Normal and anatomical variations of the liver correlating with their clinical implications

Rajani Singh, Sanket Dadarao Hiware

The liver (Liv) is the largest gland of the human body with features of right and left hepatic lobes along with caudate and quadrate lobes. In normal situation, the Liver does not contain any indentation or crater. Moreover, very often it is subjected to developmental anomalies like presence of extra or multiples lobes, presence of multiple fissures in addition to normal fissures, reidels lobe. But the Liver may have different shapes, varied number of fissures, non-development, degeneration, underdevelopment, presence of extra lobes and fissures and oversize of lobe. These anomalies may involve right and left hepatic lobes, caudate and quadrate lobes. The anomalies of the Liver present with variable incidences but are very important as these may lead to misinterpretation of radiographs and also mimic pathology leading to misdiagnosis and mismanagement of hepatic diseases. Hence chapter assumes importance for hepatic surgeons and interventional radiologists. The aim of the chapter is to throw light on the normal and variations of hepatic tissue, correlating with clinical significance so that the Liver disorders may be managed with minimum complications. The literature was scrutinized using online data bases such as google scholar, research gate, pubmed, pubmed central, medline, scielo and cross reference. Text books of Anatomy were also consulted. The literature was compiled, interpreted and presented as chapter.

Keywords: *Liver, gland, caudate lobe, quadrate lobe, variations, hepatic tissue*

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Introduction

Liver is the largest endocrine gland of the human body occupying right hypochondrium, major part of epigastrium and minor part of left hypochondrium (Standring, 2021). The main function of the liver (Liv) is secretion of bile and responsible for various other functions such as excretion of harmful chemicals,

protection and storage of glycogen, ferritin and fat-soluble vitamins (Chaurasia, 2015). The shape of the Liv is like a pyramid with four sides. The Liv is characterized by presence of five surfaces namely anterior, posterior, superior, inferior and right. As borders are concerned, only the caudal border is prominent with features of two notches, one housing the ligamentum teres (LiT) and another one for accommodating fundus of the gallbladder (Chaurasia, 2015). Deviations from the standard hepatic description is often observed. These deviations may be present since birth or may develop during life. These deviations may be in form of different shapes, varied number of fissures, non-development, agenesis, degeneration, underdevelopment, presence of extra lobes and fissures and oversize of lobes (Srimani and Saha, 2020; Singh and Rabi, 2019). Small extra lobes may be confused with the lymph node and inadvertently may be resected leading to untoward consequences (Ravikiran and Ashwini, 2024; Singh and Rabi, 2019). The multiple Liv fissures (indentations) may range from one to multiple (Sunitha Vinnakota and Neelee Jayasree, 2013). Majority of extra indentations vanish with time after birth but many of these may not vanish and remain for entire life (Sambhav et al., 2023). But when these persists, these may be misinterpreted on radiographs as cyst or collection of blood or collection of pus (Joshi et al., 2009; Ravikiran and Ashwini, 2024).

Cancer cells may enter these abnormal indentations imitating lesions in that part of Liv (Chaudhari et al., 2017). In cirrhotic diseases of the Liv, there may degenerations of right lobe of Liv with compensatory increase in size of left side of Liv along with increase in the dimensions of depression for gall bladder present on the inferior surface of the Liv (Sambhav) et al., 2023; Mandeep Gill et al., 2018). It is important to comprehend the variant morphological features of the Liv to avoid misdiagnosis and mismanagement of hepatic diseases and thereby minimize the complications. Hence the study assumes importance. The aim of this chapter is to highlight and provide insights on the variant morphological features of Liv and associate these variant features with clinical implications so as to minimize risk of causing complications. For this chapter, online data bases such as google scholar, research gate, pubmed, pubmed central, medline, scielo and cross reference were used for literature exploration. Text books of Anatomy were also consulted. The literature was compiled, interpreted and presented as chapter.

Variable features in the morphology of the Liver

Anteriorly, the Liv is separated into twin lobes namely right and left lobes by falciform ligament and (Figure 1) posteriorly and inferiorly by LiT and ligamentum venosum respectively (Standring, 2021).

But variations from this traditional configuration have also been observed. The right and left hepatic lobes normally do not possess any crater or gap. But these structures in multiple numbers have also been detected in varying incidences in various studies. In right hepatic lobe, these structures are detected to the extent of seventy-three percent and about thirty percent in left hepatic lobe (Sambhav et al., 2023).

