International Journal of Basic and Applied Medical Sciences ISSN: 2277-2103 (Online)
An Online International Journal Available at http://www.cibtech.org/jms.htm
2013 Vol. 3 (2) May-August, pp.102-109/Wazir and Mahajan
Research Article

PRENATAL MORPHOMETRIC ANALYSIS OF HUMAN FETAL GALL BLADDER

***Sangeeta Wazir and Anupama Mahajan**
Department of Anatomy, SGRDIMSAR, Amritsar, Punjab, India
**Author for Correspondence*

ABSTRACT
Study was conducted in Department of Anatomy, SGRDIMSAR, Amritsar on twenty formalin embalmed spontaneously aborted foetuses, collected from Department of Obstretrics and Gynaecology, SGRDIMSAR, Amritsar after taking consent from the parents. The age group chosen for the study was from 10 weeks to full term. Gestational age of fetus was calculated from CR Length of fetus .The foetuses were then dissected and gall bladder was taken out and the dimensions Gall bladder length and Anteroposterior diameter were calculated using vernier callipers. The measurements were then analysed statistically and inference drawn. Regression equations were also calculated.

Key Words: *Fetuses, CR Length, Vernier Callipers, Regression Equations*

INTRODUCTION
The gall bladder is a storage reservoir that allows bile acids to be delivered in a high concentration and a controlled manner to the duodenum for solubilization of dietary lipid (Shaffer, 2000). It is a distensible pear shaped structure 3 cm in width and 7 cm in length having a capacity of 30-50 ml (Touli and Craig, 2000; Frierson, 1989). The gall bladder is greyish blue in colour and usually lies recessed into the undersurface of the right lobe of the liver (Standring, 2008). It resembles a sack with a single opening and this opening is continuous with the cystic duct (Gartner and Hiatt, 2009). Gall bladder consists of a fundus, body and neck. The fundus rests on the anterior aspect of the proximal transverse colon while the body abuts on the first part of duodenum and is attached to the right lateral margin of the lesser omentum. The narrowed body passes upwards, backwards and to the left on the undersurface of the liver to approach the portal fissure. Here it continues as the neck of the gall bladder from which a small pouch (Hartman's pouch) may project down. In the region of the neck of gall bladder and the first part of the cystic duct, the mucosa is convoluted to form 5-7 fold spiral valve of heister which controls the entry and exit of bile (Glasby, 1999). The gall bladder forms a part of the biliary system. Other structures included in the biliary system are the liver and bile ducts. The biliary tract consists of the organs and ducts that produce, transport, store and secrete bile into the duodenum (Sharma, 2004). The gall bladder is supplied by cystic artery, which usually arises from right hepatic artery (Frierson, 1989). The cystic artery divides into two branches near the neck of the gall bladder into, a superficial branch and a deep branch. The superficial branch supplies the serosal surface and the deep branch supplies the interior layers of the gall bladder. However, variations in the origin and course of cystic artery are common. Because cystic artery is the end artery, the gall bladder is particularly susceptible to ischemic injury and necrosis resulting from the inflammation and interruption of hepatic arterial flow.
Embryologically, liver develops from a hepatic bud which arises from a thickened area of endoderm (hepatic rudiment) which appears at the fourteen somite stage in the region of junction of foregut and yolk sac. The hepatic bud grows ventrally and headwards within the mesogastrium, and reaches the septum transversum where it divides into right and left branches. Each branch gives rise to clusters of liver cells, the hepatic cylinders, which form two solid masses. These form the right and left lobes of liver (Dutta, 2005). During the fourth to fifth week, the hepatic bud begins to branch exclusively. Apart from forming the hepatic cells, these form the biliary apparatus within the liver and also the epithelial lining of the extrahepatic portion of extrahepatic biliary apparatus, including the hepatic duct and the gall bladder. Connective tissue and smooth muscle in the hepatic ducts and gall bladder arise from the splanchnic

