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A Cadaveric Study of Variant Morphology of Gall Bladder and its Clinical Significance

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Abstract

Introduction: As gall bladder is often a common site of open and laparoscopic procedures, the aim of the study was to note the different congenital anomalies of Gall bladder in the adult cadavers which can provide relevant information to the surgeons and radiologists performing diagnostic and therapeutic interventions at this region. The embryological basis and clinical implications of variations are discussed.

Materials and Methods: Study was carried out on 75 gall bladders of formalin fixed cadavers in department of Anatomy at K.J. Somaiya Medical College, Sion, Mumbai. The studies were carried out in the period from July 2019 to August 2021. Following parameters were noted: 1) shape 2) external morphology 3) dimensions of gall bladder which included measurement of length and breadth. Transverse diameter at the level of body of gall bladder and length from the tip of fundus to the neck of gall bladder.

Observation and Discussion: In 48 specimens, gall bladder was pear shaped. Other shapes observed were Cylindrical, Hourglass, Flask shaped and Irregular. In 1 specimen, the gall bladder was partially intrahepatic. A very prominent Hartmann's pouch was observed in 22 specimens. Length of Gall bladder ranged between 5.3 cms to 10.2 cms and transverse diameter ranged between 2.8 cms and 5 cms. Different positions of the fundus in relation to inferior border of liver were also noted.

Conclusion: Anatomical variations of Gall bladder become vital during surgical settings. Congenital anomalies and anatomical variations related to the gallbladder and extra hepatic biliary tree though not common but can be of clinical importance as failure to recognize them during operative procedures may lead to inadvertent complications. It is of greatest importance to laparoscopic surgeons during cholecystectomy to prevent alarming consequences as failure to recognise them can lead to iatrogenic injuries and increase morbidity and mortality. Every surgeon should assess for these anomalies before any operative procedures.

Keywords: Gall bladder, fundus, intrahepatic, surgeons, radiologists, laparoscopic cholecystectomy.

Introduction

Extrahepatic Biliary apparatus comprises of gall bladder, cystic duct, hepatic ducts and CBD. As variations are so commonly encountered, it has led some eminent workers to mention that there is no normal anatomy of extra hepatic biliary tract, and the onus is on the surgeon to recognize the variations when present.[1] Gall bladder being a reservoir for bile is commonly pear shaped having a capacity of 30-50ml and is palpated in the Right hypochondrium. Extending from near the right end of the porta hepatis to the inferior hepatic border and being connected to the common bile duct by the cystic duct it is described as having a fundus, body and neck. The fundus, a blind ending diverticulum lies at the lateral end of the body and usually projects below the inferior border of the liver to

a variable length. Its body is present in a fossa in the right hepatic lobe's inferior surface. Its upper surface is attached to the liver by connective tissue, elsewhere it is completely covered by peritoneum continuous from hepatic surface. It typically lies in close proximity to the duodenum, pylorus, and hepatic flexure of the right colon and right kidney. The body tapers towards the neck, which lies very close to the porta hepatis. The junction of the body and neck is sometimes straight, more often angular. The neck may show a pouch like dilatation called Hartmann's pouch towards the right. Its identification is useful in defining biliary anatomy when performing a cholecystectomy. The neck turns sharply downwards as it becomes continuous with the cystic duct and through the cystic duct drains into the right side of common hepatic duct. The mucus membrane of cystic duct is raised up into spiral folds comprising 5 to 10 irregular turns which are believed to serve the purpose of keeping the duct open so that bile can pass through it, both in and out of the gall bladder.[2] The gall bladder measures between 7-10 cm in length and maximum breadth is 3 cm. Variations in shape and size are not uncommon and are often debated by abdominal surgeons. Variations have been observed in the arrangements of ducts and even in the position of the gall bladder.[3] As gall bladder is often a common site of open and laparoscopic procedures, this study was done to observe the different congenital anomalies in the adult cadavers.

The present study aims to study the dimensions, variations of shape, external morphology and position of gall bladder which can provide the relevant information to the surgeons and radiologist performing diagnostic and therapeutic interventions at this region.

Material and Methods

The study was conducted on 75 gall bladders obtained from formalin fixed cadavers used for undergraduate students during a period of 2 years in the department of Anatomy of K. J. Somaiya Medical College, Sion, Mumbai. Ethical clearance was taken from institutional ethical committee prior to commencement of the study. The gall bladder was carefully dissected and cleaned to observe the variations in shape, its external morphology and position. Photographs were taken for proper documentation.

