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ORIGINAL ARTICLE

Morphological Variations of Gall-bladder: A Cadaveric and Ultrasonographic Study

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ABSTRACT

Introduction: The gall bladder is an important component of the extrahepatic biliary apparatus which presents various morphological variations, the knowledge of which serves to be important during radiological scans and surgeries. The study aims to identify few anatomical variations in the dimensions, shape and position of gall bladder which would serve beneficial in the above mentioned procedures as well as in other anatomical, clinical and research settings.

Methodology: The study comprised of 30 thoroughly dissected Liver specimens obtained from 10% formalin fixed cadavers of both genders and 20 ultrasonographic scans of abdomen from the Department of Anatomy and Department of Radiology, AIMS after the requested consent from Institutional Ethics Committee and the Head of Department. The study carried out for a period of four months from February 2025 to June 2025 considered the parameters length, breadth, shape of gall bladders and length of part below or above inferior border of liver for cadaveric specimens.

Results: The mean length, breadth of gall bladders in cadaveric and ultrasonographic studies were 7.82±1.29, 3.66±0.81, 6.155±0.84 and 2.39±0.59. 20 gall bladders were below the inferior margin of liver (mean length = 1.76±1.07), 5 gall bladders were above the margin (mean length = 1.68±0.86) and 5 gall bladders were at the margin. The shapes observed were pear (57%), cylindrical (37%), quadrangular (3%) and others (3%).

Conclusion: The study would serve important for working surgeons and radiologists treating and scanning cases of gall bladder diseases.

KEYWORDS:

• Gall Bladder • Ultrasonography • Morphology

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INTRODUCTION

The extrahepatic biliary system includes the gallbladder, cystic duct, common bile duct, and hepatic ducts. The gallbladder is a slate-blue, pear-shaped sac on the under surface of the right lobe of the liver, usually 7–10 cm long, 3 cm wide with capacity of 30–50 ml.[1-3] Fundus, body, and neck are external features of gallbladder. Cystic duct begins from neck gallbladder and joins with common hepatic duct to form bile duct that drains in to 2nd part of duodenum. Gallbladder stores and concentrates the bile.

The gallbladder shows significant anatomical variations in size, shape, and location, including these abnormal ones like duplication, bifidity, or absence, and also aberrant positions like intrahepatic or floating gallbladders. These variations are relevant clinically, particularly during surgical procedures such as laparoscopic cholecystectomy, where undetected anomalies may lead to complications like ductal injury and biliary leaks.[2,4-7]

Physiological states like pregnancy or pathological conditions like cholelithiasis and cholecystitis can change gallbladder volume and wall thickness. Ultrasonography continues to be the imaging method of choice because of its safety, cost-effectiveness, and reliability in assessing gallbladder morphology and pathology.[9,10]

Knowledge of the morphometry and variations of the gallbladder is vital for surgeons, radiologists, and gastroenterologists to reduce operative and diagnostic morbidity. The aim of this research is to add more knowledge through an evaluation of the morphometric measurements of the adult human gallbladder in cadavers and thereby contributing to better clinical and surgical outcomes.[1,2,4]

Ultrasonography is widely recognized as the primary imaging technique for examining gallbladder morphology. Gallbladder typically appears as a fluid-filled structure with clearly defined margins, positioned in the gallbladder fossa between the right and quadrate lobes of the liver. It is often visualized adjacent to the kidney during parasagittal imaging. Distinct layers comprising the mucosa, muscle, and serosa characterize its wall, which generally does not exceed 3 mm in thickness. Fasting prior to scanning is standard practice to avoid overestimating wall thickness caused by contractions.[9,10]

Measurement methods include two-dimensional approaches, such as the ellipsoid and sum-of-cylinders techniques, as well as three-dimensional ultrasonography, all of which provide assessments of gallbladder volume and wall thickness related to both normal and pathological states.[9,10]

Alterations in these parameters are clinically relevant, helping to identify conditions like gallstones, inflammation, pancreatitis, and biliary obstruction. Despite the utility of these measures, regional data on sonographic gallbladder dimensions remain scarce, strengthening the need for studies that establish reference values and assess their associations with demographic pathologi.[9-11]

OBJECTIVES

1. To observe shape, measure length, width and determine the relation of fundus with inferior margin of liver in cadaveric specimens.
2. To measure length and width of gallbladder in the normal USG scan of abdomen.
3. To compare the values of similar parameters in cadaveric and live study (USG).