mesoderm surrounding appropriate branches of the liver diverticulum (Johnson, 1989). The capsule and stroma are derived from the septum transversum (Bhatnagar *et al.*, 1969). The gall bladder is initially tubular in shape, and undergoes morphological changes to become saccular during the 11th week of gestation. The extrahepatic bile ducts elongate and widens as gestation progresses and intramural glands develop. The extrahepatic bile duct is well defined tubular structure by the 6th week of gestation. The intrahepatic bile ducts are in luminal continuity with the extrahepatic bile duct throughout the gestation at the portahepatis. The major bile ducts are fully formed by the 16th week of gestation (Tan and Vijayan, 2001). At 10 weeks of gestation, the gall bladder lies in a pre formed bed deeply submerged within the right lobe of the liver. At about 12 weeks gestational age, an internal demarcation between the body and fundus becomes visible. This is due to concentric mucosal elevation forming midway on the inner surface. In second trimester, after 12 weeks gestational age, a Hartmann's pouch becomes readily visible[8]. Anomalies of number may range from absent to duplications (Meilstrup, 1991). Study of the morphometry and development is important as the diseases of gall bladder whether congenital or acquired are increasing. Keeping in view the importance of the knowledge of the gross anatomy and developmental anatomy of gall bladder and other biliary tract, it was thought worthwhile to conduct the present study to find out the developmental sequences and morphometry of human fetal gall bladder.

Aims and Objectives

Lot of clinical knowledge is available about the pathological conditions of Hepatobiliary system. As the exact knowledge about the developmental anatomy of gallbladder is important to understand the wide range of congenital anomalies of the viscera, our study was just an attempt to add up in the literature on the morphological and histological development of gallbladder. We did this study with the aim:

1. To measure the crown-rump length of fetus using vernier calipers.
2. To calculate the gestational age of the fetus from the crown-rump length.
3. To carry out morphometry (GBL & APD) of fetal gall bladder at various gestational age.

MATERIALS AND METHODS

The present study was conducted in Department of Anatomy, SGRD Institute of Medical Sciences and Research, Amritsar on 20 formalin embalmed foetuses in the age group of 10 weeks to 36 weeks with no congenital anomaly. The foetuses were collected from the Department of Obstetrics and Gynecology, SGRD Institute of Medical Sciences and Research, Amritsar. Crown rump length of the foetuses was measured between the vertex of the scalp and the midpoint of apices of buttocks. Then we used the formula described by Hamilton, Boyd and Mossman for calculation of gestational age.

Rule applied was:

Age of embryo/fetus	Crown – rump length
32 days	5mm
33-55 days	5mm + 1mm/day
56 days onwards	Calculated crown-rump length at 55 days + 11/2 mm

After calculating the gestational age of fetus, we took the measurements of gallbladder. We exposed the gallbladder by making an inverted "U" shaped incision on the anterior abdominal wall. . Evisceration of liver was done along with attached gallbladder. We saw for any congenital anomalies of liver and gallbladder. The gallbladder was separated from its bed and measurements of the gallbladder were taken using vernier calliper. The dimensions taken were: Gall bladder length and anteroposterior diameter. The dimensions were then analysed statistically.

Observations

The present study was conducted in Department of Anatomy, SGRD Institute of Medical Sciences and Research, Amritsar. The study was done on 20 spontaneously aborted foetuses with the gestational age of 10 weeks to full term. The foetuses were collected from the Department of Gynaecology and Obstetrics, SGRD Institute of Medical Sciences and Research, Amritsar. Written consent of the parents was taken

before starting the thesis work on the foetuses. The CR Length of the foetuses was measured with the help of vernier calliper. The gall bladder was taken out after dissecting the foetus and the measurements of the gallbladder were taken.
The gestational age of the foetus was calculated from the CR Length using the formula given by Hamilton, Boyd and Mossman for calculation of gestational age (table 1).

Rule applied was:

Age of embryo/ fetus	Crown – rump length
32 days	5mm
33-55 days	5mm + 1mm/day
56 days onwards	calculated crown-rump Length at 55 days + 11/2 mm/day

Table 1: Showing calculated gestational age

S.No.	Crown Rump Length(mm)	Gestational Age (days)
1.	217	181
2.	52.5	72
3.	50.5	70
4.	136.3	127
5.	93.5	99
6.	338	262
7.	58	75
8.	174	153
9.	134.8	126
10.	92	98
11.	240	196
12.	178	155
13.	95	100
14.	95	100
15.	270	216
16	174	152
17	165	146
18	267	214
19	155.5	140
20	176.5	154

Using these calculated gestational ages of the foetuses, a master chart was made putting all the measurements of the gall bladder (Table 2).

