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Postnatal Gross Anatomical Development of Liver in Guinea Pigs (*Cavia porcellus*)

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ABSTRACT

The present study was undertaken to access the gross anatomy of the liver in guinea pigs of four postnatal age groups. Hepatopancreatic organs were collected from the guinea pigs received from department of Laboratory Animal Medicine, Chennai. Gross anatomical observations were recorded. The liver in guinea pig was the largest gland in the body and was found on the right side of the cranial and middle part of the abdominal cavity. The liver was related to the gall bladder, diaphragm, stomach, intestines and lesser omentum in all the postnatal groups studied. In preweaning guinea pig, the colour was dark reddish brown whereas in animals from 2-8 weeks to 16-32 weeks of age, it was pale, reddish brown. The liver showed six lobes namely the right lateral lobe, the right medial lobe, quadrate lobe, left medial lobe, left lateral lobe and caudate lobe. The caudate lobe had two parts namely caudate process and papillary process. In all the age groups, the liver showed two surfaces namely parietal and visceral surface. The hilus or portal fissure of the liver was noticed in the transverse groove formed between the dorsal and ventral parts on the visceral surface. Four borders were observed *viz*., dorsal border, ventral border, right border and left border. The liver showed six ligaments namely falciform ligament, coronary ligament, round ligament, triangular ligament, hepatorenal ligament and hepatogastric ligament.

HIGHLIGHTS

- The liver of preweaning guinea pig was found in the cranial part of the abdomical cavity but in adult on the right side of the cranial and middle abdomen.
- The liver showed six lobes, two surfaces, four borders and six ligaments.
- Hilus was found in the transverse groove between the dorsal and ventral parts on the visceral surface.

Keywords: Development, Gross anatomy, Guinea pigs, Liver

Guinea pigs are large rodents and best experimental animals for physiological, pharmacological, clinical and anatomical research because of their large body weight, stout, compact body, easiness of handling and rapid adaptation in laboratory situation (Rowlands and Weir, 1974). The liver is a critical organ in the vertebrates. It performs many functions which supports metabolism, immunity, digestion, detoxification, vitamin storage etc. Liver also interacts with the endocrine and gastrointestinal system and helps in digestion. The liver is the storage organ for fat soluble vitamins, iron and copper. It also produces clotting factor and helps in protein synthesis. Kupffer cells and pit cells play an essential role in immunologic system (Kalra and Tuma, 2020).

The understanding of the anatomical variation and embryology of rodent liver is essential to avoid any critical

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complications while performing experimental surgery on these organs. To evaluate the pathologic and clinical reactions, it is essential to understand the normal structure of the organ. Hence, a thorough knowledge on the gross anatomy of the liver is necessary for the proper diagnosis and treatment of ailments. The experimental animals like guinea pigs, mouse, rats, pigs and monkeys play an important role in human medicine, since the anatomical structure of the organs of experimental animals is similar to anatomical structure of the organs of humans (Al-Sharoot, 2014). Since, there is paucity of literature in the structure of hepatopancreatic organ of guinea pig, the present research work is carried out with the following objective to study the gross anatomy of the liver in postnatal age groups of guinea pig.

MATERIALS AND METHODS

The gross anatomy of the hepatopancreatic organ of guinea pig from postnatal age groups (Table 1) was conducted at the Department of Veterinary Anatomy, Madras Veterinary College, Chennai-7. Guinea pigs were procured from the Department of Laboratory Animal Medicine, Madhavaram Milk Colony, TANUVAS, Chennai-51. After collection of the guinea pigs, they were euthanized as per the standard operating procedure by using the Carbon dioxide asphyxiations as per CPCSEA norms and they were subjected for the dissection.

After careful dissection of the animals, hepatopancreatic organ namely liver, gall bladder and pancreas were dissected out and gross anatomical observations and morphometrical measurements namely length, width, thickness, weight and volume of the liver, gall bladder and pancreas were recorded in all the postnatal age groups.

Ethics Statement

The animal ethical committee of the Madras Veterinary College, Tamilnadu Veterinary and Animal Sciences University, Chennai, India had approved the collection of laboratory animals and handling as per the Ethical Committee approval (Lr. No. 1467/DFAB/IAEC/2018 dated 13.07.2018). The methods were performed in accordance with the guidelines of the institutional ethical committee of TANUVAS, India. All procedures were performed in accordance with the CPCSEA norms.

