

Cadaveric study of morphology of caudate lobe of the liver in North Indian population

Ruchi Sharma¹, Yogesh Yadav², Pankaj Wadhwa³, Ashish Gautam⁴, Nisha Kaul¹

¹ Santosh Medical college, Ghaziabad, Uttar Pradesh- 201204, India

² Noida International Institute of Medical Sciences, Noida, Uttar Pradesh - 201301, India

³ Department of Pharmaceutical Chemistry, School of Pharmaceutical Sciences, Lovely Professional University, Phagwara, Punjab – 144 411, India

⁴ Yashoda Super Specialty Hospital, Ghaziabad, Uttar Pradesh- 201001, India

SUMMARY

The caudate lobe is a vertically elongated central projection from posterior surface of liver. It is bordered on the right by the groove for the inferior vena cava (IVC), on the left by the fissure for the ligamentum venosum, and on the bottom by the porta hepatis. It is continuous on the superior aspect with the upper part of the right limb of the fissure for the ligamentum venosum. The morphology of the caudate lobe was studied in 100 cadaveric human livers (15-70 years old) stored in 10% formaldehyde, regardless of gender, obtained from the department of anatomy at Santosh Medical College in Ghaziabad. The caudate lobe was observed in a variety of shapes. Vertical fissures extending upward from the lower border of the caudate lobe were seen in 52% of the liver specimens, while accessory caudate fissures extending downward from the upper border were seen in 9% and accessory transverse fissures were seen in 3% cases. Caudate notch was horizontal in 11% of liver specimens. The papillary process was visible in 27% of the liver specimens; a hook shape of the papillary process was seen in one liver

specimen. Caudate process was present in 18% of the cases. Linguiform process was observed in 46% of cadaveric liver specimens.

As observed, the incidences of morphological variations of the caudate lobe are very high, so it is critical for both radiologists and surgeons to keep these variations in mind when making diagnoses and planning surgeries for a favourable clinical outcome.

Key words: Accessory fissure – Caudate lobe – Cadaveric liver – Cadaveric morphology – Vertical fissure – Papillary process – Linguiform process

INTRODUCTION

The fold of peritoneum and ligaments anatomically separate the liver into four lobes (Standring et al., 2005), with the caudate lobe as a left lobe being one of them (Chavan and Wabale, 2014; Sagoo et al., 2018). “Lobus Exiguus” is the first name of the caudate lobe, given by Adrien van den Spiegel in 1622; Glisson renamed it as “Spiegel's lobe” in 1654; and in 1957 it was renamed “segment 1” by Couinaud (Gardner

Corresponding author:

Dr Pankaj Wadhwa. Department of Pharmaceutical Chemistry, School of Pharmaceutical Sciences, Lovely Professional University, Phagwara, Punjab – 144 411, India. E-mail: pankajwadhwa88@gmail.com
Dr Ruchi Sharma. Santosh Medical college, Ghaziabad, Uttar Pradesh- 201204, India. Email: ruchi65sharma@gmail.com. Phone: +91-9968232704

