Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/kw5fzs26

GROSS AND HISTOLOGICAL STUDY OF HUMAN LIVER MORPHOLOGY INCLUDING SINUSOIDAL ARCHITECTURE AND ITS SURGICAL IMPLICATIONS

Dr. V. Subhashini Rani[1], Mrs V. Vinila[2*]

Professor, Department of Anatomy, Konaseema Institute of Medical Science and Research Foundation, Amalapuram, Andhra Pradesh, India.
Assistant Professor, Department of Anatomy, Konaseema Institute of Medical Science and Research Foundation, Amalapuram, Andhra Pradesh, India.

***Corresponding Author:** Mrs V. Vinila
*email: vinila1983@gmail.com

Abstract

Background: Did we mention that liver, which is the largest gland in the human body, displays wide variation in gross morphology and sinusoidal microarchitecture? Such variations may manifest as pathologies on imaging or may add added difficulty to hepatobiliary procedures. Such studies must encompass both morphology and histology for relevant clinical insight.

Materials and Methods: Among 36 formalin-preserved livers selected for descriptive cadaveric study at the Department of Anatomy, Konaseema Institute of Medical Sciences, February 2024 to July 2025. The gross features, which included lobes, fissures, grooves, impressions, and accessory lobes, were observed and classified according to Netter. Histological sections were stained with H&E, reticulin, and Masson’s trichrome for the assessment of lobular organization, portal triads, and sinusoidal arrangement.

Results: Out of 36 specimens, 19 (52.78%) had normal morphology, whereas 17 (47.22%) were considered to have a variation. The abnormalities observed included accessory fissures (22.22%), pons hepatis (11.11%), quadrate lobe anomalies (11.11%), accessory lobes (2.78%), and diaphragmatic grooves (11.11%). Riedel's lobe and saddle-shaped left lobes were also seen. Histology revealed a consistent classical lobular structure with hepatocyte cords radiating from central veins, fenestrated sinusoidal endothelium, and well-defined portal triads.

Conclusion: Almost 50% of livers exhibited possible morphological variants that could simulate disease or complicate surgical intervention. Thus, awareness of such variants along with sinusoidal architecture is indispensable for the interpretation of imaging and safe practice.

Keywords: Liver morphology, sinusoidal architecture, anatomical variation, cadaveric study.

Introduction

The largest glandular organ of the human body, the liver is further anatomically divided into lobes, namely the right, left, caudate, and quadrate lobes based on peritoneal and ligamentous attachments. But functionally, it is categorized according to the segmentation of Couinaud into eight segments, the segments 1-4 contribute to the functional left, while segments 5-8 contribute to the functional right lobe. Its functional segmentation based on vascular and biliary distribution has greater relevance surgical practices than the former lobar classification.[1]

Physiologically, the liver is indispensable, performing very many vital functions: metabolism; detoxification; digestion; immune modulation; nutrient storage.[2] In fact, no body tissue can survive without its metabolic support. Surgeon-wise, often external morphology of the liver is subject to distinctive features such as grooves-fissures-impressions.[3] Such grooves have been of varied lengths, curves, and number and stand as landmarks for surgery in localization of tumors, definition of resection margins, and operative orientations. They could either be congenital or acquired via diaphragmatic or rib pressure. Their variability in severity causes interpretation errors in imaging diagnostics. [4, 5] Besides macroscopic morphology, the microanatomical architecture of the liver, particularly the organization of hepatic lobules and sinusoids, contributes to hepatic function and pathology. The network of sinusoids is the primary site for the exchange of portal blood with hepatocytes and forms the basis of hepatic detoxification and metabolism.[7] Ultimately, alter the structure of the sinusoid architecture to produce at least some of the pathological states that include cirrhosis, portal hypertension, and hepatocellular carcinoma, all of which have significant surgical and clinical implications.[8] Thus, a combined study of both gross morphology and sinusoidal microarchitecture is of major theoretical and clinical significance.

