

*Original Research Article*

## MORPHOMETRIC STUDY OF CAUDATE AND QUADRATE LOBES OF THE FETAL LIVER

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### Abstract

**Background:** Liver is largest gland of the body, situated in the right upper quadrant of the abdominal cavity. It occupies whole of the right hypochondrium greater part of epigastrium and extend into the left hypochondrium reaching up to the left lateral line. Liver is divided into right and left lobe by attachment of falciform ligament anteriorly and superiorly; by the fissure for the ligamentum teres inferiorly and by the fissure for the ligamentum venosum posteriorly. The caudate lobe is situated between the ligamentum venosum, porta hepatis and the groove for the inferior vena cava. Whereas the quadrate lobe is situated between ligamentum teres hepatis, fossa for gallbladder and porta hepatis. The caudate lobe is also known as the posterior hepatic segment.

**Objective:** This study aims to correlate the length and width of the caudate and quadrate lobes of the liver with the Gestational age (GA) of the fetus.

**Methods:** This study was conducted on 131 formalin-fixed fetuses with the gestational age ranging from 12 to 36 weeks in the Department of Anatomy D Y Patil medical college in the collaboration with the OBGY Department of D Y Patil Hospital, Nerul, Navi Mumbai. Caudate and quadrate lobes of the liver were dissected and measurements of length, width, and circumference were taken with the help of vernier caliper, measuring scale, and thread.

**Results:** In this study, the length of the caudate lobe and the width of the caudate lobe was  $10.62 \pm 3.22$  mm and  $6.945 \pm 2.391$  mm respectively after calculating mean and standard deviation. The length and width of quadrate lobe was  $14.775 \pm 4.636$  mm and  $7.555 \pm 2.763$  mm respectively. The circumference of caudate and quadrate lobes were  $40.886 \pm 11.647$  mm and  $48.74 \pm 14.008$  mm respectively for the total sample size. Calculation of the length, width, and circumference of the caudate and quadrate lobe was found to be statistically significant with the gestational age of fetuses.

**Conclusion:** From this study we can conclude that there is a significant correlation between the length, width and circumference of the caudate and quadrate lobe with the gestational age.

**Keywords:** Fetus, caudate lobe, quadrate lobe, gestational age

## Introduction

The liver is one of the largest organs in the body and is located in the left hypochondrium, right hypochondrium, and epigastrium. It starts developing in the third week of embryonic development and then grows rapidly from the fifth to tenth week of pregnancy, taking up a sizable portion of the abdominal cavity. At 10<sup>th</sup> week, the liver makes up to 10% of the entire body weight. In initial stage both right and left lobes are of same size at but later right lobe grows larger <sup>[1-2]</sup>.

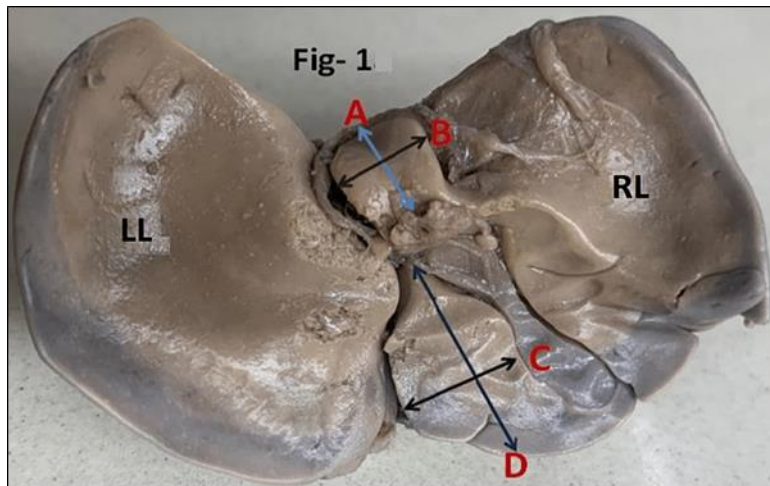
Between ligamentum venosum, porta hepatis and groove for the inferior vena cava is the caudate lobe. It is also referred to as the posterior hepatic section. It receives nourishment from the portal vein's left and right branches. The CL may enlarge in Budd-Chiari syndrome, which cause obstruction of hepatic venous outflow. The fossa for gallbladder, fissures for the ligamentum teres, porta hepatis, caudate process, and the inferior border of the liver all encircle the quadrate lobe of the liver <sup>[2-5]</sup>.