Submitted: April 21, 2022. Accepted: June 14, 2022

<https://doi.org/10.52083/EUZM3304>

et al., 2019). The caudate lobe is a vertically elongated midline projection from the posterior surface of the liver (Sibulesky, 2013). It is bound on the right by the groove for the inferior vena cava (IVC), on the left by the fissure for the ligamentum venosum, on the bottom by the porta hepatis, and on the top by the superior surface of the right upper end of the fissure for the ligamentum venosum (Dodds et al., 1990; Sagoo et al., 2018). The caudate lobe proper and the caudate process are two portions of the caudate lobe that are joined by the caudate isthmus, a thin parenchymal bridge (Gardner et al., 2019; Sarala et al., 2015). The first part is Spiegel's lobe (Couinaud's segment 1) to the left of IVC, and the second part is paracaval portion (caudate process), which extends anterior and to the right of IVC and connects the right lobe (Chavan and Wabale, 2014; Gardner et al., 2019; Sagoo et al., 2018). The papillary process is a small, rounded projection formed by the medial inferior part of the caudate lobe (Joshi et al., 2009). The caudate lobe gets its name from the fact that it frequently produces a tail-like process known as papillary process, rather than because of its caudal location (Sadanandan and Varghese, 2017). It is a distinct part of the liver, with its own vascular and biliary drainage system (Sarala et al., 2015). It has intriguing characteristics, especially in a case of cirrhosis (Sadanandan and Varghese, 2017). The complex anatomy of the caudate lobe makes cross-sectional images difficult to interpret, especially when the papillary process is enlarged or involved in diseases (Auh et al., 1984; Chavan and Wabale, 2014; Sadanandan and Varghese, 2017). The development of the caudate lobe is a complicated process. Both the right and left lobes of the liver give rise to the caudate lobe. Dodds and his colleagues proposed a theory to explain the development of the liver's caudate lobe. According to their findings, as the liver enlarges in the second trimester, the liver and mesentery of the ductus venosus rotate rightward, causing a small portion of the liver, the caudate lobe, to emerge (Dodds et al., 1990). In another study, Joshi et al. (2009) discovered rectangular shape in 58 % of the cases, triangular in 8%, irregular in 20%, a pear shape in 10%, and other shapes (square, heart, inverted flask, etc.) in 4%.

For localised benign tumours of the caudate lobe, lobectomy is the treatment of choice (Xu and Huang, 2010). Safe resection of the caudate lobe is still a challenge for surgeons. Thus, knowledge of the variations in the caudate lobe anatomy aids anatomists and radiologists in better analysing CT, MRI, and other imaging studies to avoid misdiagnosis, as well as surgeons in planning surgeries with favourable clinical outcomes and in diagnostic imaging. The goal of this study is to investigate the morphology of the caudate lobe of the human liver, as well as its variation.

MATERIALS AND METHODS

This study was conducted on 100 formalin fixed human livers (15-70 years) irrespective of sex, obtained from the department of anatomy, Santosh Medical College Ghaziabad.

Inclusion criteria: all cadaveric liver specimen included in this study had normal anatomical features.

Exclusion criteria: liver specimen with diseased and features of damaged, hepatic surgery or tumours were excluded from this study.

The shape, variation in the papillary and caudate processes, the existence of fissures, and the presence and absence of the linguiform process were all investigated in the gross anatomy of the caudate lobe (pons hepaticus). Complete pons hepaticus occurs when the IVC's retrohepatic section is entirely covered from its posterior end. When the pons hepaticus was partially completed, it covered the posterior portion of the IVC's retro hepatic section.

RESULTS AND OBSERVATIONS

In the present study, a total of 100 embalmed specimen of cadaveric human liver were studied. On examining the caudate lobe, it was found that there were no livers with caudate agenesis. The majority of caudate lobes in all livers are rectangular in shape (62%), followed by irregular (18%), pyriform (12%), triangular (3%), dumbbell (3%), horse shoe shape (1%), and like slit 1 (1%) shaped caudate lobes, as mentioned in Table 1.

Table 1. Representing the caudate lobe's shape-based classification.

SHAPE OF CAUDATE LOBE		
TYPE OF SHAPE	NUMBERS OF LIVER SPECIMEN	% AGE OF LIVER SPECIMEN
Rectangular	62	62
Irregular	18	18
Pyriform	12	12
Dumbbell	03	03
Triangular	03	03
Horseshoe	01	01
Slit Like	01	01

In Table 2, the characteristics of the cadavers such as age, sex and weight is also described for selected liver specimens.

The vertical caudate fissure extending upward from the lower border was observed in 62 % of the cadaveric liver specimens (Fig. 1A). The

Table 2. Showing the basic characteristics of the cadavers.