Table 2: The master chart

Gestational	Gall Bladder measurements	
Age(days)	**GBL**	**APD**
181	18.3	06.0
72	11.2	04.1
70	11.1	04.1
127	15.4	06.8
99	12.4	04.9
262	33.5	10.1
75	12	04.5
153	16.1	05.6
126	12.9	03.3
98	12.2	04.8
196	31.1	07.1
155	16.2	05.7
100	12.6	05.1
100	12.8	05.8
216	25.1	12.3
152	19.8	06.1
146	19.0	06.6
214	25.1	12.3
140	15.9	06.2
154	19.9	06.3

These measurements were statistically analysed using SPSS software and the findings are given in tabulated form (table 3)**.**

Table 3: Showing the range, mean, standard deviation and standard error of mean

	N	**Range**	**Mean ± SD**	**SEm**
Crown rump length	20	51-338	158.13 ± 78.97	17.658
Gestational Age	20	70- 262	141.81± 52.516	11.743
Gall Bladder length	20	11.1-33.5	17.630±06.5412	01.4627
Antero posterior diameter	20	3.30-12.30	06.1250±02.327	0.520

N= number of foetuses studied *SEm- standard error of mean*

The range for the crown rump length was 51-338mm. The mean value of CR length was 158.13mm. The standard deviation was 78.97mm and standard error of mean was 17.658mm.
The range for gestational age was 70-262days.The mean value of GA was 141.81days. The standard deviation was 52.516days and standard error of mean was 11.743days.
The range for gall bladder length was 11.1-33.5mm. The mean value of GBL was 17.630mm.The standard deviation was 6.5412mm and standard error of mean was 1.4627mm.
The range for anteroposterior diameter was 3.0-12.0mm. The mean value of APD was 6.13mm. The standard deviation was 02.327mm and standard error of mean was 0.520mm.
The table 4 given below shows the Pearson Coefficient and depicts the relationships of dimensions.

Table 4: Depicting the Pearson coefficient "r" and significance "p" values of Gall Bladder dimensions in foetuses

		GA	GBL	APD
CR	r	1.000	0.928	0.616
	p	<0.001***	<0.001***	0.004**
GA	r		0.928	0.614
	p		<0.001***	<0.01**
GBL	r			0.553
	p			0.011*

GA- gestational age, GBL- gallbladder length, APD-anteroposterior diameter
r- Pearson coefficient
p- Significance
If p > 0.05 Not Significant, p < 0.05 Significant at 5%, p < 0.01 Significant at 1%, p < 0.001 Highly Significant.

The relationship of CR Length with GA and GBL is highly significant but with APD is significant at 1%.
The relationship of GA with CR and GBL is highly significant but with APD is significant at 1%.
The relation of GBL with CR and GA is highly significant but with APD is significant at 5%.
The relation of APD with CR and GA is significant at 1% and with GBL is significant at 5% (table-4).
Regression equations for gall bladder dimensions are GBL(y) = 1.24 + 0.12 x GA (days) (Table 6)

Table 5: Depicting regression values of GBL with GA

	Model Summary					Parameter Estimates	
Equation	r^2	F	df1	df2	Sig.(p)	Constant	b1
Linear	0.861	111.046	1	18	<.001	1.24	0.12