Materials and Methods

This cadaveric cross-sectional descriptive study was conducted at the Department of Anatomy, Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, from February 2024 to July 2025. Thirty-six livers preserved in formalin were examined, which were obtained from routine dissections. Specimens with evidence of autolysis or any gross pathologic change were excluded. Grossly, each liver was washed and examined in the diaphragmatic and visceral surfaces. The observations included lobe morphology (size, shape, fissures, accessory lobes, and notches) and the presence of major and minor grooves as per classification by Netter.[9] Specimens were photographed and examined independently and blind by two anatomists on two separate occasions to eliminate bias. The data were tabulated and descriptively analysed.

Histological examination involved sampling representative tissue blocks from each lobe, fixing in 10% formalin, routine processing, sectioning these blocks in the plane of the liver at 5–7 µm, and staining them with Haematoxylin and Eosin. Selected sections were stained with reticulin and Masson's trichrome. The slides were examined under a light microscope with particular reference to lobular architecture, portal triads, sinusoidal pattern, and central vein relationships.

Result

In the present study, of the 36 liver specimens, 19 (52.78%) exhibited normal morphology. The remaining 17 (47.22%) specimens showed a variety of morphological variations, which included accessory fissures, pons hepatis, variations of the quadrate lobe, absence of the quadrate lobe, and accessory lobes (Table 1). In a few specimens, more than one variation was observed.

Table 1: Frequency distribution of human liver morphology (n=36)

Morphological Features	Number of Specimens (%)
Normal liver	19 (52.78%)
Accessory fissures	8 (22.22%)
Pons hepatis connecting left lobe with quadrate lobe	4 (11.11%)
Superior and inferior quadrate lobe	1 (2.78%)
No quadrate lobe	3 (8.33%)
Accessory lobes	1 (2.78%)

Right Lobe

Accessory fissures on the right lobe were observed in 8 (22.22%) specimens. A tongue-like projection from the right lobe, corresponding to Riedel's lobe (Type 4 Netter's), was identified in 2 (5.56%)

specimens. In 3 (8.33%) specimens, a deep renal impression and corset constriction were noted, corresponding to Type 5 Netter's.

Quadrate Lobe
Variations of the quadrate lobe were observed in 4 (11.11%) specimens. A horizontal fissure dividing it into superior and inferior parts was noted in 1 (2.78%) specimen. A pons hepatis connecting the quadrate lobe with the left lobe was found in 4 (11.11%) specimens, and absence of the quadrate lobe was seen in 3 (8.33%) specimens.

Caudate Lobe
No major variations were observed in the caudate lobe in the present series.

Left Lobe
Enlargement of the left lobe, forming a transverse saddle-like configuration (corresponding to Type 3 Netter's), was seen in 2 (5.56%) specimens. Very small left lobes with deep costal impressions, consistent with Type 1 Netter's, were observed in 5 (13.89%) specimens.

Diaphragmatic Surface
Multiple diaphragmatic grooves were identified on the superior surface in 4 (11.11%) specimens, corresponding to Type 6 Netter's.

Table 2: Frequency of Netter`s type of human liver

Type of Liver and Characteristic Features	Number of Specimens (%)
Type 6 – Diaphragmatic grooves	4 (11.11%)
Type 5 – Very deep renal impression and corset constriction	3 (8.33%)
Type 4 – Tongue-like process of right lobe	2 (5.56%)
Type 3 – Transverse saddle-like liver, relatively large left lobe	2 (5.56%)
Type 2 – Complete atrophy of left lobe	0 (0.0%)
Type 1 – Very small left lobe, deep costal impressions	5 (13.89%)

Histological examination of the liver showed well-preserved lobular architecture across all specimens. In **Figure 1**, hepatocyte cords radiated from the central vein, separated by irregular sinusoidal channels that converged centrally, while portal triads with portal vein, hepatic artery, and bile duct were seen at the periphery. **Figure 2** demonstrated classical hepatic lobules in a spoke-wheel pattern around the central vein, with thin, discontinuous sinusoidal endothelium allowing close contact between blood and hepatocytes. In **Figure 3**, low-power examination highlighted multiple portal tracts at the lobular margins, with sinusoids radially arranged between hepatocyte cords, linking peripheral vessels to the central vein.

