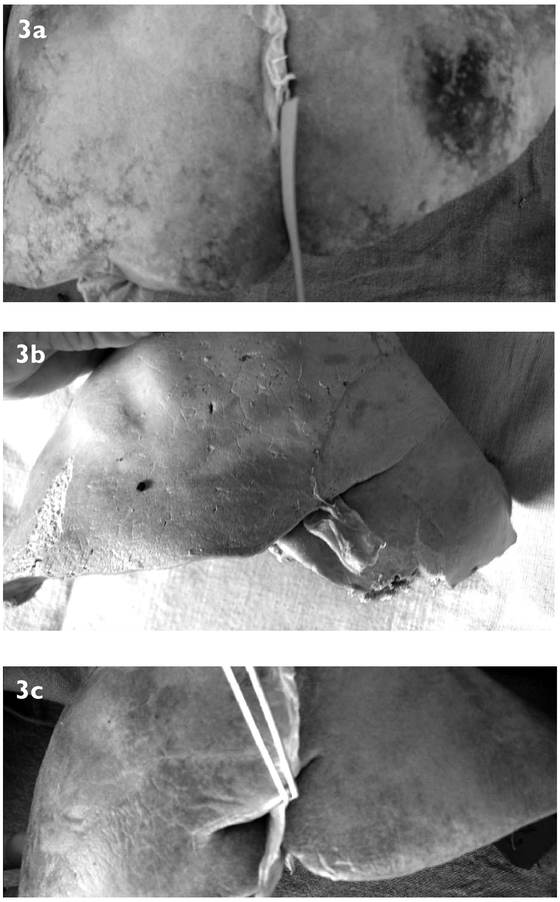

Fig. 3 Photographs show the fissure for ligamentum teres cutting the inferior border and reaching onto the anterior surface.

Spiegel's lobe or Couinaud's segment. The second part extends in front of and to the right of the inferior vena cava. It also extends caudally as a caudate process. This is termed as the paracaval portion.[3]

The presence of a notch on the inferior border, separating the caudate process and the papillary process, was seen in 18%, and a vertical fissure extending upwards from the inferior border, was observed in 30% of the livers. Kogure et al also noticed the presence of the notch along the inferior border in approximately half of the patients undergoing hepatectomy.[8] Based on the cast study, they confirmed the existence of a portal fissure between the Spiegel's lobe and the paracaval portions, and further proposed that the external notch can be used as an index to separate the Spiegel's lobe from the paracaval portion. Sahni et al observed that the frequency of occurrence of the notch decreased with advancing age.[7] Kogure et al were of the view that this external notch may be a vestige of the portal segmentation of the caudate lobe, as demonstrated in animal livers.[8] Couinaud reported that in 34 of 96 cases, the hepatic vein lay in the fissural plane.[9]

The presence of a prominent papillary process was observed in 33% of the livers in our study. Auh et al observed that on computed tomography, a normal-sized or small papillary process may be mistaken for enlarged porta hepatis nodes. An enlarged papillary process may mimic a pancreatic body mass, if it extends so far to the left that it displaces the body of the stomach anteriorly.[10] Aktan et al observed an absence of the caudate lobe in 7.41% of the 54 livers studied.[11] We did not notice an absence of the caudate lobe in any of our cases.

