

Morphometric study of the fetal heart: a parameter for echocardiographic analysis*

Estudo morfométrico do coração fetal: sua utilização como parâmetro para análise ecocardiográfica

Jennecy Sales Cavalcanti¹, Suzana Marques Duarte²

Abstract **OBJECTIVE:** To evaluate the diameter, perimeter and area of atrioventricular valves as well thickness of ventricular walls and diameter of ventricular cavity of fetal hearts. **MATERIALS AND METHODS:** Twenty fetal hearts at gestational age between 28 and 36 weeks were dissected. A paquimeter with 1/10 mm accuracy was utilized for the following morphological measurements: anteroposterior and transverse diameters, mitral and tricuspid valves areas and perimeters. **RESULTS:** Anteroposterior and transverse diameters of the left atrioventricular valve measured 10.35 ± 1.62 mm and 9.90 ± 1.79 mm, respectively; and anteroposterior and transverse diameters of the right atrioventricular valve measured 10.98 ± 1.90 mm and 9.51 ± 1.81 mm, respectively. Mitral valve area and perimeter were, respectively, 84.06 ± 25.09 mm² and 29.87 ± 3.96 mm. Tricuspid valve area and perimeter were, respectively, 84.49 ± 26.79 mm² and 28.44 ± 3.85 mm. 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 anteroposterior diameter of the right ventricle was 9.25 ± 0.85 mm, and the transverse diameter was 8.24 ± 0.42 mm. The anteroposterior diameter of the left ventricle measured 9.95 ± 0.37 mm, and transverse diameter measured 9.20 ± 0.40 mm. **CONCLUSION:** The role of morphometric data of fetal atrioventricular valves is highly significant in the echocardiographic diagnosis of possible congenital cardiac malformations. *Keywords:* Fetal echocardiography; Fetal circulation; Cardiac malformation; Heart.

Resumo **OBJETIVO:** Avaliar o diâmetro, o perímetro e a área das valvas atrioventriculares do coração fetal, bem como a espessura das paredes ventriculares e os diâmetros das cavidades ventriculares. **MATERIAIS E MÉTODOS:** Foram dissecados 20 corações de fetos com idade gestacional entre 28 e 36 semanas. Em seguida foram medidos os diâmetros ântero-posterior e transverso e aferidos as áreas e os perímetros das valvas mitral e tricúspide, bem como foram medidas as espessuras das paredes ventriculares e os diâmetros de suas cavidades, utilizando-se um paquímetro com acurácia de 1/10 mm. **RESULTADOS:** Os diâmetros ântero-posterior e transverso da valva atrioventricular esquerda mediram, em média, $10,35 \pm 1,62$ mm e $9,90 \pm 1,79$ mm, respectivamente, e os diâmetros ântero-posterior e transverso da valva atrioventricular direita, $10,98 \pm 1,90$ mm e $9,51 \pm 1,81$ mm, respectivamente. A área e o perímetro da valva mitral foram de $84,06 \pm 25,09$ mm² e $29,87 \pm 3,96$ mm, respectivamente. A área e o perímetro da valva tricúspide mediram, respectivamente, $84,49 \pm 26,79$ mm² e $28,44 \pm 3,85$ mm. No ventrículo direito a espessura da parede anterior foi de $5,00 \pm 1,70$ mm e a da parede posterior foi de $3,83 \pm 0,91$ mm; no ventrículo esquerdo a espessura da parede anterior foi de $4,25 \pm 0,87$ mm e a da parede posterior foi de $4,14 \pm 0,89$ mm. O septo interventricular teve espessura de $4,10 \pm 1,13$ mm. O ventrículo direito teve como diâmetro ântero-posterior $9,25 \pm 0,85$ mm, e como diâmetro transverso $8,24 \pm 0,42$ mm. O ventrículo esquerdo mediu $9,95 \pm 0,37$ mm para o diâmetro ântero-posterior e $9,20 \pm 0,40$ mm para o diâmetro transverso. **CONCLUSÃO:** O conhecimento dos dados morfométricos do coração do feto é de grande importância para o diagnóstico ecocardiográfico de possíveis malformações cardíacas.