RESULTS AND DISCUSSION

Topography

The liver in guinea pig was the largest gland in the body and was found on the right side of the cranial and middle part of the abdominal cavity (Fig. 2). Similar results were recorded in rabbit (Hristov *et al.,*2006), nutria (Perez and Lima, 2007), human (Sherif *et al.*, 2010), coot birds (Selman, 2013),Starling bird (Faraj and Al-Bairuty, 2016) and guinea pig, rat, rabbit and chinchilla (Stan, 2018).In contrast to this observation, Ibrahim *et al.* (2016) stated that the liver of birds was located in both right and left hepatoperitoneal cavity. In pre-weaning guinea pig, the liver was located on the entire cranial part of the abdominal cavity (Fig. 1) as reported by Faraj (2018) in the liver of adult marsh harrier birds. The liver was covered by last four ribs and had little costal impression on the diaphragmatic surface of the liver in the 12 week-old and 24 week-old guinea pigs. Similar findings were observed by Gupta *et al.* (2017) in rabbit liver. The half of the mass of the liver was located in the intrathoracic part of the abdominal cavity. The liver was related to the gall bladder, diaphragm, stomach, intestines and lesser omentum in all the postnatal groups studied (Fig. 2). But in birds, it was related to the gastrointestinal tract, heart and lung (Hunigen *et al.*, 2016). Moslem (2015) stated that it was related to heart, gizzard, sternum, oesophagus and proventriculus in ostrich and Khaleel *et al.* (2017) in gull and mallard duck found that the liver was related to

Table 1: Details of age groups of guinea pigs used for research work

Age groups	Preweaning 0-2 weeks (Male + Female)	Weaning 2-8 weeks (Male + Female)	Young one 8-16 weeks (Male + Female)	Adult 16-32 weeks (Male + Female	Total
No. of animals	3+3	3+3	3+3	3+3	24

the spleen, gizzard and heart. Caudate lobe of the liver was related to the right kidney (Fig. 7).

Physical Characters

In preweaning guinea pig (three days of age), the colour of the liver was dark reddish brown (Fig. 1) whereas in adult animals from 2-8 weeks to 16-32 weeks of age, it was pale, reddish brown in colour (Fig. 2). The liver was soft to touch and had compact appearance in all the postnatal group of animals studied. It was curved and adapted to the abdominal face of diaphragm (Fig. 3).

Fig. 1: Photograph of the liver in 10 day-old guinea pig showing its location in the entire cranial surface of the abdomen **(L** – Liver **GB** – Gall bladder)

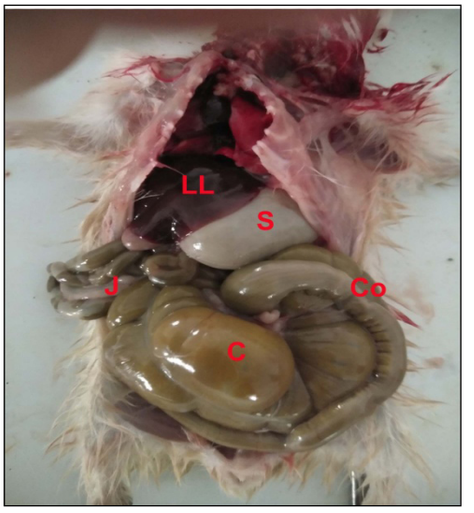

Fig. 2: Photograph showing the topography of the liver of 10 week-old guinea pig with its relation to other organs

LL – Left lateral lobe; **S** – Stomach; **J** – Jejunum; **C** – Caecum; **Co** - Colon

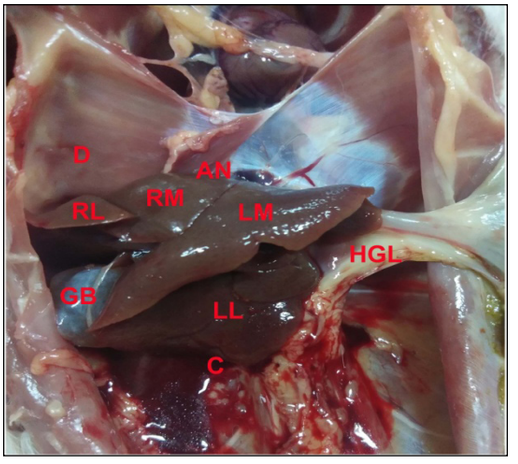

Fig. 3: Photograph of the liver in 8 week-old guinea pig showing its adaptation to the abdominal face of diaphragm

