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ULTRASOUND EXAMINATION OF PREGNANT WOMEN IN DIAGNOSING FETAL CARDIAC PATHOLOGY

© V.A. Lim

S.B. Daniyarov Kyrgyz State Medical Institute for Retraining and Advanced Training, Bishkek, Kyrgyzstan;
KAMEK Clinic Ltd., Bishkek, Kyrgyzstan

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▪ Hypothesis/aims of study. Fetal heart defects are the most common malformations causing infant mortality. The task of the obstetric care service is to make a timely diagnosis, which includes high-quality ultrasound screening and, if necessary, fetal echocardiography. This study aimed to compare fetal echocardiography with postpartum echocardiography.

Study design, materials and methods. 101 pregnant women with both isolated fetal heart defects and combined pathology were examined for the period 2017–2019.

Results. The greatest number of heart defects was detected at 23–31 weeks of gestation. The structure of the malformations is diverse, the most common one being a complete form of the atrioventricular canal defect. In multiple pregnancies, complex heart defects were often combined with abnormalities in other organ systems.

Conclusion. It is recommended to describe the heart structure in detail from 21–22 weeks of pregnancy. If cardiac pathology is detected in utero, it is mandatory to conduct an examination of other fetal organs.

▪ **Keywords:** pregnancy; fetus; heart disease; ultrasound.

РЕЗУЛЬТАТЫ УЛЬТРАЗВУКОВОГО ИССЛЕДОВАНИЯ БЕРЕМЕННЫХ С ЦЕЛЬЮ ВЫЯВЛЕНИЯ КАРДИАЛЬНОЙ ПАТОЛОГИИ У ПЛОДА

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Кыргызский государственный медицинский институт переподготовки и повышения квалификации им. С.Б. Даниярова, Бишкек, Кыргызстан;
Клиника КАМЭК, Бишкек, Кыргызстан

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▪ ***Актуальность.*** Врожденные пороки сердца наиболее часто встречающиеся пороки развития, которые приводят к смертности в младенческом возрасте. Задача акушерской службы состоит в своевременной постановке диагноза с помощью качественного скринингового ультразвукового исследования и при необходимости эхокардиографии плода.

Цель — сравнить данные фетальной эхокардиографии с эхокардиографией после родов.

Материалы и методы. За период 2017–2019 гг. была осмотрена 101 беременная как с изолированными пороками сердца у плода, так и при сочетанной патологии.

Результаты. Наибольшее количество пороков сердца выявлено на сроке 23–31 нед. гестации. В структуре пороков преобладала полная форма атриовентрикулярного канала. При многоплодной беременности сложные, комбинированные пороки сердца часто сочетались с аномалией систем других органов.

Выводы. Детально структуру сердца рекомендовано описывать с 21–22 нед. гестации. При внутриутробном выявлении кардиальной патологии следует проводить осмотр других органов плода.

▪ **Ключевые слова:** беременность; плод; пороки сердца; ультразвуковая диагностика.

Introduction

Despite the advances in medicine, the intrauterine detection of heart defects is still a relevant problem nowadays, since the diagnosis and structure of these defects are complex and diverse [1]. Approximately 60% of infants and 25% of fetuses die from cardiac pathology during the first month of life and *in utero,* respectively [2].

Heart defects are most often isolated, although they also occur in combination with extracardiac abnormalities in one-third of cases [3]. In Kyrgyzstan, congenital heart defects (CHD) rank third (26%) in incidence after abnormalities of the musculoskeletal and central nervous systems, but rank first with regard to mortality [4].

Congenital abnormalities occur two times more common in multiple than in singleton pregnancies, and CHDs are detected in 40% of cases [5].

The survival rate of children is significantly higher when the diagnosis of the CHD is made *in utero* than after birth, since no time is wasted to establish the diagnosis and transportation of the child to the cardiology department can be done promptly. In addition, with timely diagnosis, parents have the time to make a decision on the prolongation of the pregnancy and on determining the place of delivery and surgical treatment of their unborn child [6, 7].

The study aimed to compare the cardiac pathology data of fetuses obtained during the pregnancy examinations with the echocardiography results obtained after birth.

