

Difference between the left and right ventricular thickness in fetal heart

¹Dr. Thonthon Daimei, ²Prof. N. Damayanti Devi, ³Dr. Vandana Sinam

^{1,3}Senior Resident, ²Professor and Head, Department of Anatomy Regional Institute of Medical Sciences, Imphal, Manipur

Abstract: The difference in the size of the two ventricles in adult is well known and the ratio of left to right ventricular is 3:1, the reason being the difference in the resistance of the two circulations i.e. systemic and pulmonary circulation. However, in fetal life the difference in ventricular size remains unknown. Hence, this study is taken up. The fetal heart of different age group was selected from 15-35 weeks. The thickness of the right and left ventricular walls are measured accurately by using metal callipers and charted out. The difference between the two ventricular wall thickness is very minimal and negligible. The right wall was slightly thicker than the left wall. The shape of the ventricular cavity also looked different as the right cavity is oval while the left cavity looks rounded. The ventricular septum is also mildly convex towards the right side. On the contrary to the findings in adult as 3:1 ratio in terms of ventricular wall thickness the fetal ventricular size remains almost the same. The photographs of horizontal sections just below the coronary sulcus are presented and the increasing size as age advances is presented in details.

Keywords: Fetal heart, Ventricular wall thickness, Slide calliper.

I. Introduction

The difference in the size of the two ventricles in adult is well known and the ratio of left to right ventricular is 3:1, the reason being the difference in the resistance of the two circulations i.e. systemic and pulmonary circulation. However, in fetal life the difference in ventricular size remains unknown.

The concept of right ventricular dominance in the human fetus has resulted largely from autopsy studies in which right ventricular weights exceeded left ventricular weights.⁽¹⁻²⁾ The method used in these studies varied widely, and different proportions of the interventricular septum were arbitrarily designated as the right and left ventricles resulting in dissimilar, multiphasic ventricular growth curves³.

Recently attempts have been made to characterise cardiac growth in the fetus with real-time ultrasound but have provided conflicting results as to the ventricular size. Also, measurement of cardiac chamber sizes with ultrasound is restricted to the later half of the second trimester due to the limited resolution of currently available echocardiographic instrumentation⁴⁻⁸. There was no study done so far on gross anatomy of fetal heart especially on ventricular thickness, most of the study focus only by ultrasonography which has many limitation.

The magnitude and time course of the previously described differences between right and left ventricular weights during gestation are not explained by concomitant changes in the pulmonary circulation or the fetal lungs. The present study attempts to find the difference in ventricular size in fetal heart. The gestational age of fetus was established from CRL and menstrual age.

II. Materials and methods

This study was conducted in the department of Anatomy, Regional Institute of Medical Sciences, Imphal(RIMS), after obtaining due permission from the ethical committee. These fetuses were collected from the Department of OBS & GYN, RIMS with due permission from concerned parties and authorities. Any fetus showing gross maceration and malformation was excluded from the study. Age of the fetuses were determined from the LMP and CRL. 14 fetal hearts at gestational age from 15 to 35 weeks were dissected. Ventricular wall thickness of left and right side were measured with the help of slide callipers just below the coronary sulcus.

III. Results

Gestational age (weeks)	Right ventricle	Left ventricle
35	4mm	3.5mm
34	4mm	4mm
32	3mm	3mm
30	3.5mm	3mm
28	3.5mm	3mm
26	3mm	2.5mm
25	2.5mm	2mm
25	3mm	2.5mm
19	2.5mm	2mm

19	2.5mm	2mm
18	2.5mm	2mm
17	2mm	2mm
16	2mm	2mm
15	1.5mm	1mm

In the earliest age group i.e. 15 weeks, the right ventricle measure 1.5mm which is slightly bigger than the left ventricular dimension which measure only 1mm at its widest dimension. In subsequent age groups i.e. from 16 and 17 weeks, the right ventricle grows to 2mm. This is the stage whereby ventricle shows similar dimension. The right ventricle measured 2.5mm at 19 weeks whilst left ventricle is slightly smaller than left i.e measures only 2mm. Following the further development of ventricular size from 25th upto 30th weeks of gestational age, the right ventricle consistently shows bigger dimension than the left. Measurement of ventricular size at 35 weeks still shows right ventricles thicker than left ventricle, i.e 4mm and 3.5mm. Thus, on the contrary to the finding of increased thickness of left ventricle than right ventricle in the adult heart, during fetal life the right ventricular size is slightly bigger than left ventricle.