In another study, these hepatic features were found in fifty-one percent and eleven percent respectively on right and left hepatic lobes (Singh and Rabi, 2019). These craters are suggested to be associated with numerous factors like age, excessive fat and co-occurring with enlarged spleen (Sambhav et al., 2023). As per certain authors, the left hepatic lobe may move and imitate the extra spleen or local lesion in the close vicinity of the porta hepatis (PoHe) (Custer and Shafer, 1975). Another hepatic lobe variant described by Beaver has also documented with prevalence of two to thirteen percentages (Mehare et al., 2017; Nagato et al., 2011; Sangeeta et al., 2014). Another study reported these variants as eighteen percent (Sambhav et al., 2023). Another variation of hepatic visceral surface consisting of more profound area for kidney have been

reported with incidences between two to nine percent (Mehare et al., 2017; Nagato et al., 2011; Sangeeta et al., 2014; Sambhav et) al., 2023.

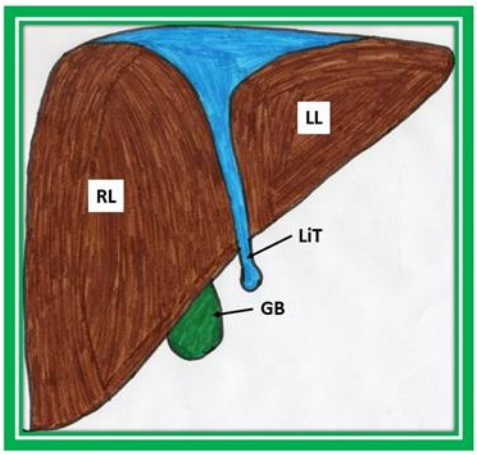

Figure 1. Anterior surface of liver with right and left lobes

RL: right lobe, LL: left lobe, LiT: ligamentum teres

There is another anatomical variation related to Liv named as Reidel's lobe (ReL). The ReL is prolongation and continuation of usual Liv tissue budding from lower border of the right lobe of the Liv. This anomaly reported to occur in range of 1.25% to 2.5% of specimens (Chaudhari et al., 2017; Sambhav et al., 2023). The etiology behind this anomaly is abnormal development of tissue which forms Liv culminating into extra lobes in relation to Liv tissue (Sambhav et al., 2023). It is suggested that age, abnormal bone formation along with inflammation of peritoneum and inflammation in pelvic region may lead to alterations in Liv tissue (Kudo, 2000).

The diaphragm forms impression on the antero-superior surface of the Liv. On this surface varying number of indentation known as diaphragmatic indentation have been reported with incidences of forty to eight percent (Chaudhari et al., 2017; Macchi et al., 2003; Sambhav et al., 2023). Majority of these indentations are formed during the life of the individuals and are attributed to lung diseases particular obstructive type (Covanţev, 2013). Some authors are of view that these Liv anomalies in vulnerable areas of parenchyma of Liv are mostly formed by the pressure created by overlying diaphragm and not due to pressure by increased size of muscles (Macchi et al., 2003).

In younger individuals, compression applied by diaphragm may hinder the normal growth of Liv tissue but in adults, pathological alterations may augment the action of diaphragm in febrile area of Liv (Macchi et al., 2003). But from clinical point, these indentations may have beneficial effect on portal fissures foretelling the route of the veins of the Liv and its tributaries.

Besides, these acts as markers of anatomy of Liv tissue in relations to its arteries and veins (Macchi et al., 2003). The anomalous development of right Liv lobe may be attributed to increased pressure in portal vein and at the same time these development anomalies involving left Liv lobe may cause volvulus of alimentary tract (Daver et al., 2005).

Caudate lobe (Figure 2)