Materials and methods

In the ultrasound department of the KAMEK clinic in Bishkek, 101 pregnant women were examined from 2017 to 2019 at 18–39 weeks of gestation with the detection of heart defects in the fetus from. After the diagnosis was established, the patients were consulted by cardiac surgeons. With combined abnormalities of the heart and other fetal organ systems, the pregnant women underwent medical genetic counseling to determine further approach of pregnancy management. In the case of pregnancy prolongation, echocardiography was performed to clarify the diagnosis of the newborn.

All the examinations were conducted using ultrasound devices of the expert class General electric voluson E8, voluson E10, and voluson S6. The results were archived on devices in the form of a loop.

All the patients gave their informed consent to participate in the study. The examination results were processed by calculating relative values (%).

Results and discussion

Table 1 presents the results of the intrauterine echocardiography performed at a term of 18–39 weeks of pregnancy, and the echocardiographic data obtained after childbirth.

Echocardiography was performed in 56 (55.4%) of 101 cases of intrauterine heart defects in the newborns to clarify the diagnosis, and the diagnoses coincided in 49 cases (87.5%). After

Fetal echocardiography and echocardiography of newborns in diagnosing cardiac pathology data
Результаты выявления кардиальной патологии при фетальной эхокардиографии и эхокардиографии новорожденных

Gestational age during examination, weeks	Structure of heart defects during fetal echocardiography	Total patients examined		Nature of the pathology in the neonatal echocardiography	
		n	%	*n*	%
18–22	Atrioventricular canal (full form)	7	6.9	2	3.5
	Fallot's tetrad	3	2.9	3	5.3
	Atresia of the mitral valve, aortic valve, and aortic hypoplasia	5	4.9	1	1.7
	Single ventricle	4	3.9		
	Interventricular septum defect	1	0.9	1	1.7
	Aortic dextraposition with interventricular septum defect	2	1.9	2	3.5

Continued table / Продолжение табл.

Gestational age during examination, weeks	Structure of heart defects during fetal echocardiography	Total patients examined		Nature of the pathology in the neonatal echocardiography	
		n	%	*n*	%
18–22	Double outlet right ventricle	1	0.9	1	1.7
	Pulmonary valve artery stenosis	1	0.9		
	Pericarditis. right-sided atriomegaly	1	0.9		
23–31	Bradycardia	2	1.9	2	3.5
	Fallot's tetrad	2	1.9	2	3.5
	Atresia of the pulmonary artery valve	4	3.9	2	3.5
	Tricuspid valve atresia	2	1.9	1	1.7
	Atrioventricular canal (full form)	10	9.9	3	5.3
	Double outlet right ventricle	5	4.9	4	7.1
	Transposition of the great arteries	4	3.9	2	3.5
	Atresia of the mitral valve, aortic valve, and aortic hypoplasia	5	4.9	1	1.7
	Single ventricle	2	1.9		
	Aortic coarctation	2	1.9		
	Common truncus	1	0.9	1	1.7
	Pulmonary valve artery stenosis	6	5.9	4	7.1
	Aortic dextraposition with interventricular septum defect	5	4.9	4	7.1
	Rupture of the aortic arch	1	0.9		
	Mitral stenosis, hypoplasia of the left ventricle and aorta	1	0.9		
	Interventricular septum defect	6	5.9	5	8.9
	Pericarditis, right-sided atriomegaly	1	0.9		
32–36	Premature beats	2	1.9		
	Fallot's tetrad	2	1.9	2	3.5
	Pulmonary valve artery stenosis	1	0.9	1	1.7
	Atrioventricular canal (full form)	1	0.9	1	1.7

End of table / Окончание табл.