LL – Left Lateral lobe; **D** – Daiphragam; **AN** – Area nuda; **LM** – Left medial lobe; **RM** – Right medial lobe; **RL** – Right lateral lobe; **C** – Caudate lobe; **GB** – Gall bladder; **HGL –** Hepatogastric ligament

Lobation

The liver of the guinea pig showed six lobes namely the right lateral lobe, the right medial lobe, quadrate lobe, left medial lobe, left lateral lobe and caudate lobe in all the groups studied (Fig. 4). In contrast to this, two lobes was observed in avian liver (Getty, 1975), in coot birds (Selman, 2013), in male turkey(Al-A'Araji, 2015), in brown falcon (Al-taee, 2017), in gull and mallard duck (Khaleel *et al.*, 2017), in quail (Sarvestani, 2017), four lobes in ostrich liver (Moslem, 2015) three lobes in rat liver (Hebel and Stromberg, 1986), four lobes in praire dog (Grace *et al.*, 1988), five lobes in Muridae and Dipodidae families of rodent (El-Salkh *et al.*, 2008), five lobes in adult rabbit (Stamatova *et al.,* 2012 and Verma *et al.,* 2015), five lobes in rabbit (Stan, 2018). Similar observations regarding the number of lobes were found in adult guinea pig (Stan, 2018). The left lateral lobe was the largest and was found visible on both visceral and parietal surface in all the postnatal ages studied. Similar results were observed by Hebel and Stromberg (1986) in rat liver, Grace *et al.* (1988) in praire dog and Stan (2018) in guinea pig. But Al-taee (2017) in brown falcon, Khaleel *et al.* (2017) in gull and mallard duck and Sarvestani (2017) in quail found that right liver lobe was larger than the left lobe. But in passenger pigeon, left lobe was divided into three parts (Nickel *et al.*, 1979). It was found on the left most part of the abdominal cavity and related to diaphragm, stomach and left body wall. On the parietal surface, it was covered to some extent by left medial lobe. The left medial lobe was observed to be medial to the left lateral lobe and was also visible on both the surfaces of the liver. The quadrate lobe was found medial to the left medial lobe. It was visible to some extent on the parietal surface but clearly visible on the visceral surface (Fig. 4). Similar findings were observed by Stan (2018) in rabbit. It was related to the gall bladder, portal fissure, round ligament and quadrate lobe, intestines and lesser omentum (Fig. 2). Dorsal to the portal fissure, attachment of the caudate lobe was identified in all the age groups studied.

The right medial lobe was noticed medial to the left medial and quadrate lobe and was separated from the left lobe by falciform ligament (Fig. 5) in all the postnatal ages of guinea pigs studied. The right medial lobe was visible on both the surfaces of the liver. It was related to the gall bladder, intestines and lesser omentum on the visceral surface (Fig. 6). The right lateral lobe was found on the extreme right side of the abdominal cavity and was visible on both the surfaces. It was found related to the right body wall and diaphragm. The visceral surface was related to the ligaments and intestines. The visceral surface showed a groove for the posterior vena cava and was seen in all the postnatal age groups of animals studied. The ventral border of the right lateral lobe had caudate lobe (Fig. 7).

The caudate lobe had two parts namely caudate process and papillary process in all the postnatal ages of guinea pigs. Stamatova *et al.*(2012) and Verma *et al.* (2015) in adult rabbit, Stan (2018) in rabbit and guinea pig observed similar findings whereas caudate lobe in praire dog was divided into anterior and posterior lobule (Grace *et al.*, 1988) and in rats, it was divided into dorsal and ventral lobe (Stan, 2018) but in the present study undivided caudate lobe was found. The caudate process was well developed with renal impression of the right kidney. Similar findings were recorded by Stan (2018) in rabbit and guinea pig. The papillary processes were two in number and triangular in shape (Fig. 4). They were in contact with the lesser curvature of the stomach. The visceral surface of the caudate and left lateral lobe had small notches.

