Fetal Echocardiography in the Second Trimester of Pregnancy

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Abstract

Fetal heart is one of the most difficult organs to examine during second trimester fetal ultrasound. Conventional two-dimensional screening ultrasound using a four-chamber view alone allows detection of 5%-60% of congenital cardiac defects. If ventricular outflows are included in routine screening protocol, the detection rate of major cardiac disease is significantly increased to 85,5%-90%. Therefore ISUOG (International Society of Ultrasound Obstetrics and Gynecology) state that the left and right ventricular outflows should be included in the "Optimal Examination" of the fetus.
Another important issue is that fetal echocardiography when combined with first and/or second trimester screening for trisomy 21 may increase the detection rate to almost 94%. This may be advantageous for patients who desire a highest sensitivity before considering invasive testing.
Keywords: *fetal echocardiography, congenital cardiac defects, trisomy 21*

Introduction

Congenital heart diseases (CHD) and defects of major vassels are ones of the most frequent fetal anomalies with a prevalence of 8 per 1000 new born alives[1]. About one half of these are major cardiac defects. What are major congenital cardiac defects? Major congenital cardiac defects are those anomalies which are clinical assertive from the first days or weeks of life and demand surgery[2]. What was established from the existing clinical studies is that 1 per 45 babies at whom second trimester screening was perform present CHD, 50% of these will demand surgery in the first year of life. Incidence of CHD is 6,5 greater than incidence of chromosomial anomalies and 4 times greater than neural tube defects[3].

Ethiology of CHD is various and include probably more factors: genetics, environamentals, colagenous disorders, diabetes, viruses.

CHD can be isolate or take part of anomalies which are seen in 90% of fetuses with trisomy 18 or 13, in 50% of fetuses with trisomy 21, in 40% of fetuses with Turner syndrom. About 70% of major CHD are due to a chromosomial anomalies. In the same time CHD can be associate with deletions, translocations or partial trisomies which can include a lot of chromosomes. In the absence of a genetic syndrome, if a couple have had another child with a CHD, than the risk of recurrency grows to 10%. If the father present or has had a CHD (surgicaly treated) the risk for the fetus to have a CHD is 2%, and if the mother is affected the risk for the fetus is 10%.

Prenatal diagnosis of CHD is various between 5% and 60%[3,4]. Why exist this variability in the sensibility of the diagnosis of CHD in second trimester of pregnancy? This variability is due to 3 factors:

- screening protocol used, for example using only four chamber view we can diagnose from 40% to 50% of CHD, adding the image of left ventricle-aorta and right ventricle-pulmonary artery we can identify from 60% to 70% of CHD;
- the level of training of the examiner;
- gestational age at the time of cardiac screening, optimal period is between 22 and 24 weeks.

There are some more factors which can influence the diagnose of CHD: obesity, fetal position, the length of time examination. However we must forget that even if it is possible the detection of a great number of CHD, cardiac anomalies are evoluating with the evolution of pregnancy, and it is possible to not detect a cardiac anomaly at 22 weeks and to detect it at 30 weeks[5].

Indications

CHD can be isolated or associated with a chromosomal syndrome (most frequent is trisomy 21).

In the majority of European countries second trimester ultrasound is compulsory and take part of prenatal investigation for the detection of congenital anomalies. From the perspective of ultrasound examination pregnant women can be divided in 2 categories[6]: with high risk for CHD (family history, diabetes, drug ingestion) which will require a detailed echocardiography examination and low risk pregnant women for CHD at whom the four chamber view is recommended[7].

Indications for fetal echocardiography are:

Maternal: family history (grade one relatives) with CHD, metabolic disease, maternal infection (Cocksackie, rubella, parvovirus), drugs ingestion (lithium, fenitoine, valproic acid, carbamasepin), high level of antibodies anti-RH, diseases with transmission (Ehler-Danlos, Marfan);

Fetal: abnormal fetal karyotype, extracardiac fetal anomalies, abnormal nuchal translucency (NT by 3,5-4,5 mm increase risk for CHD by 4 times, NT by 4,5-5,5 increase risk for CHD by 6 times), tricuspid regurgitation at 12 weeks ultrasound, abnormal ductus venosus wave at 12 weeks ultrasound, persistent cardiac rhythm anomalies.