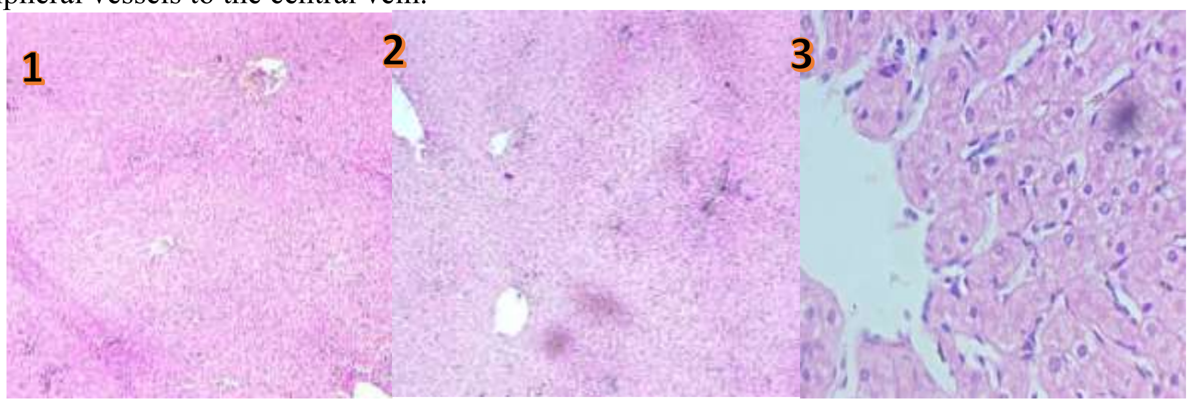

Figure 1: Cords radiated from the central vein. Figure 2: Hepatic lobules in a spoke-wheel pattern. Figure 3: Sinusoids radially arranged between hepatocyte cords.