Surfaces

In all the age groups, the liver showed two surfaces namely parietal and visceral surface. Similar findings were recorded by Perez and Lima (2007) in nutria liver, Stamatova *et al.* (2012), Verma *et al.* (2015), Gupta *et al.* (2017) in rabbits, Stan (2018) in rat, rabbit, guinea pig and chinchilla. The parietal surface was convex, smooth and adapted to the contour of the abdominal wall. It consisted of four lobes namely left lateral, left medial, right medial and right lateral lobes (Fig. 3) and visceral surface showed six lobes as stated by Stan (2018) in guinea pig. But in chinchilla, the parietal surface of the liver showed three lobes and visceral surface with four lobes (Stan, 2018) which may be due to species difference. Between the left medial and right medial lobe, falciform ligament was found (Fig. 5) and was thin in 10 days of age. The right lateral lobe on its cranial border showed area nuda, in which the liver surface was observed to be in direct contact with the diaphragm without any peritoneal covering (Fig. 8) and was in accordance with the findings of Stan (2018) in rats.

The visceral surface was concave and was found related to the stomach, descending duodenum, pancreas, transverse

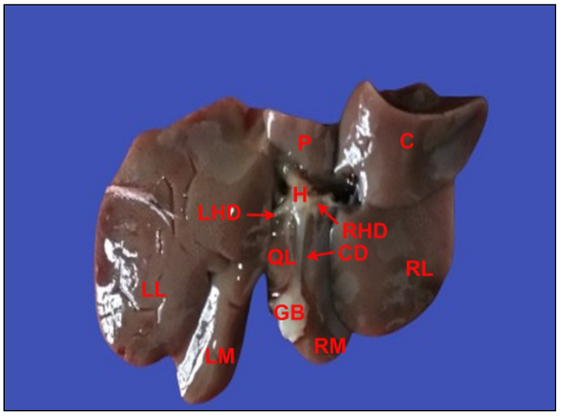

Fig. 4: Photograph of the liver in 12 week-old guinea pig showing its visceral surface with the hilus (H)

LL – Left Lateral lobe; **LM** – Left medial lobe; **RM** – Right medial lobe; **RL** – Right lateral lobe; **C** – Caudate lobe; **QL** – Quadrate lobe; **P** – Papillary process; **GB** – Gall bladder; **CD** – Cystic duct; **LHD** – Left hepatic duct; **RHD** – Right hepatic duct

Fig. 5: Photograph of the liver in 2 week-old guinea pig showing the falciform ligament (arrow)

LL – Left Lateral lobe; **RL** – Right lateral lobe

Fig. 6: Photograph of the liver in 4 week-old guinea pig showing the relationship with stomach (S) and intestine (I)

L – Liver; **K** – Kidney; **Arrow** – Gall bladder

Fig. 7: Photograph of the liver in 10 day-old guinea pig showing the relationship of caudate lobe with right kidney

L – Liver; **K** – Kidney

colon, spleen, right kidney and right adrenal gland (Fig. 7). On the visceral surface of the caudate lobe, renal impression for the right kidney was found in all the postnatal age groups of guinea pigs studied. Similar observations were reported by Perez and Lima (2007) in nutria liver, Stamatova *et al.* (2012), Verma *et al.* (2015), Gupta *et al.* (2017) in rabbits, Stan (2018) in rat, rabbit, guinea pig and chinchilla. On the visceral surface, six lobes were seen which were separated by deep fissures and was less deep in 0-2 weeks of age and became deeper from 2-8 weeks to 16-32 weeks of age. Left lateral, left medial, quadrate, right medial, right lateral and caudate lobes were found with two papillary processes and hilus of

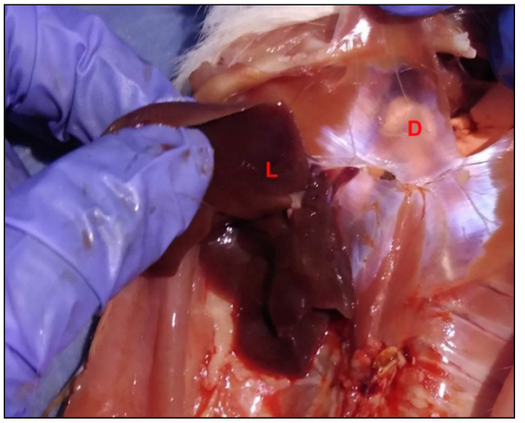

Fig. 8: Photograph of the liver of four week-old guinea pig showing the attachment of the parietal surface of the liver with diaphragm