Unitermos: Ecocardiografia fetal; Circulação fetal; Malformação cardíaca; Coração.

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* Study developed in the Department of Anatomy – Center of Biological Sciences, Universidade Federal de Pernambuco (UFPE), Recife, PE, Brazil.

1. Associate Professor of Clinical and Radiological Anatomy, Department of Anatomy, Universidade Federal de Pernambuco (UFPE), Recife, PE, Brazil.

2. MD, Resident, Hospital de Clínicas da Universidade Federal de Pernambuco (UFPE), Recife, PE, Brazil.

Mailing address: Dr. Jennecy Sales Cavalcanti. Rua Félix de Brito Melo, 912, ap. 501, Boa Viagem. Recife, PE, Brazil, 51020-260. E-mail: jennecyc@bol.com.br

INTRODUCTION

With the development of fetal echocardiography and new surgical techniques for correction of prenatally diagnosed car-

diac malformations, a sound knowledge about the normal anatomy and development of the fetal heart has become absolutely necessary^(1,2). Malformations may affect any region of the heart, including the atrioventricular ostia and cardiac valves, generally requiring immediate surgical correction, considering that these malforma-

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tions may compromise the cardiac function, and even lead to fetal or neonatal death⁽³⁻⁵⁾.

The advances of ultrasonography and its application in the investigation of the fetal development have allowed the detection of malformations, especially in the cardiovascular system, between the 16th and 20th gestational weeks, besides a more accurate analysis of fetal heart structures, including the morphology and dynamics of atrioventricular valves and great vessels^(1,6,7). The possibility of early identification of the presence of cardiac malformations still during the intrauterine life, by means of echocardiography, represents a relevant development both in the practice of pediatric cardiology and obstetrics.

Considering that echocardiography is essential for the early diagnosis of fetal cardiac malformations, it is absolutely necessary to know the morphometric features of the fetal heart to achieve an accurate diagnosis of possible malformations as well as other conditions that may cause physiological alterations in the fetal heart progressing to cardiac failure and fetal death, if not opportunely corrected^(5,8-10).

MATERIALS AND METHODS

The sample of the present study included twenty 10%-formol-fixed human hearts from both male and female fetuses at gestational ages between 28 and 36 weeks, owned by the Department of Anatomy – Centro de Ciências Biológicas (Center of Biological Sciences) of Universidade Federal de Pernambuco. The approximate gestational age (GA) was based on the Balthazar-Dervieux equation ($GA = \text{fetus length} \times 5.6 \div 7$). The hearts were macroscopically normal, without any type of malformation.

Initially, the hearts were weighted and subsequently dissected. Atrial cavities were removed by incision along the coronary sulcus. The anteroposterior and transverse diameters of the atrioventricular valves were measured with a paquimeter with a 1/10 mm accuracy. Then, the areas of the respective valves were calculated.

With the aid of the same measurement instrument, the major anteroposterior and transverse diameters of the right and left

Table 1 Measurements of atrioventricular valves of 20 fetal hearts.

Dimensions	Left atrioventricular valve	Right atrioventricular valve
Anteroposterior diameter (mm)	10.35 ± 1.61	10.98 ± 1.90
Transverse diameter (mm)	9.90 ± 1.78	9.51 ± 1.81
Atrioventricular valve area (mm ²)	84.06 ± 25.09	84.49 ± 26.79
Perimeter	29.87 ± 3.96	28.44 ± 3.85

Table 2 Measurements of ventricular cavities and walls in 20 fetal hearts.