Following parameters were noted: 1) shape 2) external morphology 3) dimensions of gall bladder which included measurement of length and breadth. Transverse diameter at the level of body of gall bladder and length from the tip of fundus to the neck of gall bladder were measured with the help of sliding vernier callipers.

Results

Specimens were examined in situ by the naked eye and then removed and measured. According to shape gall bladder were classified as Pear shaped, Cylindrical, irregular, Hourglass shaped and Flask shaped. An intrahepatic gall bladder was also observed. Different shapes and external morphology of the gall bladder observed are summarized in Table 1.

Table 1: Showing different shapes of gall bladder

	Number	Percentage
Shape		
Pear shaped	48	64.1
Cylindrical	9	12
Hourglass shaped	4	5.4
Flask shaped	11	14.6
Irregular	2	2.6
Intrahepatic	1	1.3
External Morphology		
Folded fundus	5	6.7
Folded neck	12	16
Hartman's pouch	22	29.3
Position of Fundus		
Inframarginal Fundus	49	65.3
Marginal Fundus	14	18.6
Supramarginal Fundus	12	16.1

Length of Gall bladder ranged between 5.3 cms which was the minimum length to 10.2 cms which was the maximum length observed. Average length was 7.75 cms.

Maximum transverse diameter of gallbladder at the level of body of gall bladder ranged between 2.8 cms which was the shortest transverse diameter and 5 cms which was the largest. Mean diameter was 3.9 cm.

Length of fundus below inferior margin in inframarginal type of fundus ranged between 0.7 to 2.8 cm.

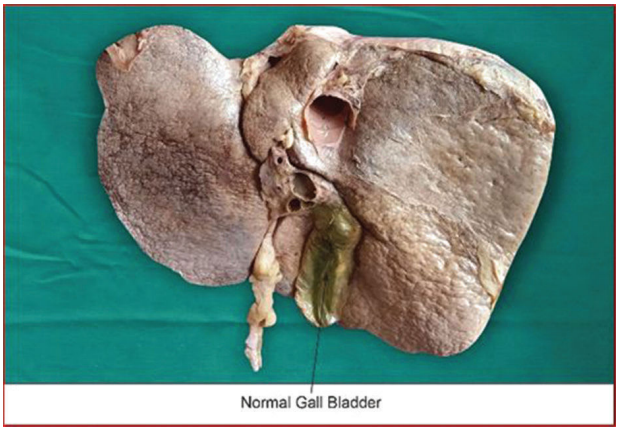

Fig. 1: Showing photographic presentation of Normal Gall Bladder.

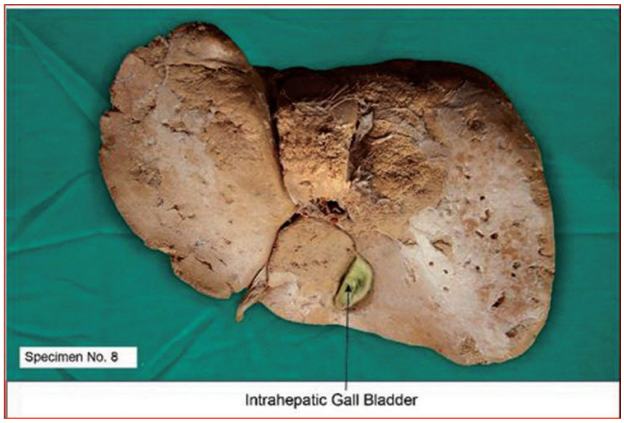

Fig. 2: Showing photographic presentation of Intrahepatic Gall Bladder.

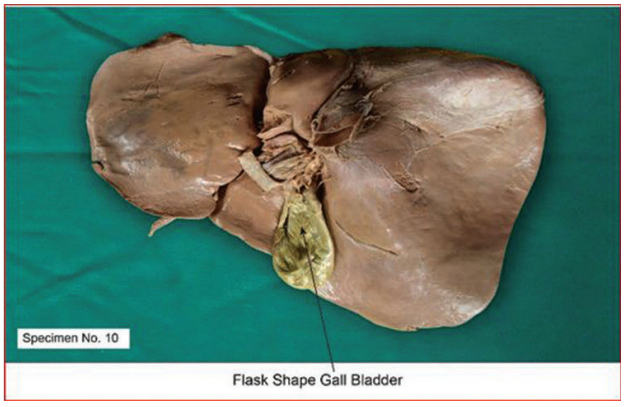

Fig. 3: Showing photographic presentation of Flask Shape Gall Bladder.