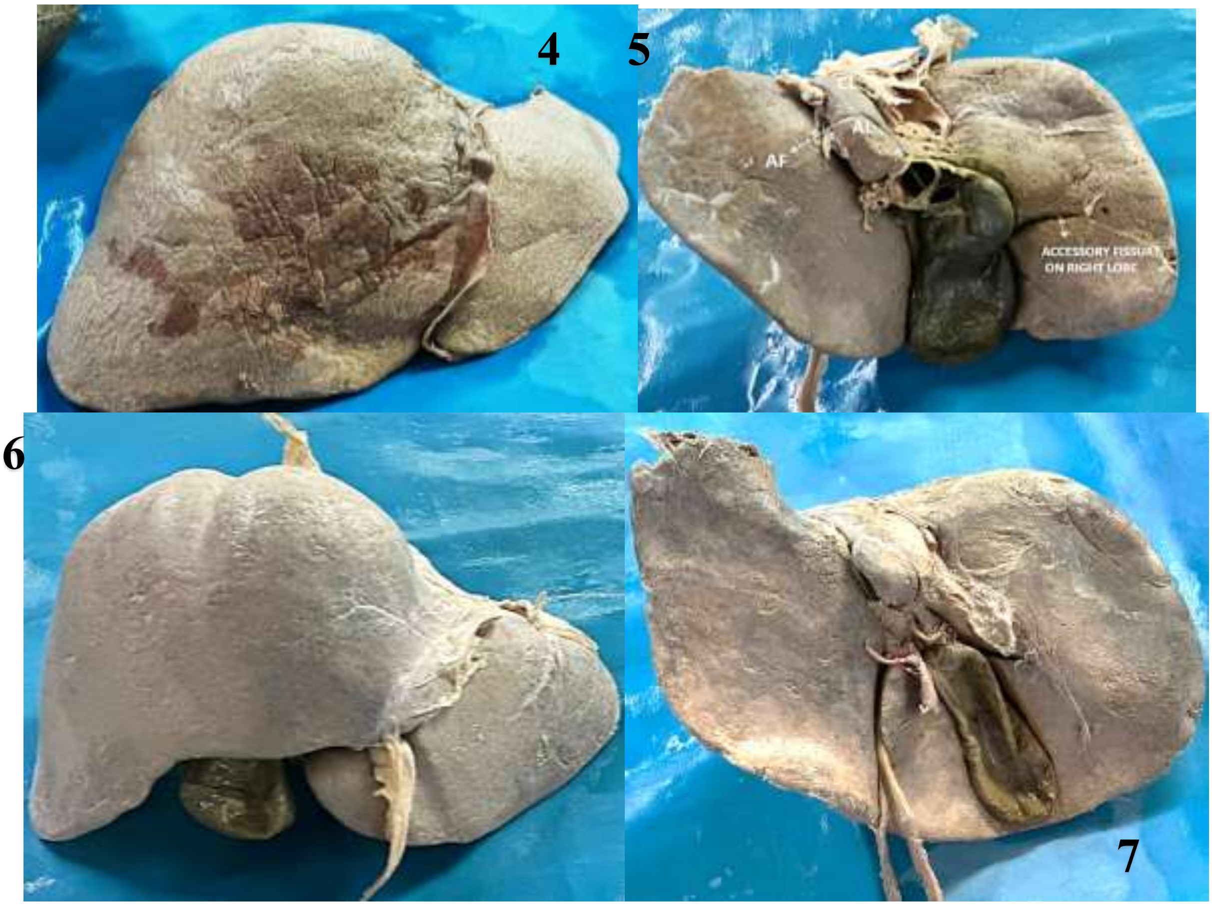

Figure 4 to 7: CL – Caudate lobe; AF – Accessory fissure; AL – Accessory lobe.
Figure 2. RL – Right lobe; LL – Left lobe; CL – Coronary ligament; LTL – Left triangular ligament; LT – Ligamentum teres hepatis; FL – Falciform ligament.

Discussion

In the present study, normal morphology was seen in 52.78% of liver specimens, while 47.22% exhibited one or more variations including accessory fissures, pons hepatis, anomalies of the quadrate lobe, accessory lobes, and diaphragmatic grooves. The findings are comparable with those of A. Sangeetha and S. Nandha Kumar (2021) [4], who reported 44% of specimens with variations among 50 livers studied.

Accessory fissures were recorded in 22.22% of the specimens, a little higher than 15.5% reported by Sunitha et al. [10] but on par with Sangeetha and Kumar [4], who reported 20%. In clinical settings, these fissures can be mistaken for hepatic cysts, hematomas, or abscesses during an imaging procedure, as stated by Auh et al. [11] The fissures were also considered weak regions of the liver that may affect resections, as put forth by Macchi et al. [12]

Pons hepatis were identified in 11.11% of specimens, which closely correlate with Patil et al. (10%) [13] and Saritha et al. (4%) [14] findings but less than 30% incidence reported by Joshi et al. [6] Presence of pons hepatis is significant as it may compress structures at the porta hepatis and cause hindrances to surgical/radiological evaluation.

Quadrate lobe variations were documented in 11.11% of specimens, including horizontal subdivision and absence (8.33%); similar incidences were described by Sangeetha and Kumar [4] (14%). Rare cases of quadrate lobe absence were also reported by Aktan et al. [15] and Ebby et al. [16] Clinically pertinent, the quadrate lobe has independent vascular and biliary supplies; absence of the quadrate lobe could affect surgical planning.

In contrast, major caudate lobe variations were not seen in this series, while in Sangeetha and Kumar (2021) [4], caudate anomalies were reported in 16% of specimens, and Aktan et al. [15] documented complete absence in 7.41%.