The curve between GBL and GA is linear

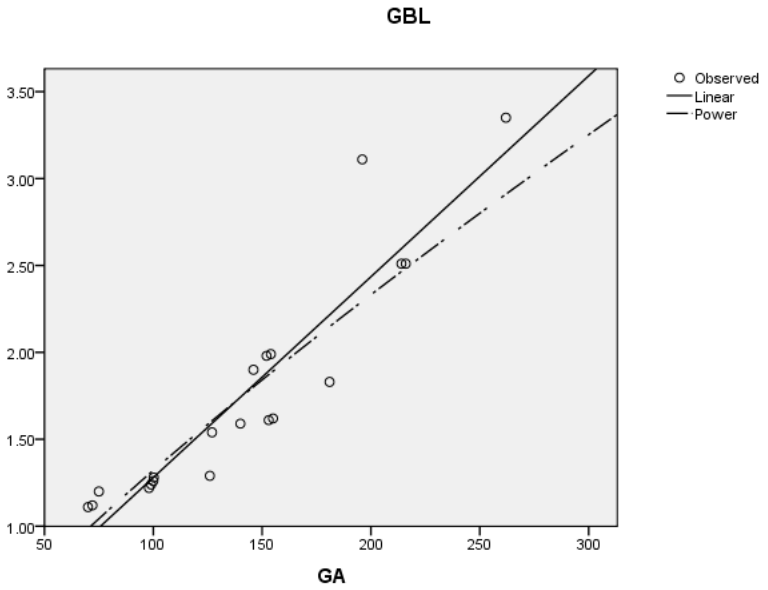

Figure 1: Scatter diagram to show relationship between GA and GBL

APD(y) = 02.27 + 0.03× GA (days) (table -6)
The curve between APD and GA is linear (figure 2).

Table 6: Depicting regression values of APD with GA

	Model Summary					**Parameter Estimates**	
Equation	r^2	F	df1	df2	Sig.	Constant	b1
Linear	0.377	10.908	1	18	<.01	2.27	0.03