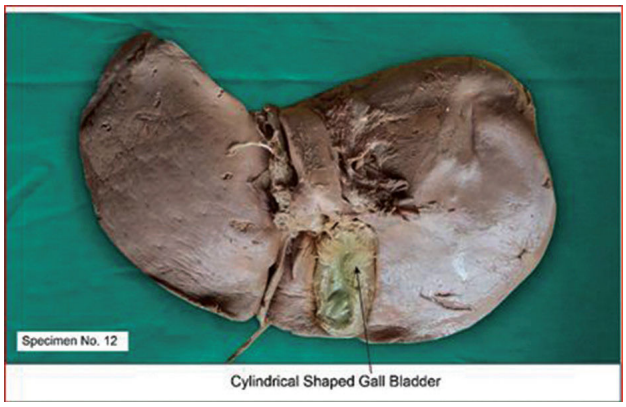

Fig. 4: Showing photographic presentation of Cylindrical Shaped Gall Bladder.

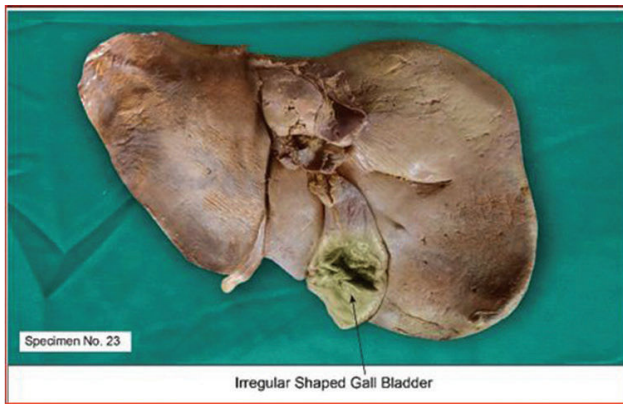

Fig. 5: Showing photographic presentation of Irregular Shaped Gall Bladder.

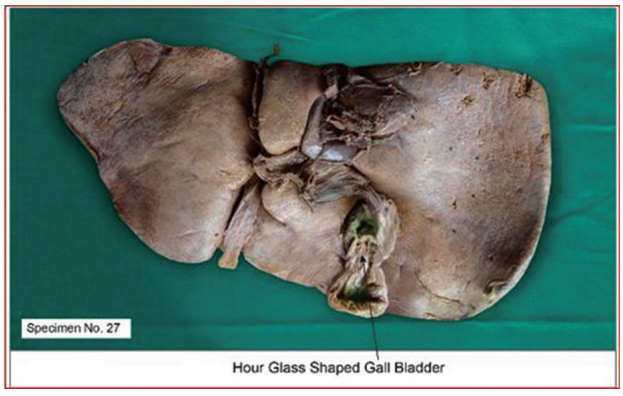

Fig. 6: Showing photographic presentation of Hour Glass Shaped Gall Bladder.

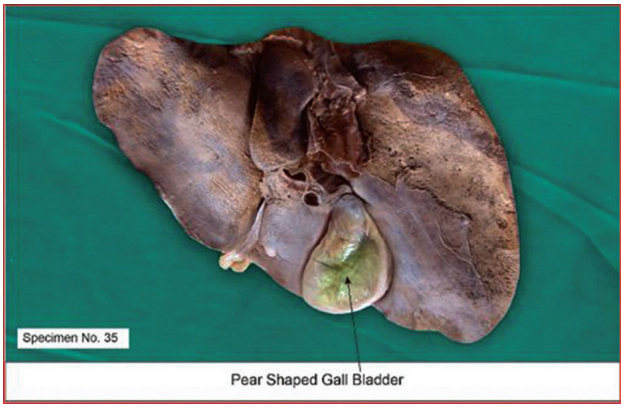

Fig. 7: Showing photographic presentation of Pear Shaped Gall Bladder.