Hence present study is done to evaluate the normal gallbladder in cadaveric specimens and ultrasonography.

MATERIAL AND METHODS

Approval was taken from the institutional ethics committee, and necessary permissions were obtained from the departments before commencing the work. This research consisted of 30 cadaveric liver specimens with gallbladders and 20 ultrasonographic images of abdomen showing liver and gallbladders. Research was conducted for four months from February to June, 2025.

This study was conducted on 30 liver specimens with gallbladders obtained from 10% formalin-fixed adult cadavers of both sexes available in the Department of Anatomy Specimens were scrupulously cleaned. Following parameters were taken. Length, transverse diameter, shape, external variations, and distance of fundus of the gallbladder below the lower margin of the liver were noted. The maximum length was recorded from the porta hepatis to the midpoint of the fundus, while the greatest breadth was measured at right angles to the long axis at the widest part using Vernier calipers and measuring tape were employed for measurements.

Figure 1: showing the measurements a) width in cms

Figure 2: b) length in cms

Data were analysed using statistical software, and P value less than 0.05 was taken as statistically significant.

Ultrasonographic Study

The ultrasound component of the study comprised 20 adult volunteers of both genders who underwent abdominal sonography after obtaining informed consent. In this arm, only the gallbladder shape was evaluated as the parameter of interest. Examinations were performed on a Samsung ultrasound unit equipped with v8 software. All subjects were instructed to fast for 6–8 hours before scanning to ensure adequate gallbladder distension and optimal visualization. Standardized scanning protocols were followed to obtain consistent images, and gallbladder shape was documented in each case.

Data from the cadaveric and ultrasonographic components were compiled and subjected to statistical analysis. Descriptive statistics, including mean, standard deviation, and range, were calculated wherever applicable, and a p value of less than 0.05 was taken as statistically significant.

RESULTS

Parameters of cadaveric gallbladder

Table 1: showing the % of shapes of gallbladder

Shape	Number	%
Pear	17	57
Cylindrical	11	37
Quadrangular	1	3
Irregular	1	3

Table 2: showing length and width in cm of gallbladder in cadaveric study

Parameter	Range	Mean
Length (cm)	5.8 – 9.5	7.82 ±1.29
Width (cm)	2.3 - 5	3.66 ±0.81

Table 3: showing the relation of fundus of gallbladder with inferior margin of liver in cadaveric study

Relation with inferior margin of liver	Number	Mean length (cm)
Above the margin	5	1.68 ±0.86
At the margin	5	-
Below the margin	20	1.76 ±1.07

Table 4: Length and width of gallbladder measurements in ultrasonographic study

Parameter	Range	Mean
Length (cm)	4.7 – 7.4	6.155 ±0.84
Width (cm)	1.3 – 3.6	2.39 ±0.59

Figure 3: showing the different shapes of gallbladder

Figure 4: Hartmann's pouch as the only external variant in 2 cases

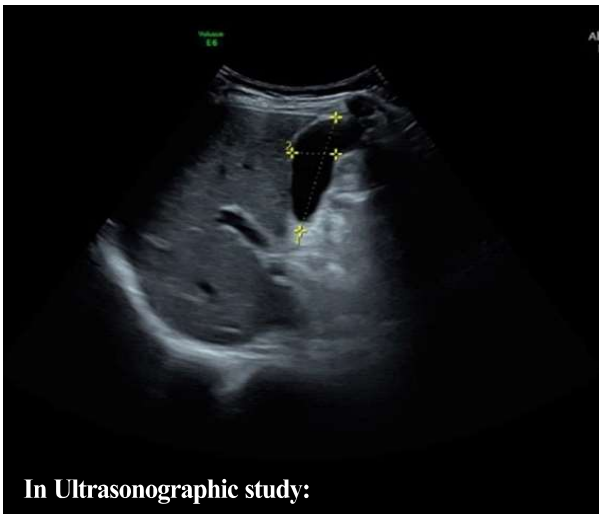

Figure 5: Ultrasonographic image of gallbladder

DISCUSSION

The gallbladder derives as an outpouching from the hepatic bud from foregut (endoderm). The proximal portion of the pouch forms the cystic duct, and the distal portion forms the gallbladder. During the initial development, the gallbladder lies in an intrahepatic position, but as it migrates to the surface of the liver, it acquires a peritoneal covering typically covering 50% to 70% of its surface.[10] The measurements obtained from the cadaveric specimen and those from ultrasonography done in vivo are comparable.[2]

