

# Studying Morphological Variations of the Liver in Human Cadavers and Insight into Their Potential Relevance in Various Clinical, Radiological, and Surgical Settings

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## Abstract

**Background:** The liver, which is mostly found in the right upper quadrant of the abdominal cavity, is an essential organ in humans. It is necessary for the synthesis of bile and clotting factors, metabolic control, and the detoxification of toxic chemicals. Investigating the morphological differences of the liver seen in human cadavers, comprehending their developmental causes, and examining their applicability in clinical, radiological, and surgical settings are the objectives of this work. **Material and Methods:** This investigation used fifty adult human livers. We extracted the livers from cadavers during routine dissections at Abhishek I Mishra Memorial medical college, located at Bhilai, CG. Specimens exhibiting any signs of illness, trauma, or surgical procedures were excluded. The liver specimens were carefully cleaned, preserved in formalin, and examined closely for external morphological traits before examination. We searched for changes in the size and shape of the liver, the position and variation of ligamentous attachments, the number and type of lobes, the presence of accessory lobes, and the presence or absence of fissures. We collected measurements using conventional anthropometric equipment and analyzed the data to determine the frequency and kind of deviations. **Results:** The predominance of certain morphological abnormalities, such as lobation, accessory lobes, fissures, notches, development of caudate and papillary processes, and notched borders, was recorded in our study, which looked at 50 cadaveric liver specimens. The authors of the current study found that 68% of the participants (n=34) had normal lobation, 36% had accessory fissures, 16% had accessory lobes (including Riedel's), 38% had fissures or groves, and 6% had misplaced ligament teres. **Conclusion:** Future research should combine embryological, radiographic, and anatomical data for better precision medicine in hepatic treatments, since anatomical insights are essential for precise radiological interpretation and surgical navigation.

**Keywords:** Liver morphology; detoxification; metabolism; clotting factors; fissures; lobes.

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## INTRODUCTION

The liver, which is mostly found in the right upper quadrant of the abdominal cavity, is an essential organ in humans. It is necessary for the synthesis of bile and clotting factors, metabolic control, and the detoxification of toxic chemicals. According to its arterial and biliary supplies, the liver is normally classified as having four anatomical lobes: right, left, caudate, and quadrate.<sup>[1]</sup> Nonetheless, a variety of morphological differences in the liver, which can be acquired or congenital, have been identified by several investigations and clinical observations.<sup>[2-5]</sup>

The diagnosis of clinical diseases, radiographic interpretations, liver transplantation, and surgical techniques may all be impacted by these anatomical variations. As a result, it is crucial from an academic and therapeutic standpoint to identify and document these variances.

Over ages, our understanding of the liver's anatomy has changed. Based on cadaver dissection, early anatomists like Galen, Vesalius, and subsequently Gray provided a systematic description of the liver.<sup>[6]</sup> However, small changes in the liver's shape could only be systematically discovered

in the living population with the introduction of contemporary imaging tools like computed tomography (CT), magnetic resonance imaging (MRI), and ultrasonography.<sup>[7]</sup>

Finding and categorizing these differences in cadaveric specimens has been the subject of several investigations carried out worldwide, including in India, in recent decades. These studies have provided vital information for clinical practice and anatomical education.<sup>[8]</sup>

Many of the liver's morphological changes can be explained by knowledge of the liver's embryology. Around the third week of intrauterine life, the hepatic diverticulum, a ventral protrusion of

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the foregut endoderm, gives rise to the liver.<sup>[9]</sup> This structure differentiates into hepatoblasts, which create the parenchyma, bile ducts, and vascular structures, as it multiplies and interacts with the septum transversum mesenchyme.<sup>[10]</sup>

A variety of morphological abnormalities can result from differences in the hepatic diverticulum's partitioning, the vitelline veins' vascularization, and the bile ducts' development. These might include profound fissures, lobe fusion or disappearance, auxiliary lobes, and changes in the location and attachment of ligaments. Therefore, the purpose of this study is to examine the morphological differences of the liver seen in human cadavers, comprehend their developmental causes, and consider their applicability in radiological, surgical, and clinical settings.

**MATERIALS AND METHODS**

This study was conducted on 50 adult human livers obtained from cadavers during routine dissections in Abhishek I Mishra Memorial Medical College, Bhilai (CG), Specimens showing signs of trauma, pathology, or surgical alterations were excluded. After being washed and stored in formalin, the liver specimens were closely inspected for outward morphological characteristics.

**The following metrics were noted:**

- Number and type of lobes
- Presence of accessory lobes



- Presence and depth of fissures



- Shape and size of the liver



- Position and variations of ligamentous attachments

Standard anthropometric instruments were used to record measurements, and the frequency and kinds of changes were ascertained by analyzing the data.

**RESULTS**

The predominance of certain morphological abnormalities, such as lobation, accessory lobes, fissures, notches, development of caudate and papillary processes, and notched borders, was recorded in our study, which looked at 50 cadaveric liver specimens. The authors of the current study found that 68% of the participants (n=34) had normal lobation, 36% had accessory fissures, 16% had accessory lobes (including Riedel's), 38% had fissures or groves, and 6% had misplaced ligament teres.