The difference between the two ventricular wall thickness is very minimal and negligible. The right wall was slightly thicker than the left wall. The shape of the ventricular cavity also looked different as the right cavity is oval while the left cavity looks rounded as shown in fig.1 to 3. The ventricular septum is also mildly convex towards the right side. On the contrary to the findings in adult as 3:1 ratio in terms of ventricular wall thickness the fetal ventricular size remains almost the same. The photographs of horizontal sections just below the coronary sulcus is presented and the increasing size as age advances is presented in details

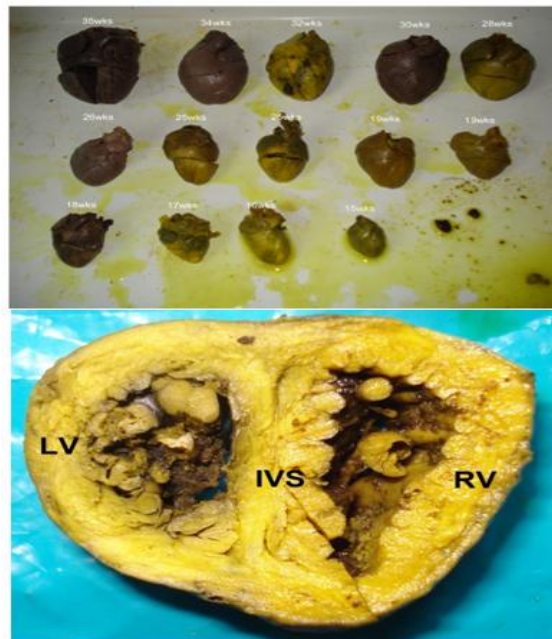


Fig.1. Fourteen fetal hearts in serial descending order from 35 wk to 15 wk and cut section just below the level of coronary sulcus.

35 WEEKS



Fig. 2- heart of 35 weeks showing ventricular thickness cut just below the coronary sulcus.

15 WEEKS



Fig.3. fetal heart of 15 weeks showing ventricular thickness cut just below the coronary sulcus.

IV. Discussion

Mandorla S, et al in their study on fetal heart by real-time-directed M-mode ultrasound from the 19th gestation week until term opined that left ventricular, right ventricular, left atrial and right atrial chamber size, interventricular septum thickness, right and left wall thickness, aortic and pulmonary diameter all increased linearly with age which was similar with the present study. Right ventricle (10.1 ± 3.1) was slightly larger than left ventricle (9.2 ± 2.8 mm) (p less than 0.001), the pulmonary artery (7.9 ± 1.9 mm) was greater than the aorta (7.6 ± 2 mm) (p less than 0.001), while no significant difference was noted between left atrium (10.8 ± 3.5 mm) and right atrium (10.1 ± 2.6 mm), right ventricular wall thickness (2.7 ± 0.9 mm) and left ventricular wall thickness (3.0 ± 1.1 mm). The ratios of left ventricular/right ventricular diameter, left atrial/right atrial and left atrial/aortic diameters, the relative wall thickness and arterial vessels diameters did not change significantly throughout the pregnancy. The ratio of interventricular septum/posterior wall thickness was 1.14 ± 0.36 and ratio of 1.5 or greater was found in 14.5% of the fetal normal heart. The ratio of left atrial/aortic diameter was 1.32 ± 0.21 and left atrium was significantly greater than aorta (p less than 0.001).¹² ST. John Sutton et al, quantitated the growth patterns of the normal fetal heart and the right and left ventricles from postmortem hearts obtained from 55 spontaneously aborted human fetuses from 8 to 40 weeks. The right and left ventricular wall thicknesses did not differ significantly but is seen increasing linearly. This similarities in free wall weights, wall thicknesses, and surface areas indicate that the right and left ventricles grow at the same rate throughout the period of gestation from completion of cardiogenesis to term, and do not support the presence of right ventricular dominance in the developing human fetal heart.⁶ Kim HD, et al in their study on Human fetal heart development after mid-term: morphometry and ultrastructural shows that the growth of both ventricular walls, the interventricular septum and that of both ventricular cross-sectional areas showed linear regression, and the left-to-right wall thickness ratios were nearly constant. Also, there were no differences in morphometric data between the left and right ventricles. Their statistical results do not support the theory of the right ventricular dominance during the fetal period.¹³ Cavalcanti JS, et al opined that the thicknesses of the anterior and posterior right ventricular walls were, respectively, 5.00 ± 1.70 mm and 3.83 ± 0.91 mm. The thicknesses of the anterior and posterior left ventricular walls were, respectively, 4.25 ± 0.87 mm and 4.14 ± 0.89 mm. The thickness of the interventricular septum measured 4.10 ± 1.13 mm. The ventricular thickness in this study is similar when compared with the present study.