Study of liver parameters can aid in early diagnosis of fetal disorders as well as in assessing the state of fetal growth. The size of liver can be aberrant in Maternal gestational diabetes, isoimmunization, intrauterine infections, cardiac abnormalities, cancers and either microsomia or macrosomia. Intrauterine growth retardation, erythroblastosis fetalis, anemia, thalassemia, and problems with the transfer of oxygen by Bart's hemoglobin are a few conditions that might result in a reduction in the size of the liver <sup>[6-11]</sup>.

## Materials and Methods

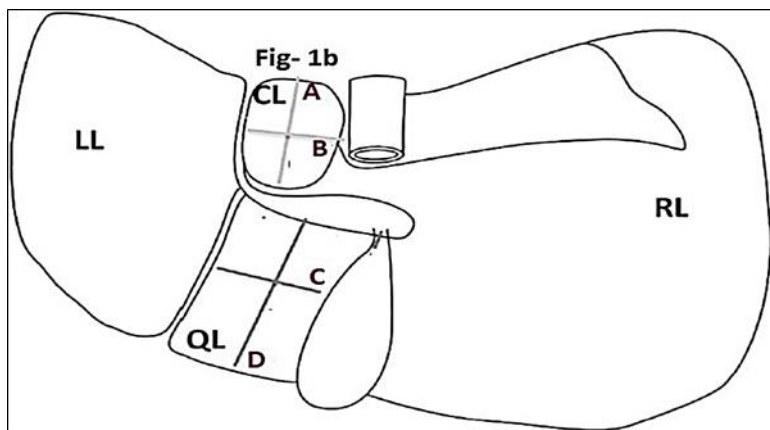
This study was conducted on 131 (40 females and 91 males) formalin-fixed fetuses with a gestational age ranging from 12 to 36 weeks in the Department of Anatomy at D Y Patil Medical College in collaboration with the OBGY Department of D Y Patil Hospital, Nerul, Navi Mumbai. The study was carried out for two and a half years (from July 2020 to December 2022). Fetuses were collected from OBGY Department soon after spontaneous miscarriages & therapeutic legal abortions with consent from the families. The history of the fetus was noted. Then, the fetus was preserved in 10% formalin for 10 days at the research lab of Anatomy Department. Approval was obtained from the Institutional Ethics Committee for Biomedical and health research D. Y. Patil School of medicine, Navi Mumbai. Collected fetuses were categorized into 6 groups according to gestational age, Group A aged <12 weeks, Group B (13-16 weeks), Group C (17-20 weeks), Group D (21- 24 weeks), Group E ( 25-28 weeks) and Group F (>28 weeks). Measuring tape, thread, vernier caliper, and ruler were used to measure the morphometric parameters in this study. The abdomen was dissected through a transverse incision that went from the umbilicus to the mid-axillary line on either side and two vertical incisions that ran from the costal arch to the iliac crest on either side of the mid-axillary line. The liver and surrounding organs were visible. Cases having a deformity or anomaly were excluded from the study. Caudate and quadrate lobes of the liver were anatomized and measurements of length, width, and circumference were taken with the aid of Vernier Caliper, thread and measuring scale.

**Statistical analysis:** Using the SPSS statistical tool, the means of the parameters concerning gestational age, sex and groups were calculated. All parameters of the caudate and quadrate lobe of the liver were statistically significant (P value is <0.05). The photograph of measurement of parameters is attached below.