Gestational age during examination, weeks	Structure of heart defects during fetal echocardiography	Total patients examined		Nature of the pathology in the neonatal echocardiography	
		n	%	*n*	%
32–36	Interventricular septum defect	3	2.9	3	5.3
	Atresia of the mitral valve, aortic valve, and aortic hypoplasia	1	0.9	1	1.7
	Aortic dextraposition with interventricular septum defect	1	0.9	1	1.7
	Double outlet right ventricle	2	1.9	2	3.5
	Myocarditis	1	0.9	1	1.7
37–40	Atresia of the mitral valve, aortic valve, and aortic hypoplasia	1	0.9	1	1.7
	Atrioventricular canal (full form)	1	0.9	1	1.7
	Fallot's tetrad	1	0.9	1	1.7
	Total	**101**		**56**	

delivery, eight newborns died (7.9%) without any echocardiography being performed.

Antenatal death of one or both fetuses occurred in five pregnancies (4.9%) with monochorionic diamniotic twins; therefore, the established diagnosis could not be confirmed in these cases. Antenatally, one of the twin fetuses with a heart defect died in three cases, such that mitral valve atresia with aortic and left ventricular hypoplasia was diagnosed in one case, in a single ventricle was detected another case, while atresia of the pulmonary artery valve was found in the third case. Complex fetal heart defects were noted in two pregnant women with antenatal death of both fetuses: a single ventricle was diagnosed in one of them and severe pulmonary valve artery stenosis was registered in the other twin.

Thirty-two pregnant women (31.7%) with various fetal heart defects terminated their pregnancies after the conclusion of the medical genetic commission. Of all the terminated pregnancies, an autopsy was performed only in two cases after obtaining parental consent.

Most of the diagnoses confirmed after childbirth were established at 32–40 weeks of gestation compared with the 18–22 weeks of gestation (second screening examination). This was due to the rare termination of pregnancy at late terms. In cases of defects such as a single ventricle, atresia of the mitral or aortic valves, and an atrioventricular canal, the pregnancies were terminated irrespective of the gestational age due to a poor prognosis for life.

It should be noted that a greater number of cardiac pathologies were detected at a gestational age of 23–31 weeks, since the left and right outflow tracts were more visible for diagnosing conotruncal pathology and the fetus was moderately mobile during this period in contrast to the earlier stages. In these terms, there was no pronounced shading from the fetal skeletal system.

Two cases of a single ventricle did not coincide with intrauterine data. One case of stenosis of the pulmonary artery valve during our examination looked like a tricuspid valve insufficiency; the lesion of the pulmonary artery valve was not reliably visualized, and the diagnosis was made after delivery. In another case, a muscular defect of the interventricular septum was revealed *in utero*, which spontaneously closed by the time of delivery. We registered two cases of cardiomegaly and moderate right-sided atriomegaly combined with

pericarditis due to acute respiratory viral infection in the history of a pregnant woman. After delivery, no abnormalities in the heart of the newborn was found according to the echocardiographic examination.

At various stages of pregnancy, rhythm disturbances were recorded in fetuses with a normal heart structure after viral infections. At stages of 24 and 29 weeks of pregnancy, two cases of complete atrioventricular block were identified, while the heart rate was 40–50 per minute. Childbirth was performed through the natural birth canal, and the infants were being monitored by the cardiologists. Two cases of extrasystole were diagnosed at different stages of pregnancy, while the rhythm returned to normal after birth.

The complete atrioventricular septal defect prevailed in a range of heart defects (19 cases), while an isolated complete atrioventricular septal defect was noted in 14 cases. In one of the cases, according to the conclusion of the commission, the pregnancy was terminated at 30 weeks of gestation, and Down's syndrome was diagnosed after childbirth.

In combination with other structural cardiac pathologies, an atrioventricular canal was diagnosed in five cases. Of these, a case of a complete atrioventricular septal defect with hypoplasia of the left ventricle and hypoplasia of the ascending aorta was revealed at 20 weeks of gestation; the child died on day 3 postpartum in the hospital maternity. At a term of 28 weeks of pregnancy, a common atrioventricular canal with transposition of the main arteries was diagnosed; the child died after surgery at 9 months of age. At a term of 30 weeks, a case of a common atrioventricular canal in combination with an aortic dextraposition and atresia of the pulmonary valve was revealed; the infant died in the first week of life. At 25 weeks of pregnancy, an atrioventricular canal with transposition of the main arteries and hypoplasia of the pulmonary artery was found; the child was operated at the Scientific Center of Novosibirsk. At a full term of 38 weeks, a case of a common atrioventricular canal with a major defect of the interventricular septum was diagnosed. After delivery, the diagnosis of a single ventricle with a single atrioventricular valve and a major interventricular septal defect was made; the child was operated at the age of 2 months, but died immediately after the surgery.