L – Liver; **D** - Diaphragm

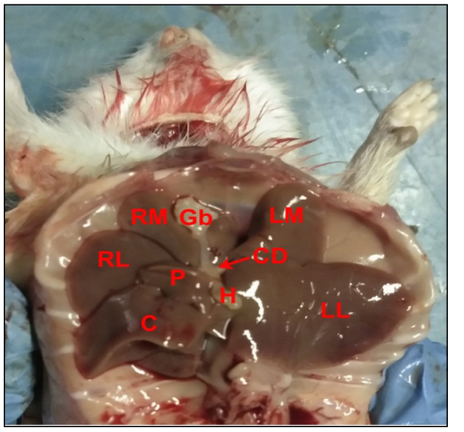

Fig. 9: Photograph of the liver of 28 week-old guinea pig showing the visceral surface with hilus (H)

LL – Left Lateral lobe; **LM** – Left medial lobe; **RM** – Right medial lobe; **RL** – Right lateral lobe; **C** – Caudate lobe; **P** – Papillary process; **Gb** – Gall bladder; **CD** – Cystic duct

the liver found between the two papillary process and the right medial lobe (Fig. 9).

The hilus or portal fissure of the liver was noticed in the transverse groove formed between the dorsal and ventral parts of the liver on the visceral surface (Fig. 4) in all the age groups of guinea pigs of present study. The location of portal fissure in the visceral surface of the liver was as reported by Perez and Lima (2007) in nutria and Stamatova *et al.* (2012) in adult rabbit. Hilus was observed with the hepatic artery and portal vein entered the liver and bile duct emerged. The portal fissure was seen with a common bile duct, hepatic artery and portal vein. The common bile duct was found on the ventral border of right side of the liver. The hepatic artery was found on the left side. The portal vein was found located on the dorsal surface of the bile duct and hepatic artery. Posterior vena cava was found dorsal to the portal vein. The cystic duct was found connecting the common bile duct with the gall bladder (Fig. 4).

In the liver of guinea pig of the all age groups studied, four borders were observed *viz*., dorsal border, ventral border, right border and left border. The dorsal border was rounded and had impression of posterior vena cava and oesophagus and the ventral border was sharp. The ventral border of the left lobe was observed to be related to the stomach, duodenum, pancreas and to some extent left kidney. The ventral border of right lobe was in relation with the proximal colon. The lateral border was sharp and found between the diaphragm and hypochondrium. The medial border of right side showed falciform ligament.

Ligaments

The liver of guinea pig in all the groups studied showed six ligaments namely falciform ligament, coronary ligament, round ligament, triangular ligament, hepatorenal ligament and hepatogastric ligament.

In the present study, the falciform ligament was well developed and noticed as a thin white band connected the parietal surface of liver on the insertion of the medial lobes with the diaphragm at the xiphoid cartilage and the ventral abdominal wall (Fig. 5) in 0-2 weeks of age and was found thicker in the guinea pigs of age groups from 2-8 weeks to 16-32 weeks. Similar results were observed by Perez and Lima (2007) in nutria liver and Stan (2018) in rats and rabbits. It separated the right and left lobes of the liver. The round ligament was found on the free margin of the falciform ligament, which connected with the umbilicus as stated by Sherif *et al.* (2010) in human liver and Stan (2018) in rats whereas Stan (2018) stated that round ligament was absent in rabbits. The falciform ligament divided the left medial lobe from quadrate lobe on the visceral surface.

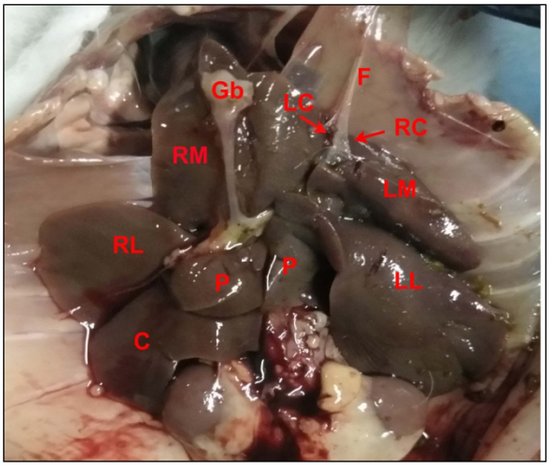

Fig. 10: Photograph of the liver in 12 week-old guinea pig showing the right caudate (RC) and left caudate (LC) ligaments on the visceral surface