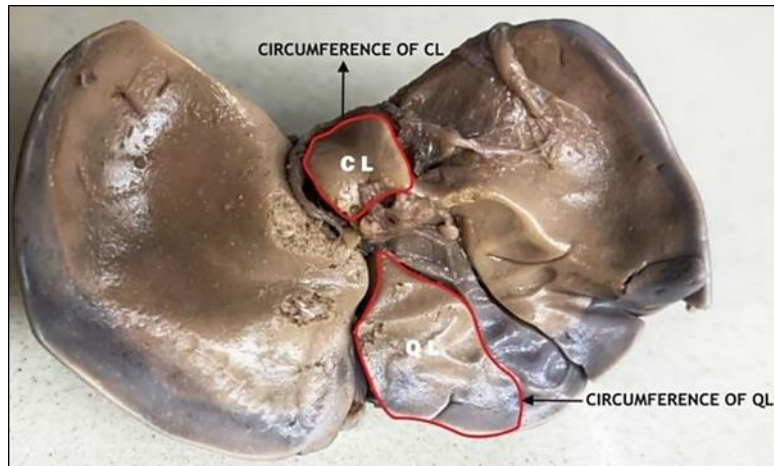
**Fig 1:** Fetal liver and its schematic representation. LL-left lobe, RL-right lobe, QL-quadrate lobe, CL-caudate lobe, A-length of CL, B-the breadth of CL, D-length of QL, C-the breadth of QL

As shown in Fig. 1 The vertical distance between the most superior and inferior points of the caudate lobe determines, its height. The caudate lobe's breadth is determined by measuring the distance transversally between its two outermost points. The height of the quadrate lobe is determined by measuring the vertical distance between its superior and inferior most points. The transverse distance separating the outermost points on either side of the quadrate lobe is the width of the lobe.



**Fig 2:** Fetal liver, showing the various parameters measured. LL-left lobe, RL-right lobe, QL-quadrate lobe, CL-caudate lobe, A-length CL, B-breadth of CL, D-length of QL, C-breadth of QL

As shown in Fig. 2 the circumference of caudate lobe (mm) was measured with the help of white thread (one end of the thread was tied with a pin and the pin was fixed at the upper end of ductus venosus) and this was measured by keeping thread around the caudate lobe of the liver. Circumference of quadrate lobe (mm): Measurement was taken with white thread, one end of the thread tied on the pin and the pin was fixed at the upper end of the fissure for ligamentum teres hepatis. Then this was measured by keeping thread around the caudate lobe of the liver.



**Fig 3:** Schematic Diagram of the circumference of caudate and quadrate lobe of the liver  
As shown in Fig. 3 quadrate lobe (QL) and caudate lobe (CL) of fetal liver.

Results

Table 1: Descriptive statistics of the measured parameters at different age groups (MI-minimum value, MA-maximum value)