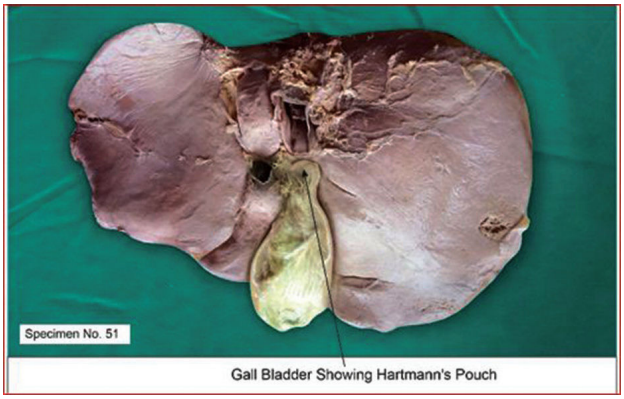

Fig. 8: Showing photographic presentation of Gall Bladder Showing Hartmann's Pouch.

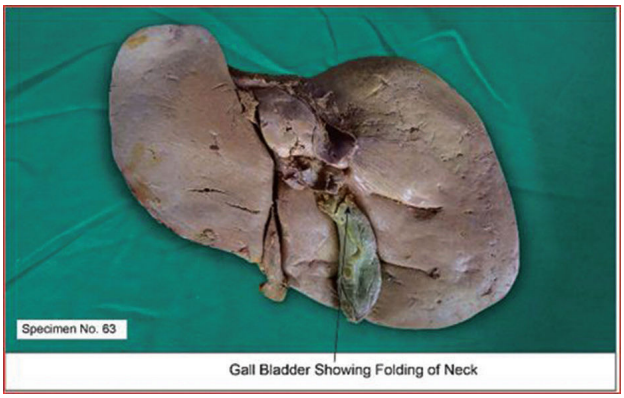

Fig. 9: Showing photographic presentation of Gall Bladder Showing Folding of Neck.

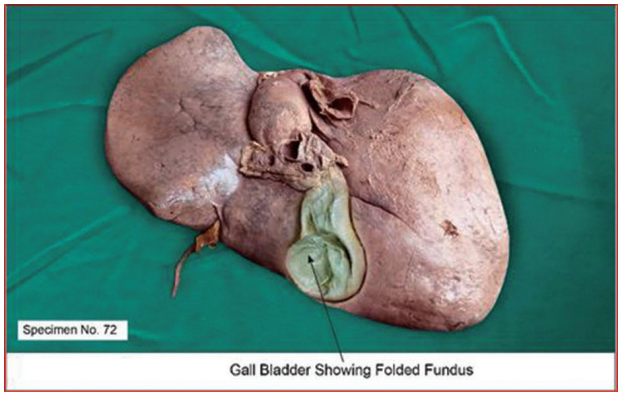

Fig. 10: Showing photographic presentation of Gall Bladder Showing Folded Fundus.

Fig. 11: Showing photographic presentation of Supra Marginal Gall Bladder.

Fig. 12: Showing photographic presentation of Infra Marginal Gall Bladder.

Discussion

Phrygian Cap or folded fundus is a triangular deformity where the fundus is folded on the body. It is of not pathological but sometimes is wrongly interpreted for layer of stones or hyperplastic cholecystosis.[4] According to Hollinshead, the gall bladder is relatively constant in its development and the Phrygian cap, could be due to a disproportion between the size of the gall bladder and that of the gallbladder bed, but without any pathological significance.[5] Bartel (1916) was the first who reported 43 cases of folded fundus at autopsy.[6] Later Boyden (1935) reported it in 7.5% of the 80 autopsy specimens.[7] The folded fundus was reported in 3-7.5% of GB by Lichtenstein & Nicosia.[8] Sreekanth et al studied 100 gall bladder specimens in 2016, and observed folded fundus in 2%, folded

neck in 4% and both folded fundus and neck in 2%. Mishra et al observed 2 specimens of folded neck and 4 specimens of folded fundus in their study of 50 gall bladder specimens.[9] In the present study, the folded fundus of the gall bladder was seen in 5 (6.7%) specimens and folded neck in 12 (16%) specimens. The gallbladder varies greatly in size and shape and occasionally it becomes difficult to distinguish between various parts. There may be a contrast in the size of gall bladder in some physiological states and even in some diseases. It may increase in size (cholecystomegaly) due to obstruction of cystic duct or common bile duct, after vagotomy and in sickle cell disease. Increase in size has also been observed in diabetes, pregnancy and obesity. A very small gall bladder may be found in cystic fibrosis.[10] In present study the length of the gall bladder ranged between 5.3 to 10.2cms and was similar to the findings of Jaba Rajguru et al (2012), Rajendra R et al (2015) and J desai, et al (2015).[11,12,13] The breadth of the gall bladder in the present study was in the range of 2.8 to 5 cms and was similar to the findings of Chari & Shah (2008) Jaba Rajguru et al (2012), Prakash AV et al (2013), Rajendra R, et al (2015) and J desai, et al (2015).[14,15]