Enlargement with saddle-like appearance (5.56%) and small lobes with costal impressions (13.89%) were observed on the left lobe, corresponding to Netter's Types 3 and 1. Similar variations were reported by Sangeetha and Kumar (2021) [4], and Demirci and Diren [17] pointed out that the variations may mimic hepatic pathology on imaging. Diaphragmatic grooves were found in 11.11% of specimens, lower incidence than 20% by Sangeetha and Kumar and 40% by Macchi et al. [12] Generally, these grooves are produced by pressure from the diaphragm and can serve as surgical landmarks, though they may be misinterpreted as pathological fissures.

Histological examination revealed well-preserved lobular organization in all specimens. Hepatocyte plates radiated from the central vein in a spoke-wheel arrangement, separated by irregular sinusoidal channels, with portal triads clearly visible at the periphery (Figures 1–3). These findings align with the classical descriptions of Ross & Pawlina (2016) [18] and Martinez-Hernandez & Martinez (1991) [19], who identified hepatic sinusoids as discontinuous capillaries located between hepatocyte plates. The thin, fenestrated endothelium observed in our samples further corroborates reports by Simionescu & Siminoescu (1988) [20] and Wisse et al. (1983, 1985) [21], emphasizing its role in efficient metabolic exchange.

The radial arrangement of sinusoids from periportal regions toward the central vein in our study mirrors observations made by Bhunchet & Wake (1998) [22] and Lamers et al. (1999) [23], who described human sinusoidal drainage as occurring exclusively into central veins. This contrasts with animal studies, where dual drainage patterns have been noted—for example, in rats, sinusoids connect to both central and sublobular veins. Our specimens consistently demonstrated convergence into the central vein, supporting human-specific findings reported by Muktyaz et al. (2013) [24] and Lamers et al. (1999) [23].

Surgical Implications

A surgeon and a radiologist must take note of the morphology of variations in liver such as accessory fissures, pons hepatis, quadrate lobe anomalies, accessory lobes, and diaphragmatic grooves. These morphologies may on imaging resemble cysts, abscesses, traumatic lacerations or tumors. If these variants are not recognized, there would be misdiagnosis and unnecessary procedures or surgeries. During hepatobiliary procedures, pons hepatis may complicate dissection or cause an increased risk of injury to a vessel or bile duct when unusual lobar configurations are present. Hence, awareness and preoperative recognition of such variations help in accurate radiological interpretation, safer surgical planning, and avoidance of intraoperative complications.

Conclusion

Nearly half (47.22%) of the liver specimens under consideration, in the present study, showed one or other types of morphological variations-anatomies such as an accessory fissure, pons hepatis, quadrate lobe anomalies, accessory lobes, and diaphragmatic grooves-while normal anatomy was observed in 52.78%. Histopathological examination showed well-formed lobular architecture with classical hepatic sinusoidal architecture. These findings reaffirm that variations in the anatomical and structural configuration of the liver are common, often closely mimicking pathological lesions on imaging. Understanding these variations is thus important for correct interpretation and avoiding diagnostic pitfalls on imaging because of abnormal radiological features.

References

1. Mahadevan V. Anatomy of the liver. Surgery (Oxford). 2020;38(8):427-31. doi:10.1016/j.mpsur.2014.10.004.
2. Kalra A, Yetiskul E, Wehrle CJ, et al. Physiology, Liver. [Updated 2023 May 1]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. Available from: https://www.ncbi.nlm.nih.gov/books/NBK535438/
3. Chaudhari HJ, Ravat MK, Vaniya VH, Bhedi AN. Morphological study of human liver and its surgical importance. J Clin Diagn Res. 2017;11(3):AC09-12.