Parameters	<12 weeks		13-16 weeks		17-20 weeks		21-24 weeks		25-28 weeks		>28 weeks		Total	
	MI. & MA.	Mean & SD	MI. & MA.	Mean & SD	MI. & MA.	Mean & SD	MI. & MA.	Mean & SD	MI. & MA.	Mean & SD	MI. & MA.	Mean & SD	MI. & MA.	Mean & SD
Circumference of Caudate L. (mm)	18.28 & 35.91	26.91 ± 6.28	12.22 & 43.23	31.061 ± 12.344	14.42 & 52.27	37.214 ± 9.093	22.89 & 63.17	42.916 ± 9.313	35.5 & 60.74	47.822 ± 7.656	69.14 & 82.3	76.85 ± 6.866	12.22 & 82.3	40.886 ± 11.647
Circumference of Quadrate L. (mm)	17.86 & 41.49	32.02 ± 8.15	13.83 & 52.72	34.018 ± 15.391	23.63 & 94.51	43.967 ± 11.75	19.37 & 69.72	51.565 ± 9.764	35.52 & 87.34	59.276 ± 11.277	78.75 & 96.4	86.17 ± 9.154	13.83 & 96.4	48.74 ± 14.008
Length of caudate L. (mm)	2.25 & 12.98	7.085 ± 4.09	3.45 & 12.37	8.37 ± 3.762	4.6 & 15.03	9.056 ± 2.233	6.62 & 19.62	11.91 ± 2.697	6.73 & 17.62	12.269 ± 3.06	13.75 & 18.62	15.45 ± 2.745	2.25 & 19.62	10.62 ± 3.22
Width of caudate L. (mm)	2.01 & 7.09	4.45 ± 2.14	2.29 & 6.58	4.628 ± 1.912	3 & 10.16	6.151 ± 1.494	3.87 & 13.41	7.472 ± 1.995	4.78 & 13.69	9.027 ± 3.428	6.84 & 12.64	9.62 ± 2.907	2.01 & 13.69	6.945 ± 2.391
Length of Quadrate L. (mm)	3.02 & 18.5	9.88 ± 6.35	3.12 & 17.56	10.56 ± 5.878	3.5 & 20.77	12.929 ± 3.689	9.42 & 25.34	16.083 ± 2.929	8.8 & 27.02	17.847 ± 4.94	18.25 & 30.19	23.826 ± 6.008	3.02 & 30.19	14.775 ± 4.636
Width of Quadrate L. (mm)	1.01 & 6.64	4.045 ± 2.43	1.44 & 9.92	5.474 ± 2.728	3.7 & 10.25	6.931 ± 1.724	4.52 & 18.38	8.218 ± 2.4	3.44 & 18.32	8.384 ± 3.967	10.48 & 16.02	12.933 ± 2.823	1.01 & 18.38	7.555 ± 2.763

**Table 2:** Pearson's correlation coefficients (r) and p values show statistically significant correlation for all the measured parameters

Parameters	r-value	P -value
Circumference of Caudate L. (mm)	0.646	<0.0001
Circumference of Quadrate L. (mm)	0.641	<0.0001
Length of caudate L. (mm)	0.542	<0.0001
Width of caudate L. (mm)	0.49	<0.0001
Length of Quadrate L. (mm)	0.572	<0.0001
Width of Quadrate L. (mm)	0.462	<0.0001

**Table 3:** Descriptive statistics of the measured parameters of males and females in different age groups (SD-Standard deviation)

Parameters	<12 weeks	13-16 weeks		17-20 weeks		21-24 weeks		25-28 weeks		>28 weeks
	Male	Male	Female	Male	Female	Male	Female	Male	Female	Male
	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD	Mean & SD
Circumference of Caudate L. (mm)	26.91 ± 6.28	37.05 ± 9.07	23.066 ± 12.87	36.877 ± 8.459	37.74 ± 10.23	42.56 ± 9.9	43.93 ± 7.58	48.58 ± 6.468	45.73 ± 11.23	75.72 ± 9.31
Circumference of Quadrate L. (mm)	32.02 ± 8.154	38.56 ± 14.08	27.963 ± 17.8	44.86 ± 12.6	42.56 ± 10.46	51.46 ± 10.014	51.85 ± 9.36	56.62 ± 9.017	66.57 ± 15.026	87.57 ± 12.48
Length of caudate L. (mm)	7.085 ± 4.09	9.445 ± 3.09	6.936 ± 4.76	9.147 ± 2.388	8.91 ± 2.019	11.69 ± 2.65	12.515 ± 2.83	11.68 ± 3.165	13.88 ± 2.35	16.185 ± 3.44
Width of caudate L. (mm)	4.45 ± 2.14	5.602 ± 1.795	3.33 ± 1.309	6.09 ± 1.62	6.24 ± 1.307	7.29 ± 1.615	7.96 ± 2.83	9.437 ± 3.467	7.9 ± 3.53	11.01 ± 2.305
Length of Quadrate L. (mm)	9.88 ± 6.35	13.08 ± 5.5	7.19 ± 5.335	13.13 ± 3.591	12.608 ± 3.92	15.81 ± 2.62	16.86 ± 3.67	17.0118 ± 4.966	20.14 ± 4.69	24.22 ± 8.443
Width of Quadrate L. (mm)	4.045 ± 2.43	6.417 ± 2.537	4.216 ± 2.919	6.96 ± 1.64	6.87 ± 1.89	7.91 ± 1.74	9.095 ± 3.63	8.175 ± 4.023	8.95 ± 4.346	14.16 ± 2.63