Pear shape is the most common shape of gall bladder observed by almost all authors during literature study followed by flask shape. Other shapes observed in the range of 2 - 6% by most authors have been cylindrical, Irregular and hourglass shape.[16,17,18] Hourglass gallbladder is a constriction at the junction of middle and lower third of gallbladder, which divides the gallbladder into a wider upper zone and a smaller lower portion. Courvoisier (1890) reported the first case of hourglass gallbladder and considered it to be a cicatrical contraction secondary to inflammation.[19] In the present study, hour glass gallbladder is seen in 4 specimens.

Some authors have observed shapes like elliptical.[20], bilobed[17] and retort shape[11] which were not observed in our study.

The different measurements and shapes of gall bladder reported by different authors have been summarized in Table 2.

Table 2 Showing measurements of gall bladder and shapes as reported by different authors

Author	No. of specimens	Length (cms)	Breadth (cms)	Shape
Rajguru J et al. (2012)	60	12-May	2.5 - 5	Pear (85%), flask (5%), cylindrical (3.33%), Irregular (1.67%), hourglass (3.33%), Retort (1.67%)
Sah et al (2013)	30	3.9 – 9.0	0.7- 5.2	Pear (60%), Flask (26.7%), Tubal (6.7%), Hourglass (6.7%).
Rajendra et al (2015)	78	11-Apr	2.5 - 5	Pear (53.2%), cylindrical (11.4%), hourglass (6.3%) oval (11.4%) others (16.5%).
J desai, et al (2015)	50	4.5 -11	2.8 - 5	Pear (84%), cylindrical (10%), hourglass (2%), retort (4%)
Nadeem (2016)	70	4.5 -11.6	2.7 - 5.2	Pear (82.85%), flask (2.86%), Cylindrical (2.86%), irregular (1.43%), Bilobed (1.43%), others (7.14%)
Tiwari (2018)	50	10-May	2.4 - 4.7	Pear (52%), flask (28%), cylindrical (12%), Irregular (4%) hourglass (4%)
Present study (2021)	75	5.3 - 10.2	2.8 - 5	Pear (64%), flask (14.6%), cylindrical (12%), Irregular (2.6%) hourglass (5.3%)

Hartmann's pouch is a widening at the lateral end of the neck of gall bladder which is considered a contrast finding by most authors like Hollinshead (1983)[5], McGregor (1986)[4], Keith Moore (2006)[21] and Standring (2008).[2] It is of two types namely congenital and acquired type. In congenital type all the three layers of gall bladder wall are present, whereas the acquired variety is a result of any disease process and has little or no smooth muscle in its wall. It is often associated with cholelithiasis and carcinoma of the gall bladder. Gall stones can get impacted here sometimes causing a rare complication called Mirizz's syndrome due to formation of Mucocoele which can compress the common hepatic duct or bile duct. The calot's triangle and cystic duct may not be discernible during surgeries due to a large Hartmann's pouch. Hence the existence of Hartmann's pouch should be ascertained preoperatively before any surgery to prevent intra operative and post operative complications.[23] Futura and Kinfu (2001)[22] observed a higher prevalence of Hartman's pouch in females than males. Sanjay Sah (2018)[16] observed Hartmann's pouch in 40% specimens.

Nadeem in his study observed Hartmann's pouch in 7.14% specimens[17] and Sreelekha et al[24] in 6.77% specimens. In the present study Hartmann's pouch is present in 22 (29.3%) of the specimens.