Ventricle	Diameter	Thickness
Right	Anteroposterior: 9.25 ± 0.85	Anterior wall: 5.00 ± 1.70
	Transverse: 8.24 ± 0.42	Posterior wall: 3.83 ± 0.91
Left	Anteroposterior: 9.95 ± 0.37	Anterior wall: 4.25 ± 0.87
	Transverse: 9.20 ± 0.40	Posterior wall: 4.14 ± 0.89
		Interventricular septum: 4.10 ± 1.13

ventricular cavities were measured. Also, the thicknesses of the anterior and posterior ventricular walls, as well as the interventricular septum were measured. The data resulting from these measurements were statistically analyzed.

RESULTS

Data regarding anteroposterior and transverse diameters, as well as areas of right and left atrioventricular valves are shown on Table 1. Table 2 demonstrates anteroposterior and transverse diameters of right and left ventricular cavities as well as thicknesses of ventricular walls and interventricular septum.

DISCUSSION

Congenital cardiopathy is defined as any structural alteration affecting a fetal or neonatal heart. A significant prevalence is reported in the population — 8 to 12 cases/1000 live neonates —, with death occurring in the first month of life in 20%–30% of cases^(9,11,12). Therefore, the early diagnosis of congenital cardiopathies is important, considering the sudden clinical manifestation, including the possibility of death⁽¹³⁾.

Up to some years ago, a single aspect of the fetal cardiovascular physiology could be routinely monitored: the fetal cardiac frequency⁽¹⁾. Early in the eighties, studies were published in the literature describing

the fetal echocardiography technique, and from that time on, the analysis of the intracardiac anatomy, cardiac function and detection of fetal malformations have become feasible^(1,14).

An early prenatal diagnosis of severe congenital cardiopathies improves the perinatal prognosis, allowing a more appropriate planning of a perinatal strategy, considering the high probability of a sudden neonate death.

Several echocardiographic studies have been performed to establish the cardiac cavities dimensions and biparietal diameters in normal fetuses^(15,16). The values found present a slight variation, depending on the method, the cut (four-chamber or transverse), and the phase of cardiac cycle were the measurements were taken (systole or diastole)⁽¹⁾. Coincidentally, these studies report that the cardiac cavities present a three-fold or four-fold increase in size from the 17th week to the end of the gestational period⁽¹⁷⁾, demonstrating a linear pattern of growth in relation to the gestational age and biparietal diameter⁽¹⁵⁻¹⁹⁾. However, the mitral and tricuspid flow velocities do not present a significant variation along the gestation, and the maximum tricuspid peak-velocity is slightly higher than the maximum mitral peak-velocity⁽¹⁾. On the other hand, the mitral and tricuspid valves diameters are similar to each other, differently from the adult heart, where the tricuspid valve diameter is approximately 1.5-fold larger than the mitral valve diameter⁽²⁰⁾.

Morphometric data of fetal atrioventricular valves could not be found in the reviewed literature for comparison with those found in the present study. It can be assumed that alterations in the normal dimensions of atrioventricular valves may result in disorders detectable by combined pulsatile Doppler, 2D imaging and color flow mapping⁽¹⁾. Blood flow velocity, direction and volume can be evaluated to aid in the determination of the presence of valvular regurgitation or stenosis⁽¹⁾. So, it can be presumed that the data found in the present study can be utilized as parameters for fetal echocardiographic findings.

The present study, that is aimed at establishing the morphometry of the mitral and tricuspid valvular apparatuses as well as the ventricular cavities diameters and thicknesses of fetal heart walls; on the other hand, determining if a fetal heart can reproduce the same configuration observed in vivo is not feasible. Notwithstanding, other experimental studies have demonstrated that, when a heart stops beating, it becomes hyper-relaxed and, after the inevitable effect of the cardiac *rigor mortis*, it contracts itself, presenting with an architecture similar to the cardiac contraction at end-systole⁽²¹⁻²³⁾.

CONCLUSION

The role of morphometric data of fetal atrioventricular valves is highly significant

in the echocardiographic diagnosis of possible congenital cardiac malformations.

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