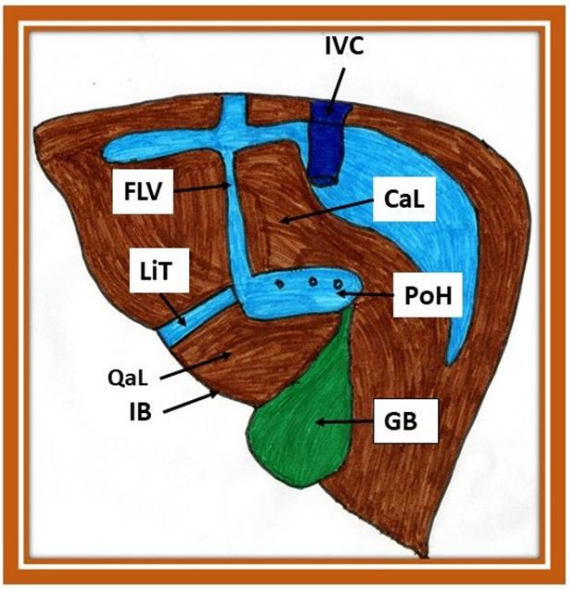

Figure 2. Posterior surface of liver with caudate and quadrate lobes

CaL: caudate lobe, PoH: porta hepatis, IVC: inferior vena cava, FLV: fissure for ligamentum venosum, QaL: quadrate lobe, LiT: ligamentum teres, IB: inferior border of the liver, GB: gall bladder

The caudate lobe (CaL) located on the posterior surface, is bounded by groove for inferior vena cava, PoHe and fissure for ligamentum venosum (Standring, 2021). This lobe may vary in the shape and in number of fissures.

In standard conditions, the CaL has rectangle shape but other shapes such as pear shape, inverted pear shape have also been reported (Sambhav et al., 2023). These authors detected above mentioned shapes with incidences of forty percent, thirteen percent and ten percent respectively. Majority of authors observed rectangle shape of the CaL in their studies with range of 48% -94.5%. Extended CaL was found in eight percent (Sambhav et al., 2023) and in three percent of individuals (Arora and Srivastava, 2016). Larger size of the CaL of the Liv is indication of cirrhotic diseases of the Liv (Lafortune et al., 1998). Applied anatomy of the CaL is very important for clinicians (Abdalla et al., 2002).

Another important structure on posterior surface of Liv is the presence of papillary process (PaP). This process was found in 46.25% (Reddy et al., 2017) and in 32.5% (Sambhav et al., 2023). But very eminent PaP was observed in nineteen percent of cases (Reddy et al., 2017) and 17.5% of individuals (Sambhav et al., 2023). The PaP was found to be absent in all Liv specimens observed (Chavan and Wabale, 2014) while in another study it was absent in eight percent of cases (Sambhav et al., 2023).

An important feature of posterior surface of Liv is the presence of caudate process (CaP). The pronounced CaP was found in fifteen percent of Liv (Sambhav et al., 2023) and in 9% of Liv (Sarla et al., 2015). Yet in another study, the CaP was observed in all specimens observed (Reddy et al., 2017). Some authors are of view that PaP may be confused with some Liv disorders in absence of knowledge of variant anatomy of PaP. Sometimes, the PaP may be subjected to local ailment or it may undue increase in size. These conditions of PaP may result in erroneous reading o radiographs (Auh et al., 1984)

Quadrate lobe (Figure 2)

The quadrate lobe (QaL) has got less attention from the investigators as compared to CaL. It may be due to fact that the QaL is affected by disorders less commonly as compared to CaL (Sambhav et al., 2023).

The QaL is located on the inferior surface of the Liv and depression for gallbladder, PoHe, fissure for LiT and inferior hepatic border forms its boundaries (Chaurasia, 2015). Conventionally, the QaL is rectangular in shape but other shapes like quadrangle, triangle are also cited besides rectangle shape. Few authors found quadrangle shape of QaL in 85% of specimens (Reddy et al., 2017) while others found this shape in 25% of cases (Sambhav et al., 2023). Least common shape of the QaL was observed was rectangle in fifteen percent of specimens (Sambhav et al., 2023) and in ten percent of individuals (Reddy et al., 2017). In addition to these shapes, triangle shape of the QaL was detected in 17.5% cases (Sambhav et al., 2023).

Pons hepatis (PHe) is another variation observed on the visceral hepatic surface of the Liv. The PHe is a hepatic tissue forming bridge over the fissure for LiT. Its incidence ranges between 1-30% with minimum incidence of one percent reported by Chaudhari et al., 2017 and maximum incidence of thirty percent reported by Joshi et al., 2009. The variable incidences of PHe are also documented in literature (Singh and Rabi, 2018; Patil et al., 2014). The presence of the PHe may hide the fissure for LiT mimicking pathology and also may distort the measurements of the two Liv lobes (Sambhav et al., 2023). In some studies, the QaL was found to be absent in 2.5% of Liv (Sambhav et al., 2023) and in four percent of specimens (Joshi et al., 2009). A tiny, undersized and missing QaL may cause misinterpretations of imagery creating misdiagnosis as depression in which gallbladder lies will directly approximate the fissure for LiT (Sambhav et al., 2023). An extra lobe if present in relation to QaL may cause twisting producing intense abdominal symptoms and signs (Chin et al., 2018). The possible explanation for development of extra lobes may be displacement of early hepatic tissue or it may be due to persistence of various partitions during development of Liv (Stattaus et al., 2008). The QaL is found to undergo wasting in cirrhotic hepatic diseases and may be due to diminished blood supply to the QaL (Lafortune et al., 1998).