**Table 4:** The best-fit regression formulas for caudate and quadrate lobe of fetal liver

Parameter	Regression Formula
Circumference of Caudate L. (mm)	$Y = 3.254 + (1.846 \times \text{GA in Weeks})$
Circumference of Quadrate L. (mm)	$Y = 3.793 + (2.205 \times \text{GA in Weeks})$
Length of caudate L. (mm)	$Y = 1.884 + (0.429 \times \text{GA in weeks})$
Width of caudate L. (mm)	$Y = 1.087 + (0.287 \times \text{GA in weeks})$
Length of Quadrate L. (mm)	$Y = 1.514 + (0.651 \times \text{GA in weeks})$
Width of Quadrate L. (mm)	$Y = 1.164 + (0.314 \times \text{GA in weeks})$

To ensure no data entry error, the data were organized in an Excel spreadsheet. In this study, the GA of the fetuses are ranging from 12 to 36 weeks. All received fetuses were divided into 6 Groups, Group A aged <12 weeks, Group B (13-16 weeks), Group C (17-20 weeks), Group D (21-24 weeks), Group E (25-28 weeks) and Group F (>28 weeks). The values of each group were expressed as mean  $\pm$  standard deviation. Descriptive statistics of the measured parameters at different age groups are shown in Table 1. Pearson's correlation was applied to assess the correlation of the parameters measured with GA is given in Table 2. Descriptive statistics of the measured parameters of males and females in different age groups are shown in Table 3. There was a highly significant link showing that QL and CL growth correlated with GA. The best-fit regression formulas for the caudate and quadrate lobe of the fetal liver are given in Table 4. The CRL ranged from 128.3 mm to 278.4mm. The size of the caudate and quadrate lobes of the liver increased with advancing gestational age and there were significant

correlations between the gestational age of the fetus and the liver parameters ( $p < 0.001$ ). During prenatal development, the mean length of the caudate lobe of the liver ranged from  $7.085 \pm 4.09$  mm in the 12 weeks of gestational age to  $15.45 \pm 2.745$  mm in the 28-36th week of fetal life. This dimension increased respectively, length of the caudate lobe can be calculated by regression equation:  $y = 1.88 + (0.429 \times \text{GA in weeks})$ . The mean width of the caudate lobe of the liver ranged from  $4.45 \pm 2.14$  mm in the 12 weeks of gestational age to  $9.62 \pm 2.907$  mm in the 28-36th week of fetal life. The width of the caudate lobe can be calculated by regression equation:  $y = 1.087 + (0.287 \times \text{GA in weeks})$ . At the time of fetal development, the mean length of the quadrate lobe of the liver ranged from  $9.88 \pm 6.35$  mm in the 12 weeks of gestational age to  $23.82 \pm 6.008$  mm in the 28-36th week of fetal life. This dimension increased respectively, length of the quadrate lobe can be calculated by regression equation:  $y = 1.514 + (0.651 \times \text{GA in weeks})$ . The mean width of the quadrate lobe of the liver ranged from  $4.045 \pm 2.43$  mm in the 12 weeks of gestational age to  $12.93 \pm 2.82$  mm in the 28-36th week of fetal life. The width of the quadrate lobe can be calculated by regression equation:  $y = 1.164 + (0.314 \times \text{GA in weeks})$ .