LL – Left Lateral lobe; **LM** – Left medial lobe; **RM** – Right medial lobe; **RL** – Right lateral lobe; **C** – Caudate lobe; **P** – Papillary process; **GB** – Gall bladder; **F** – Falciform ligament

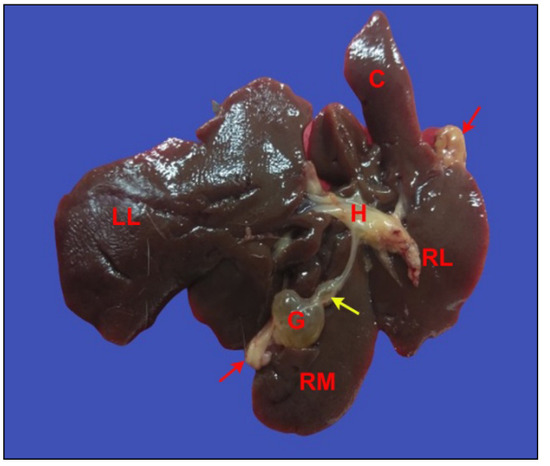

Fig. 11: Photograph of the liver in 28 week-old guinea pig showing the visceral surface with hilus (H)

LL – Left Lateral lobe; **RM** – Right medial lobe; **RL** – Right lateral lobe; **C** – Caudate lobe; **G** – Gall bladder; **Dilatation of cystic duct** (Yellow arrow); **Right and left triangular ligaments** (Red arrow)

The coronary ligament was observed as a direct continuation of falciform ligament on the viseral surface (Fig. 10). The coronary ligaments were two in number namely right and left and were found in the liver of 2-8 weeks old and 16-32 week-old guinea pig and were in accordance with the findings of Sherif *et al.* (2010) in human liver and Stan (2018) in rats. The coronary ligament was not observed in the liver of 0-2 weeks of age and the coronary ligament was not seen as two divisions in the liver of 8-16 weeks of age. The right coronary ligament had upper and lower layer. The upper layer was observed to be connected the dorsal margin of the area nuda to the diaphragm. The lower layer was found below the upper layer and connected the diaphragm with dorsal margin of the liver.

The dorsal border of the liver had two triangular ligaments namely right and left and was observed in the liver of 16-32 weeks of age (Fig. 11) as stated by Sherif *et al.* (2010) in human liver and Stan (2018) in rats and guinea pigs. The right triangular ligament was short. The coronary ligament of the right side was continued as small right triangular ligament. The left triangular ligament was well developed, undivided and connected the dorsal part of the left lateral lobe to the diaphragam whereas Perez and Lima (2007) noted two parts of each left and right triangular ligament in nutria liver.

The hepatorenal ligament was observed on the ventral border of the caudate lobe to the medial aspect of the right kidney and duodenum. Similar findings were observed in nutria liver by Perez and Lima (2007)and in rabbits and guinea pigs liver by Stan (2018). The hepatogastric ligament was found connected the lesser curvature of the stomach with the papillary process as stated by Stamatova *et al.* (2012) in adult rabbit liver and Stan (2018) in guinea pig liver. On the right side, the hepatogastric ligament was continued as hepatoduodenual ligament but was wide in chinchilla as stated by Stan (2018).

CONCLUSION

The liver in guinea pig was the largest gland in the body and was found on the right side of the cranial and middle part of the abdominal cavity. In preweaning guinea pig, the colour of the liver was dark reddish brown but in adult animals it changed to pale, reddish brown in colour. The liver of the guinea pig showed six lobes namely the right lateral lobe, the right medial lobe, quadrate lobe, left medial lobe, left lateral lobe and caudate lobe of which left lateral is the largest lobe. Parietal and visceral surfaces found and the hilus was noticed in the transverse groove formed between the dorsal and ventral parts of the liver

on the visceral surface. The liver showed six ligaments namely falciform ligament, coronary ligament, round ligament, triangular ligament, hepatorenal ligament and hepatogastric ligament.

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