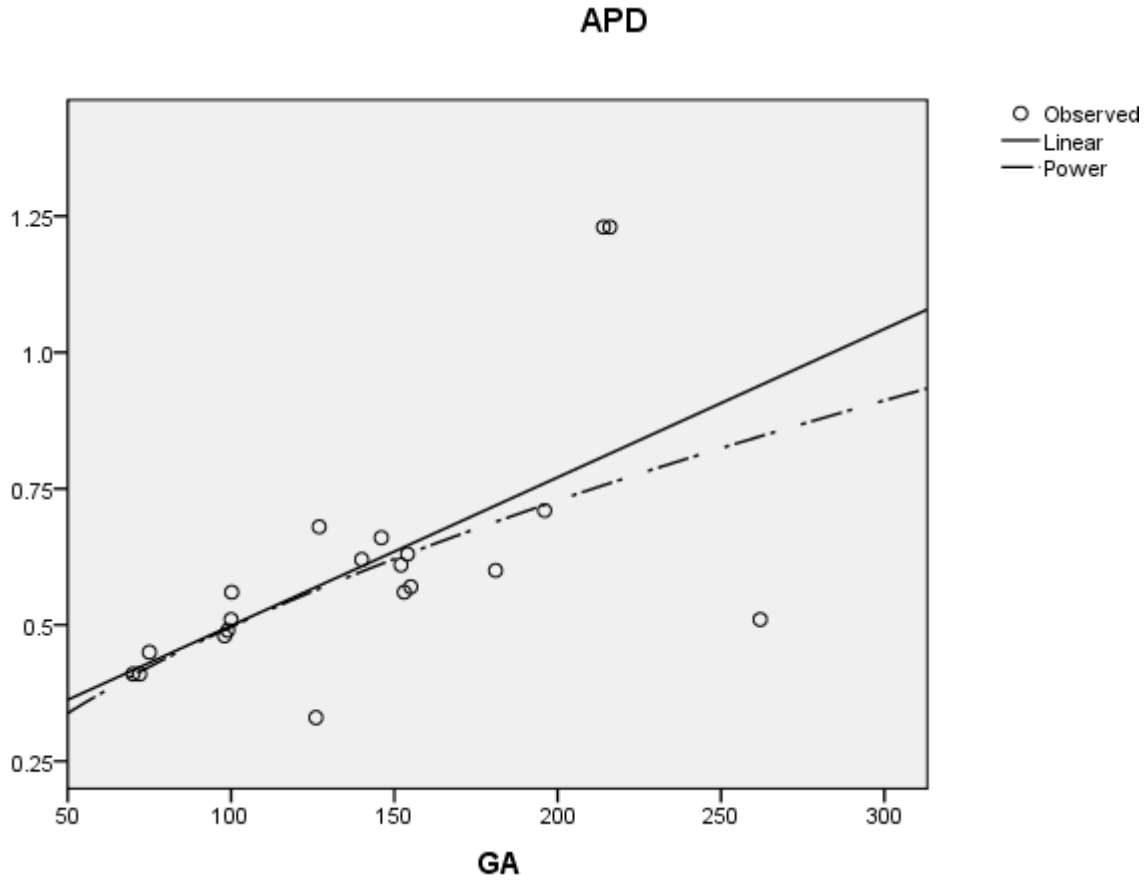

Figure 2: Scatter diagram to show relationship between GA and APD

DISCUSSION

In our study we had taken the spontaneously aborted foetuses from 10 weeks to full term and those foetuses were taken which were not showing any apparent congenital anomaly. The measurements of gall bladder were taken using vernier calliper and various parameters studied were: GBL, APD, IFW and FW. The readings were statistically analysed.

In the present study all the parameters of the gallbladders showed a linear growth pattern. There are three reports on the growth of the fetal gallbladder measured by ultrasonography between 15 weeks gestational age and term (Hata *et al.*, 1987; Goldstein *et al.*, 1994; Chan *et al.*, 1995). In two investigations Hata *et al.*, (1987) and Chan *et al.*, (1995), the fetal gallbladder size increased linearly until 30 weeks of gestation, and became constant. However, in a third investigation Goldstein *et al.*, (1994), a linear growth function between fetal gallbladder size and gestational age was observed throughout pregnancy. But in

the study done by Haffajee (2000), the growth showed a curvilinear growth pattern. Our study showed a pattern similar to Goldstein *et al.,* (1994).

Using the Pearson Correlation analysis we calculated the strength of relationship between various parameters. All the parameters had significantly positive relationship with the gestational age. The relation between the GBL, IFW and FW with GA was significantly positive. The relationship between APD and GA was significant at 1%. The same results were found in the study done by Moon *et al.,* (2007), Goldstein *et al.,* (1994) and Albay *et al.,* (2010).

The mean gall bladder length in our study was 11.1 – 33.5 mm whereas the mean gall bladder length in Haffajee (2000), study done on foetuses was 2.21 – 281.6mm. The lowest and the highest gallbladder length is more in our study in comparison to Haffajee (2000).The mean anteroposterior diameter in our study was 03.0 – 12.0 mm but the mean anteroposterior diameter for the same gestational age ranged from 0.90.3 – 9.03.3 mm as per (Haffajee, 2000). Our readings are more as compared to Haffajee (2000).

Table 7: Comparison of fetal gall bladder measurements

Parameter (mm)	Haffajee (2000)	Present study (2012)
GBL	2.21- 28.1.6	11.1- 33.5
APD	0.90.3 – 9.03.3	03.0-12.0

GBL- Gall bladder length *APD- Anteroposterior diameter*

The ‘r’ value for GBL in our study is more close to the ‘r’ value in study of Wei et al in comparison to the studies of Moon et al and Goldstein et al. The ‘r’ value for APD in study of Moon et al is close to the ‘r’ value in our study (table-8).

Table 8: Comparison of “r” values of gall bladder parameters

Parameters	Present study	Wei *et al.,*	Moon *et al.,*	Goldstein *et al.,*
GBL	0.928	0.85	0.741	0.7767
APD	0.614	----------	0.598	----------

GBL- Gallbladder length *APD- Anteroposterior diameter*
r- Pearson coefficient

The regression equations for GBL in our study is GBL(y) = 01.24 + 0.12 x GA and according to Goldstein et al the equation is y = - 0.41060 + 0.0907×GA.

Table 9: Comparison of linear regression equations for the calculations of gall bladder parameters:

Parameters	Present study	Goldstein *et al.,*
GBL	y= 01.24 + 0.12× GA	y = - 0.41060 + 0.0907× GA

GBL- Gallbladder length *GA- gestational age*

Conclusion

This study was undertaken at Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar with the aim of finding the correlation between the gestational age and the individual measurements of fetal gall bladder.