## Discussion

Understanding normal liver growth is essential for tracking healthy fetal development. A study by Kavita M *et al.* [1] observed the length, width of the caudate and quadrate lobe at 12-36 weeks GA. The fetuses that were retrieved were divided into five groups based on gestational ages: group A (12-16 weeks), group B (17-21 weeks), group C (22-26 weeks), group D (27-31 weeks) and group E (32-36 weeks). According to them, the length of caudate was ( $0.6 \pm 0.2$  cm,  $1.6 \pm 0.4$  cm,  $1.2 \pm 0.5$  cm,  $1.7 \pm 0.4$  cm,  $2.0 \pm 0.7$  cm) in males and ( $1.2 \pm 0.5$  cm and  $1.3 \pm 0.3$  cm) in females in groups B, C respectively. They observed the width of the caudate lobe ( $0.4 \pm 0.1$  cm,  $1.0 \pm 0.3$  cm,  $1 \pm 0.8$  cm,  $1.3 \pm 0.4$  cm,  $1.5 \pm 0.5$  cm) in males and ( $0.9 \pm 0.3$  cm at group B and  $0.9 \pm 0.4$  cm at group C) in females respectively. The length of the Quadrate lobe was  $0.9 \pm 0.1$  cm,  $1.5 \pm 0.3$  cm,  $1.8 \pm 0.8$  cm,  $1.9 \pm 0.8$  cm,  $3.1 \pm 1.0$  cm in males whereas  $1.5 \pm 0.2$  cm and  $1.6 \pm 0.4$  cm in female at B & C group. The width of the Quadrate lobe was  $0.4 \pm 0.2$  cm,  $1.0 \pm 0.4$  cm,  $0.9 \pm 0.3$  cm,  $1.1 \pm 0.4$  cm, and  $1.5 \pm 0.6$  cm in males. The female width of the Quadrate lobe was  $0.9 \pm 0.3$  cm in group B and  $1.1 \pm 0.3$  cm in group C respectively. These findings are quite similar to our study.

In a study conducted by Mamtha H *et al.* [4] shows that the length and width of the quadrate lobe were  $21.5 \pm 5.5$  mm and  $11.1 \pm 3.5$  mm. The length and width of the caudate lobe were  $15.6 \pm 5.3$  mm and  $10.2 \pm 2.6$  mm respectively.

Study by Monika P *et al.* [9] assessed the quantitative anatomy of the liver's visceral surface in the human fetus. In terms of gestational ages, the obtained fetuses were categorized as group 18-21 weeks, group 22-25 weeks, and group 26-30 weeks, whereas each group is separated into male and female. According to them, the mean value and standard deviation circumference of the quadrate lobe was ( $38.4 \pm 6.2$  mm,  $42.8 \pm 10.1$  mm,  $61.2 \pm 6.7$  mm) in males and ( $38.7 \pm 7.7$  mm,  $46.6 \pm 9$  mm,  $61.6 \pm 9.6$  mm) in female. Circumference of the caudate lobe was ( $32.5 \pm 6.4$  mm,  $42.4 \pm 4.7$  mm, and  $48.5 \pm 10.6$  mm) in males and ( $42.0 \pm 7.0$ ,  $47.8 \pm 7.7$ ) in females respectively. The results obtained in the current study are similar to their findings.