The present study characterise the right and the left ventricular growth of the human fetal heart with gestational age and body habitus from the early part of second trimester to birth. This period cover the whole cardiac growth phase from after completion of cardiogenesis until term. Assessment of the ventricular growth in terms of wall thickness was done by measuring the right and left ventricular wall just below the coronary sulcus. Although measurement of ventricular wall thickness could not be regarded as representative of and diastolic thickness in vivo, assessment of changes in wall thickness with gestational age allowed us to examine the increasing ventricular muscle mass as the two ventricular chambers grew in size. In our study right and left ventricular thickness did not differ significantly, increasing linearly and at the same rate with the gestational age and body size.

The similarities between right and left ventricles may be explained by closer scrutiny of their respective function. During fetal life oxygenated blood from the placenta is slip-streamed from the ductus venosus via the inferior vena cava to the left atrium through a widely patent foramen ovale⁹⁻¹⁰. In the presence of such large intraatrial communication preload in the two ventricles must be the same. In addition the right ventricle eject more than 95% of its stroke volume into the systemic circulation via the ductus arteriosus throughout the

gestation¹¹. The ductus arteriosus has a similar diameter to the pulmonary trunk and ascending aorta and since both ventricles effectively eject into a common systemic circulation, their afterloads must be very similar. The right and the left ventricles may therefore be regarded as two muscular pumps working in parallel with the same preload and similar afterloads. Since afterload is a major determinant of ventricular muscle mass, then from a mechanical standpoint, right and left ventricular muscle masses should be same.¹⁴ Thus the anatomic findings of similar right and left ventricular wall thickness throughout gestation are consistent with these theoretical mechanical considerations.

V. Conclusion

We conclude that wall thickness of right and left ventricles do not differ much and grow at the same rate throughout the gestation and right ventricle is slightly thicker than the left ventricle.

REFERENCE

- [1]. Emery JL, Macdonald MS: The weight of the ventricles in the late week of intra-uterine life. *Br Heart J* 22:563, 1960.
- [2]. Muller W: Die Massenverhältnisse des Menschlichen Herzens. Leopold Voss, Hmburg and Leipzig 1883. Quoted by Bardeen CR in Determination of the size of the heart by means of X-Rays. *Am J Anat* 23: 423,1918.
- [3]. Smith HL: The relation of the weight of the heart to the weight of the body and the weight of the heart of age. *Am Heart J* 29: 79,1928-29.
- [4]. Sahn DJ, Lange LW, Allen HD, Goldberg SJ, Anderson C, Giles H, Haber K: Quantitative real-time cross-sectional echocardiography in the developing normal human fetus and newborn. *Circulation* 62: 588, 1980.
- [5]. Allan LD, Joseph MJ, Boyd EGCA, Campbell S, Tynan MI: M-mode echocardiography in the developing human fetus. *Br Heart J* 47:573, 1932.
- [6]. St. John Sutton MG, Gewitz MH, Shah B, Cohen A, Reichek N, Gabbe S, Huff DS: Quantitative assessment of cardiac chamber growth and function in the normal human fetus: a prospective longitudinal echocardiographic study. *Circulation* 69: 645, 1984.
- [7]. Wladimiroff JW, McGhie JW: M-mode ultrasonic assessment of fetal cardiovascular dynamics. *Br J ObstetGynaecol* 88: 1241, 1981.
- [8]. Wladimiroff JW, Vosters R, McGhie JS: Normal cardiac ventricular geometry and function during the last trimester of pregnancy and early neonatal period. *Br J ObstetGynaecol* 89: 839, 1982.
- [9]. Rudolph AM, Heymann MA: Circulatory changes during growth in the fetal lamb. *Circ Res* 26: 289, 1970.
- [10]. Kurtz AB, Warner RJ, Kurtz RJ, Dershaw DD, Rubin CS, Cole-Beuglet C, Goldberg BB: Analysis of biparietal diameters as an accurate indicator of gestational age. *J Clin Ultrasound* 8: 319, 1980
- [11]. Grossman W, Jones D, McLaurin LP: Wall stress and patterns of hypertrophy in the human left ventricle. *J Clin Invest* 56:56, 1975.
- [12]. Mandorla S, Narducci PL, Bracalente B, Pagliacci M. Fetal echocardiography. A horizontal study of biometry and cardiac function in utero: *G ItalCardiol*. 1986 Jun;16(6):487-95.
- [13]. Kim HD, Kim DJ, Lee IJ, Rah BJ, Sawa Y, Schaper J. Human fetal heart development after mid-term: morphometry and ultrastructural study. *J Mol Cell Cardiol*. 1992 Sep;24(9):949-65.
- [14]. Cavalcanti JS, Duarte SM. Morphometric study of the fetal heart: a parameter for echocardiographic analysis. *Radiol Bras* vol.41 no.2 São Paulo Mar./Apr. 2008