The conclusion drawn from the study was that:

- The range for gestational age was 70-262 days. The mean value of GA was 141.81days. The standard deviation was 52.516days and standard error of mean was 11.743days. The range for the crown rump length was 51-338mm. The mean value of CR length was 158.13mm. The standard deviation was 78.97mm and standard error of mean was 17.658mm.
- The range for gall bladder length was 11.1-33.5mm. The mean value of GBL was 17.630mm.The standard deviation was 6.5412mm and standard error of mean was 1.4627mm.

- The range for anteroposterior diameter was 3.0-12.0mm. The mean value of APD was 6.13mm. The standard deviation was 02.327mm and standard error of mean was 0.520mm.
- The relationship of GA with CR and GBL was highly significant but with APD wais significant at 1%.
- The regression equation for Gallbladder length (GBL) is GBL(y) =1.24+ 0.12 x GA (days).
- The regression equation for Anteroposterior diameter is APD(y) =02.27+ 0.03× GA (days).
- The scatter diagram for all the measured variables with gestational age was linear.

REFERENCES

Albay S, Malas MA, Koyuncu E and Evcil EH (2010). Morphometry of the gallbladder during fetal period. *Surgical and Radiologic Anatomy* **32**(4) 363-9.

Bhatnagar SM, Kothari ML and Mehta LA (1969). Essentials of Human Embryology **2** Bombay (Orient Longman) 123.

Chan L, Rao BK and Jiang Y *et al*., (1995). Fetal gallbladder growth and development during gestation. *Journal of Ultrasound Medicine* **14** 421-25.

Dutta AK (2005). Essentials of Human Embryology **5**. Calcutta (Current Books International) 142.

Frierson HF (1989). The gross anatomy and histology of the gall bladder, extrahepatic bile duct ducts, vaterian system and minor papilla. *American Journal of Surgical Pathology* **13** 146.

Gartner LP and Hiatt JL (2009). Color textbook of histology **3**. India (Elsevier) 434-36.

Glasby MA, Owen WJ and Kristmundsdottir F (1999). The Liver, Biliary system, Pancreas and Spleen. In: Applied Surgical Anatomy (Butterworth- Heinemann Publishers) 115-6.

Goldstein I, Tamir A, Weisman A, Jakobi P and Copel JA (1994). Growth of the fetal gall bladder in normal pregnancies. *Ultrasound in Obstetrics and Gynecology* **4**(4) 289-93.

Haffajee MR (2000). The fetal gallbladder morphology and morphometry by microdissection. *Journal of Surgical Radiological Anatomy* **22** 261- 70.

Hata K, Aoki S, Hata T, Murao F and Kitao M (1987). Ultrasonographic identification of the human fetal gall bladder in utero. *Gynecologic and Obstetric Investigation* **23**(2) 79-83.

Johnson KE (1989). Human Developmental. Singapore (John Wiley & Sons) 212-3.

Meilstrup JW, Hopper KD and Theime GA (1991). Imaging of the gall bladder variants. *American Journal of Radiology* **157** 1205-08.

Moon MH, Cho JY, Kim JH, Lee YH, Jung SI, Lee MS and Cho HC (2008). In utero development of the fetal gallbladder in the Korean population. *Korean Journal of Radiology* **9**(1) 54-8.

Shaffer EA (2000). Control of gall bladder motor function. *Alimentary Pharmacology and Therapeutics* **14**(2) 2-8.

Sharma S (2004). Development of Biliary Tract. Encyclopedia of Gastroenteroogyl: Emroy University Hospital, USA 210-11.

Standring S (2008). Gray's anatomy The anatomical basis of clinical practice. In: Borley NR, Healy JC. Abdomen and Pelvis **40**. Spain (Churchil Livingstone Elsevier.) 1177.

Tan CE and Vijayan V (2001). New clues for the developing human biliary system at the porta hepatis. *Journal of Hepatobiliary Pancreatic Surgery* **8**(4) 295- 302.

Toouli J and Craig A (2000). Sphincter of Oddi- Function and Dysfunction. *Canadian Journal of Gastroenterology* **14** 411.

Wei, Haller, Rachlin and Berman (1993). Sonographic evaluation of fetal gallbladder in utero-incidence of visualisation and morphology. *Journal of Diaganostic Medical Sonography* **9**(6) 291-96.