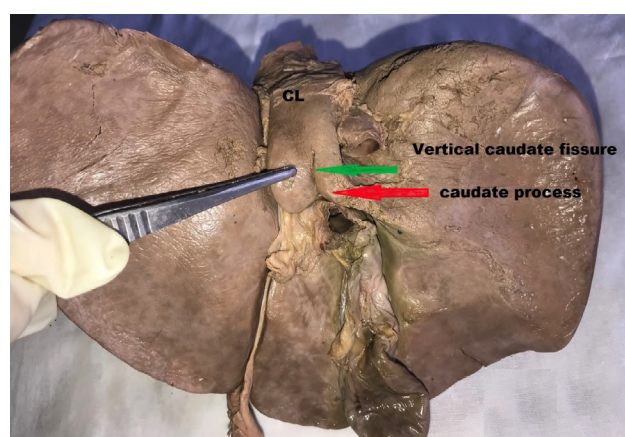
SERIAL NUMBER	AGE (IN YEARS)	SEX (M/F)	WEIGHT(GM)
1.	15	M	1445
2.	23	M	1772
3.	27	M	1680
4.	37	M	1789
5.	37	F	1810
6.	39	M	1867
7.	42	M	1787
8.	44	M	1850
9.	46	M	1759
10.	46	F	1450
11.	47	F	1278
12.	48	M	1800
13.	48	F	1722
14.	49	F	1786
15.	49	M	1789
16.	49	M	1850
17.	50	M	1745
18.	50	F	1590
19.	51	F	1353
20.	51	F	1366
21.	52	M	1484
22.	52	M	1722
23.	52	F	1452
24.	53	F	1588
25.	53	M	1668
26.	53	F	1670
27.	54	M	1737
28.	54	F	1756
29.	55	F	1775
30.	55	F	1637
31.	55	F	1437
32.	56	M	1900

SERIAL NUMBER	AGE (IN YEARS)	SEX (M/F)	WEIGHT(GM)
33.	57	F	1400
34.	57	F	1345
35.	57	F	1436
36.	57	M	1787
37.	57	F	1638
38.	57	M	1735
39.	57	F	1190
40.	58	M	1762
41.	58	M	1236
42.	58	M	1543
43.	58	F	1735
44.	58	F	1647
45.	58	M	1670
46.	58	M	1785
47.	59	M	1788
48.	59	F	1686
49.	59	M	1432
50.	60	M	1690
51.	60	F	1545
52.	60	M	1715
53.	61	M	1566
54.	61	F	1434
55.	62	M	1764
56.	62	F	1544
57.	63	M	1578
58.	63	M	1732
59.	63	M	1460
60.	64	M	1745
61.	64	F	1230
62.	64	F	1373
63.	65	M	1792
64.	65	M	1800
65.	65	F	1158
66.	65	F	1830
67.	65	F	1120
68.	66	F	1710
69.	66	F	1562
70.	66	M	1570
71.	66	F	1563
72.	66	M	1637
73.	66	F	1379
74.	66	M	1784
75.	67	M	1700
76.	67	M	1745
77.	67	F	1690
78.	67	F	1627
79.	67	F	1162
80.	67	M	1763
81.	68	M	1800
82.	68	M	1764
83.	68	F	1672

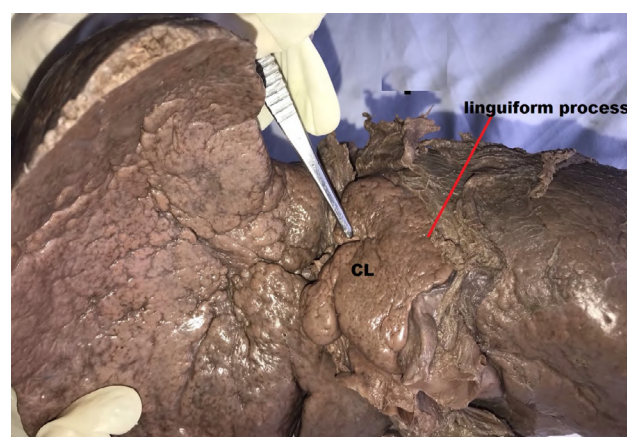
SERIAL NUMBER	AGE (IN YEARS)	SEX (M/F)	WEIGHT(GM)
84.	68	F	1736
85.	68	F	1050
86.	69	M	1675
87.	69	M	1630
88.	69	F	1565
89.	69	M	1530
90.	69	F	1320
91.	69	M	1465
92.	69	M	1647
93.	70	M	1445
94.	70	M	1045
95.	70	M	1257
96.	70	M	1761
97.	70	M	1576
98.	70	M	1645
99.	70	F	1753
100.	70	M	1680