4. Sangeetha A, Kumar SN. Morphological variations of the liver and its applied significance: a cadaveric study. J Datta Meghe Inst Med Sci Univ. 2021;16(3):303-7.
5. Rutkauskas S, Gedrimas V, Pundzius J, Barauskas G, Basevicius A. Clinical and anatomical basis for the classification of the structural parts of liver. Medicina (Kaunas). 2006;42(2):98-106.
6. Joshi MM, Chavan SK. Morphological study of adult human cadaveric liver. Int J Anat Res. 2017;2(6):4284-9.
7. Wang Q, Liu J, Yin W, Wang A, Zheng J, Wang Y, et al. Microscale tissue engineering of liver lobule models: advancements and applications. Front Bioeng Biotechnol. 2023;11:1303053. doi:10.3389/fbioe.2023.1303053.
8. Gibert-Ramos A, Sanfeliu-Redondo D, Aristu-Zabalza P, Martínez-Alcocer A, Gracia-Sancho J, Guixé-Muntet S, et al. The hepatic sinusoid in chronic liver disease: the optimal milieu for cancer. Cancers (Basel). 2021;13(22):5719. doi:10.3390/cancers13225719.
9. Netter F. Atlas of Human Anatomy. 2nd ed. New York: Guilford Press; 2000.
10. Sunitha V, Neelee J. A new insight into the morphology of the human liver: a cadaveric study. ISRN Anat. 2013;2013:689564. doi:10.5402/2013/689564.
11. Auh YH, Lim JH, Kim KW, Lee DH, Lee MG, Cho KS. Loculated fluid collections in hepatic fissures and recesses: CT appearance and potential pitfalls. Radiographics. 1994;14(3):529-40.
12. Macchi V, Feltrin G, Parenti A, De Caro R. Diaphragmatic sulci and portal fissures. J Anat. 2003;202(3):303-8.
13. Patil S, Sethi M, Kakar S. Morphological study of human liver and its surgical importance. Int J Anat Res. 2014;2(2):310-4.
14. Saritha S, Ramani R, Nagajyothi Y, Yesender. Cadaveric study of morphological variations in the human liver and its clinical importance. Int J Med Sci Clin Inventions. 2015;6(7):1020-31.
15. Aktan ZA, Savas R, Pinar Y, Arslan O. Lobes and segment anomalies of the liver. J Anat Soc India. 2001;50(1):15-6.
16. Ebby S, Ambike MV. Anatomical variation of ligamentum teres of liver – a case report. Webmed Cent Anat. 2012;3(5):WMC003389.
17. Demirci A, Diren HB. Computed tomography in agenesis of the right lobe of the liver. Acta Radiol. 1990;31(2):105-13.
18. Ross MH, Pawlina W. Histology: A text and atlas with correlated cell and molecular biology. 7th ed. Philadelphia: Wolters Kluwer; 2016.
19. Martinez-Hernandez A, Martinez J. The role of capillarization in hepatic failure: studies in carbon tetrachloride-induced cirrhosis. Hepatology. 1991;14(5):864-74. doi:10.1002/hep.1840140514.
20. Simionescu N, Simionescu M. The cardiovascular system. In: Weiss L, editor. Cell and tissue biology. Baltimore: Urban & Schwarzenberg; 1988. p. 355-98.
21. Wisse E, Braet F, Luo D, De Zanger R, Jans D, Crabbe E, et al. Structure and function of sinusoidal lining cells in the liver. Toxicol Pathol. 1996;24(1):100-11. doi:10.1177/019262339602400114.
22. Bhunchet E, Fujieda K. Capillarization and venularization of hepatic sinusoids in porcine serum-induced rat liver fibrosis: a mechanism to maintain liver blood flow. Hepatology. 1993;18(6):1450-8. doi:10.1002/hep.1840180626.
23. Lamers WH, Hilberts A, Furt E, Smith J, Moorman AF. Human sinusoidal drainage occurs exclusively into central veins. Anat Rec. 1999;254(3):1-7.
24. Muktyaz H, Nema U, Suniti RM, Mahboobul H. Anatomical study of accessory sulci of liver and its clinical significance in North Indian population. Int J Med Health Sci. 2013;2(3):224-9.