In our center, we detected fatal ductal-dependent heart diseases, including two cases of hypoplastic left-heart syndrome (mitral atresia, aortic atresia, and left ventricular fibroelastosis). In both cases, the newborns died in the hospital maternity hospital on days 2 and 5 after birth. At 34 weeks of gestation, atresia of the mitral and aortic valves with severe hypoplasia of the left ventricle in combination with an aortic arch rupture was also identified. The child died during the first week of life.

Aortic coarctation and rupture of the aortic arch complicate prenatal diagnosis. With aortic coarctation, the isthmus that is narrowed *in utero* may return to normal size after delivery. With ultrasound examination at 26 weeks of pregnancy, we found a perimembranous interventricular septal defect in combination with aortic hypoplasia. At the time of examination, the arch and isthmus were not clearly visualized, but aortic arch rupture and aortic coarctation were diagnosed. After delivery, the child was operated at the Scientific Center of Novosibirsk, and aortic coarctation was diagnosed. At week 2 of gestation, one of the fetuses from dichorionic twins was found to have aortic coarctation in combination with a muscle defect of the interventricular septum. After delivery, echocardiography did not confirm the diagnosis of coarctation. The child died at 4 months of age, and a diagnosis of circulatory failure was made during the postmortem examination.

Another significant group of defects that must be diagnosed *in utero* are conotruncus defects (Fallot's tetrad, double outlet right ventricle, transposition of the main arteries, and common arterial trunk), which account for up to 30% of all CHDs [8]. Conotruncal heart defects occurred in both singleton and twin pregnancies. One of the fetuses from a dichorionic twin pregnancy, was diagnosed with Taussig-Bing disease (double outlet right ventricle with transposition of the main arteries and subpulmonary defect of the interventricular septum) at 28 weeks of gestation. At 3 months of age, the child was operated in Athens, but died immediately after the surgery. A similar heart defect was diagnosed at 35 weeks of gestation, and the child died at the age of 2 months prior to the surgery.

In one of the fetuses from monochorionic diamniotic twins, during the second screening

examination, a double outlet right ventricle with vascular transposition, hypoplastic aortic annulus fibrosus, and ascending aorta were revealed at 20 weeks of gestation. After labor, at the Bakoulev Center for Cardiovascular Surgery, computed tomography revealed a double outlet right ventricle, transpositional arrangement of the vessels, and a rupture in the aortic arch. The child was operated, and is being prepared for the second stage of the surgery.

We examined a pregnant woman with dichorionic diamniotic twins after *in vitro* fertilization at week 30 of pregnancy. One of the fetuses had an aortic dextraposition, a subaortic interventricular septal defect, and a pulmonary artery hypoplasia. After delivery, the patient was diagnosed with a double outlet right ventricle, an interventricular septal defect, and a pronounced stenosis of the pulmonary artery valve. In addition to the heart defect, the child had an omphalocele. At 25 weeks of gestation, in one of the fetuses from dichorionic twins, transposition of the main arteries with a defect of the interventricular septum and hypoplasia of the pulmonary artery was revealed. The child was operated in Samara. In addition, soft and hard palate clefts, heterotaxy syndrome, and asplenic syndrome were detected.

At the term of 35 weeks of a singleton pregnancy, a routine ultrasound examination revealed a double outlet right ventricle with a subaortic interventricular septal defect and pulmonary artery hypoplasia. The child was operated in Istanbul.

During the second screening examination at a term of 22 weeks, we found a Fallot's tetrad, and the child was successfully operated at the Scientific Institute of Tomsk. Two cases of a rare form of Fallot's tetrad with agenesia of the pulmonary valve were also diagnosed at weeks 32 and 27 of gestation. One child was successfully operated in Istanbul. In the second case, the diagnosis was confirmed after the labor, but we do not know how the child evolved after birth.