In the present study, we observed that the circumference of the caudate lobe is ( $26.91 \pm 6.28$  mm,  $37.05 \pm 9.07$  mm,  $36.877 \pm 8.459$  mm,  $42.56 \pm 9.9$  mm,  $48.58 \pm 6.468$  and  $75.72 \pm 9.31$  mm) in males in group-A, B, C, D, E, and F respectively. Circumference of the caudate lobe in females is ( $23.066 \pm 12.87$  mm,  $37.74 \pm 10.23$  mm,  $43.93 \pm 7.58$  mm,  $45.73 \pm 11.23$  mm, and  $79.12$  mm) in groups-B, C, D, E, and F respectively. Circumference of the quadrate lobe in males is ( $32.02 \pm 8.154$  mm,  $38.56 \pm 14.08$  mm,  $44.86 \pm 12.6$  mm,  $51.46 \pm 10.014$  mm,  $56.62 \pm 9.017$  mm, and  $87.57 \pm 12.48$  mm) in group-A, B, C, D, E, and F respectively. Whereas the circumference of the quadrate lobe in females was observed that  $27.963 \pm 17.8$  mm,  $42.56 \pm 10.46$  mm,  $51.85 \pm 9.36$  mm,  $66.57 \pm 15.026$  mm, and  $83.36$  mm in the group-B, C, D, E, and F respectively. The length of the caudate lobe observed that  $7.085 \pm 4.09$  mm,  $8.37 \pm 3.762$  mm,  $9.056 \pm 2.033$  mm,  $11.91 \pm 2.697$  mm,  $12.269 \pm 3.06$  mm, and  $15.45 \pm 2.745$  mm in group-A, B, C, D, E, and F respectively. The width of the caudate lobe observed that  $4.45 \pm 2.14$  mm,  $4.628 \pm 1.912$  mm,  $6.151 \pm 1.494$  mm,  $7.472 \pm 1.995$  mm,  $9.027 \pm 3.428$  mm, and  $9.62 \pm 2.907$  mm at group-A, B, C, D, E, and F respectively. The length of the quadrate lobe observed that  $9.88 \pm 6.35$  mm,  $10.56 \pm 5.878$  mm,  $12.929 \pm 3.689$  mm,  $16.083 \pm 2.929$  mm,  $17.847 \pm 4.94$  mm, and  $23.826 \pm 6.008$  mm in group-A, B, C, D, E, and F respectively. The width of the quadrate lobe observed that  $4.045 \pm 2.43$  mm,  $5.474 \pm 2.728$  mm,  $6.931 \pm 1.724$  mm,  $8.218 \pm 2.4$  mm,  $8.384 \pm 3.967$  mm and  $12.933 \pm 2.823$  mm in group-A, B, C, D, E, and F respectively. A study by Monika P *et al.* [10] also had similar findings.

A study by Soner A *et al.* [11] observed that the length of CL was  $5 \pm 1$  mm,  $10 \pm 3$  mm,  $16 \pm 3$  mm and  $18 \pm 4$  mm in the first, second, third and full term fetus respectively. Width of CL was  $4 \pm 1$  mm,  $7 \pm 2$  mm,  $11 \pm 2$  mm and  $13 \pm 3$  mm in the first, second, third and full term fetus respectively. Length of QL was  $8 \pm 1$  mm,  $14 \pm 4$  mm,  $23 \pm 6$  mm and  $29 \pm 5$  mm in the first, second, third and full term fetus respectively. Widths of QL was  $4 \pm 1$  mm,  $8 \pm 3$  mm,  $13 \pm 4$  mm, and  $17 \pm 5$  mm in the first, second, third and full term fetus respectively. He demonstrated a high positive correlation between the sizes of the CL and the QL and the GA. Comparisons of these parameters among groups revealed no significant difference in the height of the CL between the 3rd and 4th groups, while the widths of the caudate and QL as well as the lengths of the QL demonstrated a significant increase ( $p < 0.05$ ). There were no differences in the parameters between males and females, this study is lower grade similar to our study. We found highly significant correlations between the circumference of the caudate and quadrate lobe with gestational age ( $< 0.0001$ ). The present study is quite similar to the other studies. Simultaneously, the length and width of the caudate and quadrate are also statistically highly significant ( $p < 0.0001$ ) in all age groups to correlate between the morphometric parameter of the caudate and quadrate lobe of the liver with gestational age.

### Limitations

The morphometric study of the fetal liver about its gestational age was carried out solely based on gross morphological aspects. In further studies, the research can be broadened by observing the histological appearance of cells by using modern technology.



## Conclusion

This present study concluded that there is a significant correlation between the length, width, and circumference of the caudate and quadrate lobe with the gestational age. The outcomes of this study would be valuable for liver ultrasonography examinations. To calculate the lengths and widths of QL and CL prenatally, regression equations were used in this work. The results of this study will be valuable for liver ultrasound examinations and will also be relevant for evaluating fetal autopsy evidence.

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