**Table 1: Observed Morphological Variations in Human Liver (n = 50 specimens)**

Morphological Feature	Variation	Number of Specimens (n)	Percentage (%)
Lobation	Normal (4 lobes)	34	68%
	Left lobe hypertrophy	12	24%
	Right lobe hypoplasia	4	8%
Shape of Right Lobe	Wedge-shaped	26	52%
	Quadrilateral	14	28%
	Irregular/Elongated	10	20%
Accessory Lobes	Present	4	8%
	Riedel's lobe	4	8%
Fissures and Grooves	Accessory fissures	16	32%
	Prominent sagittal groove	3	6%
	Oblique/transverse grooves	2	4%
Notched Borders	Single notch	6	12%
	Multiple notches	2	4%
	Absent	42	84%
Caudate Process	Well developed	10	20%

	Poorly developed/absent	42	84%
Papillary Process	Prominent	6	12%
	Rudimentary	16	32%
	Absent	28	56%
Ligamentum Teres Position	Normal	47	94%
	Laterally displaced	3	6%

## DISCUSSION

Our discovery that 32% of specimens had supplementary fissures is consistent with a broad range of occurrence worldwide. These fissures are important landmarks, including the Rouviere's sulcus in 65.6% of instances, according to a thorough cadaveric investigation that included 93 livers and revealed a prevalence of 51.6%.<sup>[11]</sup> There have been reports of accessory fissure rates ranging from 20% to 60% in North Indian populations. 37.1% of the livers in one Indian cadaver series (n=35) had accessory fissures. It is important to differentiate these deep fissures since they can appear on imaging as cysts or trauma.<sup>[11]</sup>

In 16% of the specimens, we discovered accessory lobes, including Riedel's lobe in 8%. This is consistent with a large cadaveric analysis that found an auxiliary lobe prevalence of 27.9%.<sup>[11]</sup> According to American data, the prevalence of auxiliary lobes is around 24%, but Indian research found them in 12–16% of cadavers.<sup>[2]</sup> Despite being clinically benign, Riedel's lobe may be misdiagnosed as an abdominal tumor or hepatomegaly during ultrasonography or surgery. Overall, 16% of specimens had visible notches, with 12% having single notches and 4% having multiple notches. Twenty-eight percent of the 48 livers in a Nepali cadaveric research had inferior-border notches.<sup>[12]</sup> These notches act as useful anatomical markers and may influence the surgical isolation of liver segments.

Twenty percent of the specimens had significant caudate processes, while twelve percent had prominent papillary processes. One research in North India (n=70) identified hypertrophied processes in 21.8% of specimens, while another observed larger papillary and caudate processes in 4.3% and 1.4% of specimens, respectively.<sup>[13]</sup> Furthermore, caudate lobe morphologies were categorized as piriform (59.7%), irregular (26%), and rectangular (14.3%) based on CT-based in vivo data from 196 patients; caudate processes were evident in 92.9% of cases and papillary processes were missing in 87.2% of cases.<sup>[14]</sup> Decomposition, fixation, or methodological variations might be the cause of the disparity between cadaveric and radiologic results.

According to our data, right lobes are primarily wedge-shaped (52%), followed by quadrilateral (28%), and irregular (20%) shapes. Although there are few exact comparable data, research,<sup>[15]</sup> found that 20% of our specimens had underlying diaphragmatic grooves, which were probably caused by diaphragm impingement. These morphological changes of the right lobe frequently mirror these grooves. To avoid misclassifying diaphragmatic grooves as traumatic fissures or pathological indents, it is essential to comprehend these differences.

Our results are similar to those of a Nepalese research (2021) that examined 32 cadaveric livers and found accessory fissures in 56.3% and lobes in 12.5%.<sup>[11]</sup> According to a

study,<sup>[4]</sup> enlarged papillary processes were seen in 11.4% of cases, accessory fissures in 32.9%, and liver surface abnormalities in 45.7% of cases.<sup>[4]</sup> According to Indian research (2020), out of 35 specimens, 37.1% had accessory fissures, 11.4% had left-lobe lingular processes, and 25.7% had accessory lobes. Another research highlighted the significance of morphological abnormalities in imaging and surgery by connecting them to embryological development.<sup>[17]</sup>

On CT/MRI and ultrasound, accessory fissures and lobes may appear as tumors, cysts, or traumatic lesions. Avoiding incorrect diagnosis is made easier by knowing their independent prevalence (20–56%). In order to prevent confounding features like Rouviere's sulcus, it is crucial to recognize diaphragmatic grooves, caudate processes, and notches during procedures such as laparoscopic cholecystectomy.<sup>[16]</sup> In segmental liver resections, variations in lobation and shape affect the surgical margins. Strategies for excision or transplantation may be complicated by underdeveloped lobes or abnormalities in papillary/caudate processes.

Early embryonic processes in vitelline vein formation and hepatic diverticulum partitioning may give rise to morphological variations. According to research,<sup>[17]</sup> disturbances in these processes are probably the cause of congenital hypoplastic lobes, accessory lobes, and varied processes.

### Study Strengths & Limitations

**Strengths:** The current study thoroughly examined several exterior liver differences, including lobes, fissures, notches, and processes. Additionally, it has shown a direct anatomical link with results from imaging and cadaveric investigations conducted throughout South Asia.

**Limitations:** The current authors conclude that tissue collapse or fixation artifacts may cause cadaver-based results to deviate from imaging findings. Future research should consider the sample size (n=50), which restricts geographical generalizability and lacks in vivo radiologic correlation (CT/MRI).

## CONCLUSION

For precise radiological interpretation and surgical navigation, these anatomical insights are essential. During preoperative planning and intraoperative procedures, radiologists and surgeons should regularly take these variances into account. Anatomical, radiographic, and embryological data integration should be the goal of future studies in order to improve precision medicine techniques for hepatic therapies.

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### Conflicts of interest

There are no conflicts of interest.

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