This combined study aimed to assess the morphological variations as well as the morphometric measures of the gallbladder in cadavers as well as by ultrasound.

Table 5: Shows comparison of incidence of different shapes with studies reported by other authors in cadaveric study

Shape	Neginhal D D[6] et. al. (2018)	Srivastava S.[4] et. al. (2019)	Nayak[3] et al. (2021)	Singh[2] et al. (2022)	C Divya[5] et al. (2022)	Present Study(2025)
Pear	23(46%)	21(70%)	32(80%)	22(46%)	84(84%)	17(57%)
Cylindrical	10(20%)	3(10%)	2(5%)	14(29%)	8(8%)	11(37%)
Quadrangular	–	–	1(2.5%)	–	–	1(3%)
Others	17(34%)	6(20%)	5(12.5%)	12(25%)	8(8%)	1(3%)

In the current study, the pear-shaped gallbladder was the most common variant, which was present in 57% of the cadavers, comparable with other studies except the study reported by Nayak et al. (80%) and C Divya et al. (84%). Study. Although the pear shape is the most common overall in the literature, the distribution of the other shapes may differ among different groups.

Table 6: Showing the comparison of length and width with other authors in cadaveric study

Parameter	Singh[2] et al.	Nayak[3] et al.	Srivastava S[4], Khan A Z	C Divya[5] et al.	Neginhal D D[6], Kulkarni U K	Present Study
Region	**Patna**	**Bhopal**	**UP**	**Kolar**	**Mumbai**	**Karnataka**
Length (cm)	8.13 ± 2.1	7.54 ± 1.62	8.27 ± 1.19	8.99 ± 1.34	6.762±0.810	7.82±1.29
Width (cm)	3.90 ± 1.53	3.44 ± 0.76	4.03 ± 0.70	3.74 ± 0.77	3.492±0.75	3.66±0.81

The mean length of the gallbladder in the current cadaveric sample was 7.82 ± 1.29 cm. Slightly higher values were recorded by Srivastava S et al and C. Divya et al. and lower shown by Neginhal D et al. The mean width of the gallbladder in the current study came out to be 3.66 ± 0.81 cm. and is in par with the observations of all studies shown in table except Srivastav S *et al*.

Table 7: Comparison of length and width of gallbladder by ultrasonographic studies

Parameter	Adeyekun et al. (2013)	Siva Prasad Chavva[8] et. al. (2018)	Aska Farouq Jamal[7] et al. (2022)	Present Study (2025)[9]
Length (cm)	6.16±1.09	6.19±1.09	6.51±0.61	6.155±0.84
Width (cm)	2.98±0.59	2.82±0.59	2.87±0.42	2.39±0.59

In the ultrasonography part of the current study parameters are comparable with other studies. When we compare the parameters in cadaveric and ultrasonographic measurements of the gallbladder values are more in the cadavers. This is seen by the difference in the cadaveric mean measurements of the length (7.82 ± 1.29 cm) and the ultrasonographic mean measurements (6.155 ± 0.84 cm).

CONCLUSION

The present study demonstrates that variations in the morphology and position of the gallbladder are not uncommon and have significant clinical importance. Awareness of these anatomical variations is essential for anatomists, radiologists, and surgeons to ensure accurate diagnosis and safe surgical practice. Proper knowledge

of gallbladder anomalies helps prevent misinterpretation during imaging and reduces the risk of iatrogenic injuries, especially during laparoscopic cholecystectomy. Understanding these variations ultimately contributes to improved surgical outcomes and reduced morbidity. The study would serve important for working surgeons and radiologists treating and scanning cases of gallbladder diseases.

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