accessory caudate fissure (Fig. 1C), which extends downwards from the upper border, was detected in 9% of liver specimens, as were the accessory transverse fissure (Fig. 1B), which was seen in 3% of liver specimens, and the accessory oblique fissure, which has been seen in 6% liver specimens. At the inferior border of the caudate lobe, 11% of liver specimens had horizontal caudate notches (Fig. 1G). In 15% of cadaveric liver specimens, the accessory fissure was visible between the caudate process and the duodenal impression. There was a link between the vertical inferior fissure in the caudate lobe and the accessory fissure present between the duodenal

impression and the caudate process in 5 of the 15 liver specimens. The papillary process (Figs. 1C and 1H) was prominent and visible in 27% of the livers, with 16 of them being very prominent. In 18% of the cadaveric liver specimens, a prominent caudate process (Figs. 1C and 1H) was also observed. The shape of the papillary process in one specimen is similar to a hook (Fig. 1I), for which there is no existing description and no comparable finding in the literature. As shown in Table 3, pons hepaticus and linguiform process were found in 58% of cadaveric liver specimens, covering the retro-hepatic IVC to varying degrees.

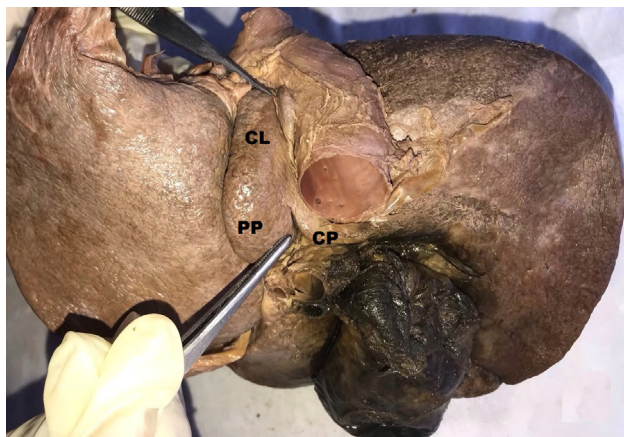


1A: The caudate lobe (CL) is shown in its rectangular shape, with forceps on the papillary process.



1B: Showing irregular shape of caudate lobe; forceps is on accessory transverse fissure on caudate lobe.

Fig. 1.- A-B: Represents the cadaveric morphology of the liver's caudate lobe.



1C: Representing pyriform shape of caudate lobe (CL); Prominent papillary process (PP); Caudate process (CP); Upper forceps is pointing on accessory caudate fissure (vertical) extending downward from upper border of caudate lobe.



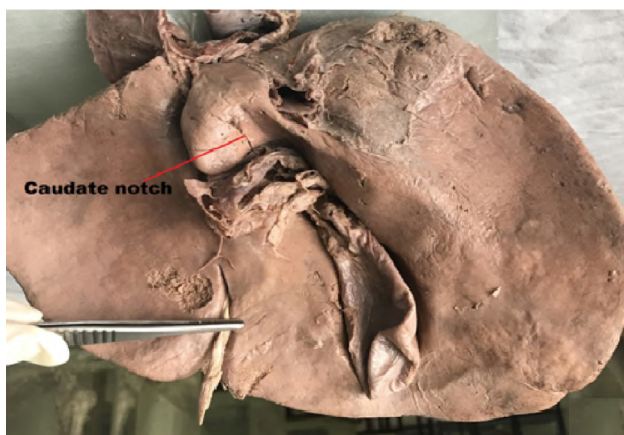
1D: Demonstration of triangular shape of caudate lobe (CL).



1E: Showing horseshoe shape caudate lobe (CL).



1F: Representing forceps on vertical caudate fissure.