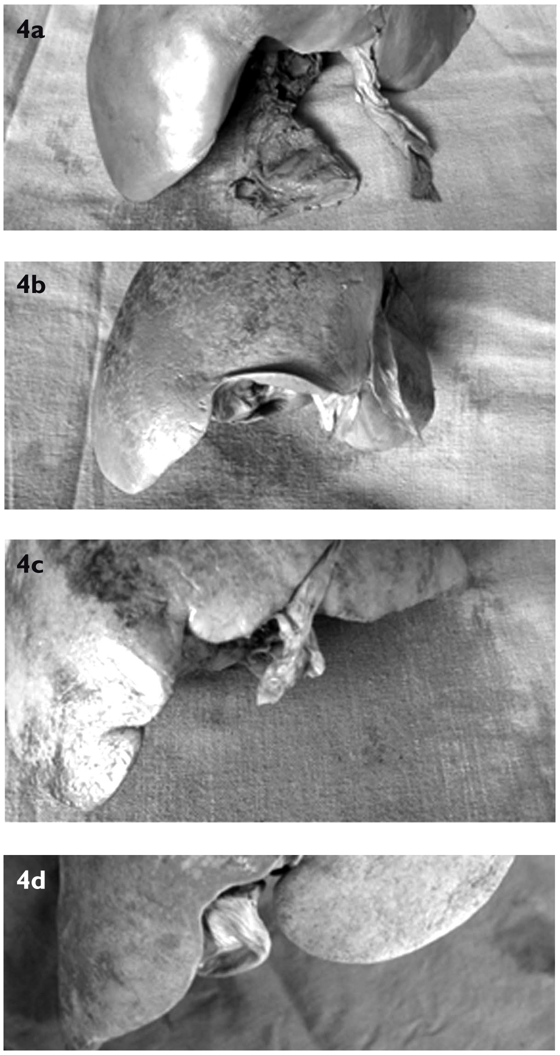

Fig. 4 Photographs show the various contours of the inferior border of the liver.

The different shapes of the quadrate lobes encountered in the study, and the presence of the pons hepatis bridging the fissure for ligamentum teres are important findings. A very narrow, buried or absent quadrate lobe may create confusion in the mind of the radiologist, as the fissure for ligamentum teres in such cases would be very near to the left margin of the gall bladder fossa. In cases of the pons hepatis bridging the fissure for ligamentum teres, normal visualisation of the fissure would not be possible and dimensions of the right and the left lobes may be mistaken.

Table I. Occurrence of accessory fissures on the liver surface.

Position of the accessory fissure on the liver surface	% of cases
Extending from the right margin of the porta hepatis into the inferior surface of the right lobe.	28
Extending from the right margin of the fossa for the gall bladder into the inferior surface of the right lobe.	22
On the posterior and inferior surfaces of the right lobe in any position other than those already mentioned.	30
On the left lobe.	18

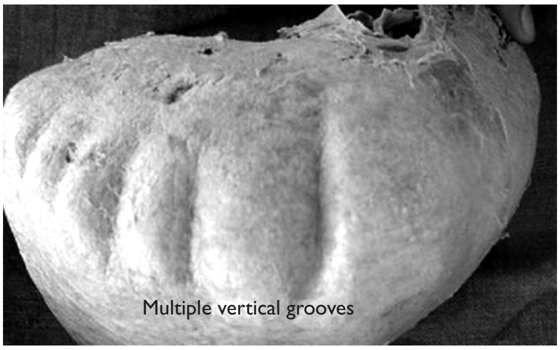

Fig. 5 Photograph shows multiple grooves on the anterosuperior surface of a liver specimen.

Prominent vertical grooves on the anterosuperior surface were found in 6% of the livers. A higher incidence of such grooves was observed by Macchi et al [12,13] and Auh et al.[14] According to Schafer and Symington (1896) and De Burlet (1910) (as quoted by Macchi et al), diaphragmatic sulci result from uneven growth of the hepatic parenchyma caused by variable resistance offered by different bundles of the diaphragm muscle.[12] But more recently, radiological and corrosion cast studies have attributed the formation of sulci to the existence of weak zones of hepatic parenchyma, represented by the portal fissures between the adjacent sagittal portal territories. These weak zones offer a lower resistance to external pressure of the diaphragm.[12,13] 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.[12]

In our study, the posterior and the inferior surfaces of the right lobe was the most common site of accessory fissures, other than the diaphragmatic fissures. Accessory fissures were also noted in the left and quadrate lobes. According to Auh et al, the accessory hepatic fissures are potential sources of diagnostic errors during imaging. Any collection of fluid in these fissures may be mistaken for a liver cyst, intrahepatic haematoma or liver abscess. Implantation of peritoneally-disseminated tumour cells into these spaces may mimic intrahepatic focal lesions.[15] Mazziotti et al advocated the use of intraoperative ultrasonography in liver surgery to determine the anatomical location and the extent of the lesion, thereby minimising unnecessary tissue dissections and traumatic surgical manoeuvres. Knowledge of possible variations is important during such evaluations.[3]

In conclusion, this study highlights the frequent occurrence of morphological variations on the liver surface. The findings of the study may be gainfully utilised by imaging specialists and surgeons, to respectively avoid possible errors in interpretations and subsequent misdiagnosis, and to assist in planning appropriate surgical approaches.

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