Intrahepatic gallbladder can be partial or complete, when the gall bladder projects out from the liver partly it is of partial type and if completely embedded within the liver parenchyma it is of complete type. Congenital arrest in the movement of gall bladder in intrauterine life from the intrahepatic position to its normal position is responsible for this anomaly. These gall bladders are more susceptible to cholelithiasis due to incomplete emptying of the gall bladder produced by stasis. Surgeries on such gall bladders are challenging and can cause complications.[25]

The fundus extending beyond the inferior margin is critical for surgeons during cholecystectomy. Lurje A et al., in 1937 studied 194 cadavers and was the first to classify the relation of fundus to the edge of the liver into supra marginal, marginal and infra marginal. He reported 33% to be supramarginal, 13.9% to be marginal, and 53.1% to be inframarginal type.[26] Rajguru J et al (2012)[11], in his study of 100 specimens reported 8% to be supramarginal, 5% to be marginal, and 87% to be inframarginal type. Sreelekha et al (2019)[24] in her study on 58 specimens reported 34.5% to be supramarginal, 22.4% to be marginal, and 43.1% to be inframarginal type. In the present study supramarginal was reported in 16.1% specimens, marginal in 18.6% and inframarginal in 65.3%. Their extension beyond the inferior margin as reported by Lurje et al ranged between 0.5 to 4 cm.[26] Other authors have reported the range to be between 0.4 and 2.5 cm (Anjankar) and (Sreekanth C) et al[27,9] and between 1.8 to 4 cm (Sreelekha).[24] In the present study, the length varied between 0.7 to 2.8 cm which was similar to the observations of Anjankar.

Embryological Basis

Between the third to fourth week of development around the 18th day, hepatic diverticulum of foregut develops and projects ventrally & cranially into surrounding mesoderm of septum transversum. By 25th somite stage the hepatic diverticulum enlarges and gets divided into a large cranial portion pars hepatica & a small caudal portion pars cystica, which give rise to liver, gall bladder and biliary duct system. The pars cystica gives rise to gall bladder & cystic duct. The connection between the hepatic diverticulum and the foregut narrows, forming the bile duct. An arrest during this normal development or any deviation from the normal can result in variations in the formation of gall bladder and biliary system.[28]

Clinical Considerations

Congenital biliary duct malformations can appear at any time and may catch the surgeon unaware during laparoscopic surgery, and hence should always be kept in mind in the presence of confused or poorly defined anatomy during preoperative imaging. In such cases an intraoperative cholangiography may sometimes become necessary in order to avert an accidental duct clipping or injury or bleeding resulting in future strictures.[29] Dharmendra kumar et al in his study concluded that congenital anomalies and anatomical variations of extra-hepatic biliary tree though are not common but can be of clinical importance.[30] The gall bladder and biliary tract are closely related to adjacent organs. Hence their anatomical variations become vital during surgical settings. Failure to recognize them during operative procedures may lead to inadvertent complications. Laparoscopic cholecystectomy for gallstone disease reveals a much clearer anatomy of the biliary tree as compared to open surgery and the extra-hepatic biliary system can be evaluated for its anatomical variations and congenital anomalies.[31] The surgeons should also be familiar with arterial anomalies during laparoscopic cholecystectomy to avoid iatrogenic injuries. A tortuous course of common hepatic artery or right hepatic artery running in front of the origin of cystic duct known as "Cater pillar turn or Moynihan's hump" are most vulnerable.[32] The short cystic artery arising from the looped right hepatic artery is also susceptible to trauma during cholecystectomy causing bleeding and leakage of bile. An awareness of extra hepatic biliary ductal and arterial anatomic relationships can avert a number of complications of laparoscopic cholecystectomy.[33] In patients with intrahepatic gall bladder, cholecystitis is difficult to diagnose as peritoneal inflammation is absent. In such patients cholelithiasis is treated with a cholecystostomy rather than a cholecystectomy.[34] Information regarding location of fundus of gall bladder and its peritoneal covering is important for surgeons as it is sometimes associated with torsion of gall bladder.[35]

Conclusion

Congenital anomalies and anatomical variations related to the gallbladder and extra hepatic biliary tree though are not common but can be of clinical importance. They are important for radiological studies, investigative procedures, surgical

interventions and their clinical outcomes. It is of greatest importance to laparoscopic surgeons during cholecystectomy to prevent alarming consequences as failure to recognise them can lead to iatrogenic injuries and increase morbidity and mortality. Every surgeon should assess for these anomalies before any operative procedures. It is the duty of the anatomist to bring awareness about these anatomical variations.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

SPS drafted the manuscript, performed the literature review & SR assisted with writing the paper.

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