Rarely, the fissure for LiT may be absent (Chaudhari et al., 2017; Patil et al., 2014; Nayak et al., 2013; Muktyaz et al., 2013).

Accessory fissures

The accessory fissures (indentations) are common finding and may be present in right hepatic lobe, left hepatic lobe, in CaL or in QaL. In one study, the extra indentations were observed to the extent of eighty percent of individuals. In this study, the extra indentations were detected in 57.5% of CaLs, in 17.5% of QaLs with maximum of 72.5% in right Liv lobe and 30% of left Liv lobe (Sambhav et al., 2023). The extra hepatic indentations in CaL were observed with variable frequency by different authors (Singh and Rabi, 2019; Chaudhari et al., 2017; Sambhav et al., 2023). But there is single study depicting the presence of extra lobes in QaL (Sambhav et al., 2023). The extra indentations are documented to occur more frequently in right Liv lobe (Singh and Rabi, 2019; Joshi et al., 2009). As orientation is concerned, these extra indentations in hepatic tissue may be vertical, transverse or oblique. The extra indentations with vertical orientation were found with maximum incidence of 71.4% in CaL (Sambhav et al., 2023) and in the range of 30-35% in another study (Reddy et al., 2017). Remaining indentations in the Liv were transverse and oblique types in these studies. In one study performed in 2017, indentation in CaL were found in 43.75% of individuals (Reddy et al., 2017). Out of these total fissures in CaL, perpendicular indentations were present to the extent of 35% while

incidence of horizontal indentations were 2.5%. Few authors are of view that majority of sulcus in right Liv lobe are oriented with hepatic segments. However, other scientists are of opinion that these indentations are regions of fragile areas in the Liv as validated by imagery and corrosion studies (Covanţev, 2013). There is a common consensus that incidence of extra hepatic indentation is more as compared to that of extra lobes in Liv. The extra indentations in the Liv may be associated with disorders of the Liv and may be linked with medical conditions such as hernia of the diaphragm, increase blood pressure in portal vein and volvulus of gut (Covanţev, 2013). These hepatic indentations may also be confused with wounded and injured hepatic tissue in individuals with traumatic injury of the abdomen (Yadav and Deka, 2008). The right lobe of the Liv may be featured by presence of sulcus for vessels. The prevalence of such indentations lies between 4.7% - 27.3% (Srimani and Saha, 2020; Swathi, 2020). The occurrences of such indentations in right hepatic lobe in recent study was found to be twenty percent (Sambhav et al., 2023). These indentations have immense clinical significance during resecting gallbladder using laparoscopic technique and also during resecting hepatic segments as these are used in identifying hepatic pedicles involving biliary tract (Srimani and Saha, 2020; Joshi et al., 2009). However, these indentations may be source of mistakes during diagnosis by imagery (Sambhav et al., 2023). Though these sulci may be of tremendous use during resecting hepatic segments yet when fluid enters these spaces, these may be confused with hepatic vesicle, pus or blood filled sac or hepatic nodules (Singh and Rabi, 2019). The clinicians may consider the cancer cells implanted in the peritoneum as local lesions in the Liv (Joshi et al., 2009).

Accessory notches

The inferior border of the Liv is characterized by single notch named as cystic notch housing the fundus of the gall bladder (Chaurasia, 2015). In a study conducted in 2023, multiple notches were detected in thirteen percent of individuals but in another study the occurrence of multiple notches were observed in ten percent of Liv specimens (Singh and Rabi, 2019).

Conclusion

Liver is the largest digestive glands occupying mainly right hypochondrium. Very often it is subjected to developmental anomalies like presence of extra or multiples lobes, presence of multiple fissures in addition to normal fissures, reidels lobe. These anomalies may involve right and left hepatic lobes, CaL and Qa lobes. These anomalies present with variable incidences but are very important as these may lead to misinterpretation of radiographs and also mimic pathology leading to misdiagnosis and mismanagement of hepatic diseases.

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