We also identified eight fetuses with a diagnosis of aortic dextraposition with a subaortic interventricular septal defect, while the defect was combined with cystic dysplasia of the right kidney in one case. In another case, the pregnancy was terminated at a term of 24 weeks. After the autopsy, the Eisenmenger syndrome was diagnosed.

Difficulties during the examinations were caused by multiple pregnancies, since the fetal position was inconvenient for examination, especially in the case of advanced pregnancy. A single ventricle was difficult to identify at stages of up to 22 weeks of gestation, especially with close examination of the outflow tracts. It is with these defects that the diagnoses made by ultrasound specialists often do not coincide, and different formulations are given. In addition, according to the conclusion of the medical genetic commission, pregnancies were terminated without a subsequent autopsy.

During examination, an isolated lesion of the pulmonary valve may be neglected. This diagnosis is made mostly during color Doppler imaging, as the fetal heart looks less changed in the usual two-dimensional mode, especially at terms of up to 25 weeks of gestation. In our center, eight cases of pulmonary artery valve stenosis were identified, which were accompanied by insufficiency of the tricuspid valve, and there was an enlargement of the right atrium in some cases. In one case, the infant was successfully operated in Kiev.

According to statistics, more than 50% of all heart defects are represented by the defect of the interventricular septum [9]. Intrauterine slit-like defects of the interventricular septum are not visualized, and they are mostly detected after childbirth. During the examination, we recorded six cases of an isolated defect of the muscular septum. One fetus from monochorionic twins had an isolated muscular interventricular septal defect. Four cases of perimembranous interventricular septal defects were diagnosed; one of them was successfully operated at the Scientific Institute of Heart Surgery in Bishkek.

Conclusions

1. Heart defects are very diverse. Structural changes such as stenosis of the pulmonary artery valve, interventricular septal defects, and aortic coarctation can be neglected during the second screening examination (18–22 weeks). In this regard, we recommend in Kyrgyzstan to amend the protocol of obstetricians and gynecologists on antenatal care, to include mandatory ultrasound examination at a term of 30–32 weeks of pregnancy. Complex abnormalities of the heart

combined with structural pathologies of other organs are common. Based on the research results, the severe condition of infants born with cardiac pathology can be verified once again; therefore, when intrauterine heart defects are detected, detailed examination of other organs in dynamics is necessary.

2. The diagnosis of cardiac pathology at early terms of pregnancy is still difficult, especially in the presence of a single ventricle and an atresia of the pulmonary artery valve. For this reason, we suggest that a detailed fetal echocardiography for a more accurate determination of the defect structure should be performed starting from 21–22 weeks of pregnancy. In the presence of multiple pregnancies, visualization of the heart is often complicated; therefore, the diagnosis should not be established at the early stages.
3. Currently, many parents refuse to perform a fetal autopsy in case of pregnancy termination to clarify the diagnosis. Given the large number of pregnancies terminated, accurate diagnosis of the CHD structure remains a priority, since the conclusion of the doctors making the prenatal diagnosis determines the fate of the unborn children.

Additional information

Conflict of interest. The author declares no obvious and potential conflicts of interest related to the publication of this article.

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Ethical considerations. The study was approved by the Bioethics Committee of the I.K. Akhunbaev Kyrgyz State Medical Academy (protocol No. 17 dated May 13, 2017).

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Information about the author *(Информация об авторе)*

Виктория Анатольевна Лим — аспирант кафедры акушерства, гинекологии и репродуктологии. Кыргызский государственный медицинский институт переподготовки и повышения квалификации им. С.Б. Даниярова, Бишкек, Кыргызстан; врач ультразвуковой диагностики. Клиника КАМЭК, Бишкек, Кыргызстан.
E-mail: vika.lim@mail.ru.

Viktoria A. Lim — MD, Post-Graduate Student. The Department of Obstetrics, Gynecology, and Reproductive Medicine, S.B. Daniyarov Kyrgyz State Medical Institute for Retraining and Advanced Training, Bishkek, Kyrgyzstan; KAMEK Clinic Ltd., Bishkek, Kyrgyzstan.
E-mail: vika.lim@mail.ru.