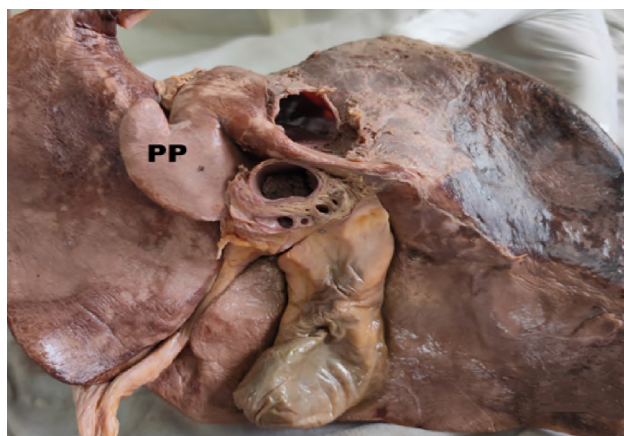


1G: Displaying the caudate notch.



1H: Representing caudate lobe (CL); Papillary process (PP); Caudate process (CP).

Fig. 1.- C-H: Represents the cadaveric morphology of the liver's caudate lobe.



1I: Representing a papillary process with a hook shape (PP).



1J: Here the arrow is on the linguiform process, which covers the retro hepatic IVC, and the forceps is inserted into the IVC.

Fig. 1.- I-J: Represents the cadaveric morphology of the liver's caudate lobe.

Table 3. Representing the caudate lobe's shape-based classification.

PONS HEPATICUS / LINGUIFORM PROCESS	NUMBERS OF LIVERS	% AGE OF LIVER
COMPLETE	16	16
PARTIAL	42	42
ABSENT	42	42

DISCUSSION

According to Sagoo and colleagues, the rectangular shape of the caudate lobe was found in the majority of cases in NWI population livers, and it was the least common in UKC population livers. According to the group, 60 % of NWI people and 80 % of UKC people have a well-developed caudate process (Sagoo et al., 2018). Wabale and his co-workers (Chavan and Wabale, 2014) discovered a notch at the inferior edge of the caudate lobe in 54% of livers. In 21.4% of the livers, Michael and colleagues (Gardner et al., 2019) observed an inferior caudate notch, and 19.6% of the livers had a vertical caudate fissure. Sarala and her colleagues revealed a notch separating the caudate lobe from the caudate process in 31% of livers, and a vertical fissure extending upward from the inferior border in 30% of instances (Sarala et al., 2015). Chavan and his colleagues observed no papillary process in any of their study groups, but many others have reported a 52% prevalence of papillary process in the UKC population (Chavan and Wabale, 2014; Dodds et al., 1990; Gardner et al., 2019; Sagoo

et al., 2018; Sarala et al., 2015; Sibulesky, 2013). In addition, Joshi and co-workers discovered a vertical caudate fissure in 30% of the livers and notching along the inferior border of the caudate lobe in 18% of the livers (Joshi et al., 2009). Auh et al. (1984) also reported variability in the caudate process in a North American study. According to Reddy and his colleagues, rectangular shapes were found in 78.75% of the livers, pear shapes in 16.25%, and other shapes in one or two livers. In 35% of the livers, they discovered a vertical fissure extending upward from the lower border of the caudate lobe (Reddy et al., 2017). They also discovered caudate processes in all of the examined livers, which were of varying thickness. Aside from that, they discovered a prominent papillary process in 46.25 % of the cases; papillary process is very prominent in 18.9 % of the cases (Reddy et al., 2017; Sahni et al., 2000).

There have also been reports of the presence of a caudate notch in 18% of livers and a vertical caudate fissure in 30% of livers (Mamatha et al., 2014; Saxena et al., 2016). Mittal and his researchers (2021) observed that the caudate lobes had

a rectangular shape in the majority of these cases, a pear-shaped caudate lobe with a crack along its superior border in 2% of cases, and a small caudate lobe in 8% of cases. In 8% of the patients, the researchers identified a significant papillary process. Various investigations have also documented the occurrence of rectangular, irregular, pear-shaped dumbbell-shaped livers, triangular livers, and pyriform (Contractor et al., 2019; Mittal et al., 2021; Singh et al., 2017; Syamala et al.,). The presence of an accessory lobe or caudate lobe duplication has also been discovered in various reports (Aktan et al., 2001; Sadanandan and Varghese, 2017). Notches were also found in 50% of the caudate lobe of the liver in patients undergoing hepatectomy, according to Kogure et al. (2000). Several other researchers discovered a hepatic vein in the caudate notch. As a result, the caudate lobe proper can be distinguished from the paracaval portion by using the caudate notch as a landmark, and the presence of an underlying vein can be identified in liver resection surgeries involving the caudate lobe (Gardner et al., 2019; Kogure et al., 2000). Phad and their group members reported notch and fissures separating papillary process from rest of caudate lobe in 2.5% cases. They also observed enlarge papillary process in 5% cases (Phad et al., 2014). A fissure separates the papillary process from the caudate process of the liver, according to Dev et al. (2014). The papillary process's continuity with the caudate lobe and the characteristics of the liver, on the other hand, make it easier to distinguish between the papillary process and extrahepatic paracaval mass (Dev et al., 2014). In the majority of cases, Syamala and colleagues reported papillary process. They recently discovered prominent papillary process in 27% of cases, with papillary process being very prominent in 16% of livers. In one of the caudate lobes of the liver, the shape of the papillary process is hook-like. On imaging, the large papillary process can mimic a mass lesion in the pancreatic head region or enlarge the periportal lymph node, and it can also mimic a pancreatic tumour if it extends to the left and the stomach is displaced to the anterior side (Syamala et al.). In various other reports, hepatocaval shunt performance is also hampered. In the majority of cases, different research groups observed a linguiform process (Chaudhari et al., 2017).

The sound knowledge of normal and variation in anatomy of liver is important. The incidences of morphological variations of the caudate lobe are very high, so it is very important for both radiologist and for surgeons to keep these variations in mind while making diagnosis to avoid any confusion, and in planning surgeries for favourable clinical outcome. In our study, a prominent caudate process was found in 18% of the livers. The presence of the caudate process is important to know in order to avoid diagnostic ambiguity because it can mimic neoplastic disease on cross-sectional imaging. The presence of a well-developed caudate process may obstruct the hanging manoeuvre, which is performed during major liver resection surgeries and involves passing the surgical instrument through the space anterior to the retro-hepatic IVC. During liver resection surgeries, the presence of a linguiform process makes the retro hepatic approach difficult. Due to the linguiform process, which makes IVC repair difficult in trauma patients, surgeries are extremely difficult. The shape of caudate lobe, presence of caudate fissure and notch, presence of linguiform process, prominent papillary process and variable caudate process have been described in detail in the present study, and it is expected that it would help surgeons in hepatobiliary surgeries, liver transplant surgeries, as well as radiologists in proper interpretation of CT and USG.

CONCLUSION

In the current study, rectangular shapes were found in 62 percent of caudate lobes, followed by irregular shapes (18%) and others (20%). However, we found no evidence of an accessory caudate lobe or caudate duplication in our research. We also found a vertical caudate fissure in 52% of the livers, and a horizontal caudate notch in 11% of the cases. The current study found a linguiform process in 58 percent of patients, with varying degrees of involvement of the retro hepatic IVC.

REFERENCES

- AKTAN Z, SAVAS R, PINAR Y, ARSLAN O (2001) Lobe and segment anomalies of the liver. *J Anat Soc India*, 50(1): 15-16.
- AUH YH, ROSEN A, RUBENSTEIN WA, ENGEL IA, WHALEN JP, KAZAM E (1984) CT of the papillary process of the caudate lobe of the liver. *Am J Roentgenol*, 142(3): 535-538.

- CHAUDHARI HJ, RAVAT MK, VANIYA VH, BHEDI AN (2017) Morphological study of human liver and its surgical importance. *J Clin Diagn Res*, 11(6): AC09.
- CHAVAN N, WABALE R (2014) Morphological study of caudate lobe of liver. *Indian J Basic Appl Med Res*, 3(3): 20411.
- CONTRACTOR J, KODIYATAR B, VANIYA V (2019) A morphological study of caudate lobe in human cadaveric liver. *Sch Int J Anat Physiol*, 2: 128-131.
- DEV G, SHARMA R, SHARMA B (2014) Hepatic papillary process - An anatomic variant of liver. *JK Science*, 16(4): 184.
- DODDS WJ, ERICKSON SJ, TAYLOR AJ, LAWSON TL, STEWART ET (1990) Caudate lobe of the liver: anatomy, embryology, and pathology. *Am J Roentgenol*, 154(1): 87-93.
- GARDNER MT, CAWICH SO, ZHENG Y, SHETTY R, GARDNER DE, NARAYNSINGH V, PEARCE NW (2019) Morphology of the caudate lobe of the liver in a Caribbean population. *Italian J Anat Embryol*, 124(3): 364-376.
- JOSHI S, JOSHI S, ATHAVALE S (2009) Some interesting observations on the surface features of the liver and their clinical implications. *Singapore Med J*, 50(7): 715.
- KOGURE K, KUWANO H, FUJIMAKI N, MAKUUCHI M (2000) Relation among portal segmentation, proper hepatic vein, and external notch of the caudate lobe in the human liver. *Ann Surg*, 231(2): 223.
- MAMATHA Y, MURTHY C, PRAKASH B (2014) Study on morphological surface variations in human liver. *Int J Health Sci Res*, 4: 97-102.
- MITTAL A, GOYAL GL, KAMATH VG (2021) Variations in hepatic segmentation on the surface of liver-a cadaveric study. *JK Science: J Med Educ Res*, 23(1): 43-46.
- PHAD VV, SYED S, JOSHI R (2014) Morphological variations of liver. *Int J Health Sci Res*, 4(9): 119-124.
- REDDY N, JOSHI S, MITTAL P, JOSHI S (2017) Morphology of caudate and quadrate lobes of liver. *J Evol Med Dental Sci*, 6(11): 897-902.
- SADANANDAN R, VARGHESE S (2017) Morphology of caudate lobe of liver. *J Evol Med Dental Sci*, 6(90): 6268-6273.
- SAGOO MG, ALAND RC, GOSDEN E (2018) Morphology and morphometry of the caudate lobe of the liver in two populations. *Anat Sci Int*, 93(1): 48-57.
- SAHNI D, JIT I, SODHI L (2000) Gross anatomy of the caudate lobe of the liver. *J Anat Soc India*, 49(2): 123-126.
- SARALA H, JYOTHIKAKSHMI T, SHUBHA R (2015) Morphological variations of caudate lobe of the liver and their clinical implications. *Int J Anat Res*, 3(2): 980-983.
- SAXENA A, AGARWAL KK, JAKHWAL C, SINGH S, DAS AR (2016) Some variable facts of liver: embryological and clinical perspective. *Int J Anat Radiol Surg*, 5(1): 64-67.
- SIBULESKY L (2013) Normal liver anatomy. *Clin Liver Dis*, 2(Suppl 1): S1.
- SINGH R, SINGH K, MAN S (2017) Duplicate caudate lobe of liver with oblique fissure and hypoplastic left lobe of liver. *J Morphol Sci*, 30(4): 309-311.
- STANDRING S, ELLIS H, HEALY J, JOHNSON D, WILLIAMS A, COLLINS P, WIGLEY C (2005) Gray's anatomy: the anatomical basis of clinical practice. *Am J Neuroradiol*, 26(10): 2703.
- SYAMALA G, VEERNALA P, SHRAVYA ECA (2019) Descriptive study of morphological variations of thyroid gland in adult human cadavers in Siddhartha Medical College, Vijayawada. *J Dental Med Sci*, 18(8): 44-47.
- XU L-N, HUANG Z-Q (2010) Resection of hepatic caudate lobe hemangioma: experience with 11 patients. *Hepatobil Pancreatic Dis Int: HBPD INT*, 9(5): 487-491.