Screening ultrasound examination of the fetal heart

Second trimester ultrasound examination of the fetal heart is concentrated about 2 elements:

- if there is a potential heart disease;
- if heart disease is associated with a chromosomal anomaly, especially trisomy 21, which is most frequent.

In the year 2006 ISUOG (International Society of Ultrasound in Obstetrics and Gynecology) had established for the screening ultrasound examination of fetal heart, performed between 20 and 22 weeks, 2 levels of examination[8]:

- Basic cardiac exam;
- Extended cardiac exam.

Basic cardiac exam consist compulsory in obtaining the image of four-chamber view[9,10]. The elements which must be identified at basic cardiac exam are:

- **common:** normal cardiac situs, the axis of the normal heart is 450 +/- 200 directed towards the left half of the fetus, fetal heart represent 1/3 from thoracic area, most of the heart in the left half of thorax, the presence of 4 chambers, the absence of pericardic fluid and hypertrophy;
- **atrium:** 2 atrium almost equals, left atrium being the posterior one and closer to vertebral body, the opening of foramen ovale in left atrium, the presence of septum primum;
- **ventricle:** 2 ventricle almost equals, right ventricle beeing the anterior one, right behind sternum, absence of ventricular hypertrophy, presence of banding moderator at the level of the apex of right ventricle, interventricular septum intact, the crux of the heart which represent the meeting of atrial septum, ventricular septum and 2 atrioventricular valves;
- **atrioventricular valves:** both valves are mobile, tricuspid valve insert on interventricular septum closer to cardiac apex than mitral valve, frequency of fetal heart 120-160/min.

Extended cardiac exam involve examination of the images of left ventricle - aorta and right ventricle - pulmonary artery. Assessment of the great vessels and their crossing improve the incidence of detection of heart diseases, especially for conotruncal cardiophathy: tetralogy Fallot, transposition of great vessels, double emergence from right ventricle, common arterial trunk[11].

Ultrasound examination of fetal heart was made easier by Yagel[12], who propose to examine the heart on the base of 5 transversal successive planes. First level, the inferior one, is a transversal section at superior abdominal level and includes: the stomach, liver, vertebral body and aorta. This plane is compulsory to demonstrate normal situs, situs solitus, that is the stomach is to the left, the abdominal

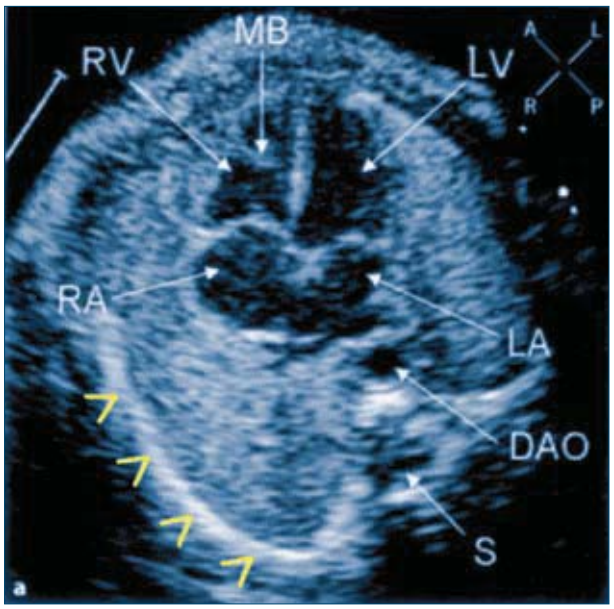

Figure 1. Four chamber view

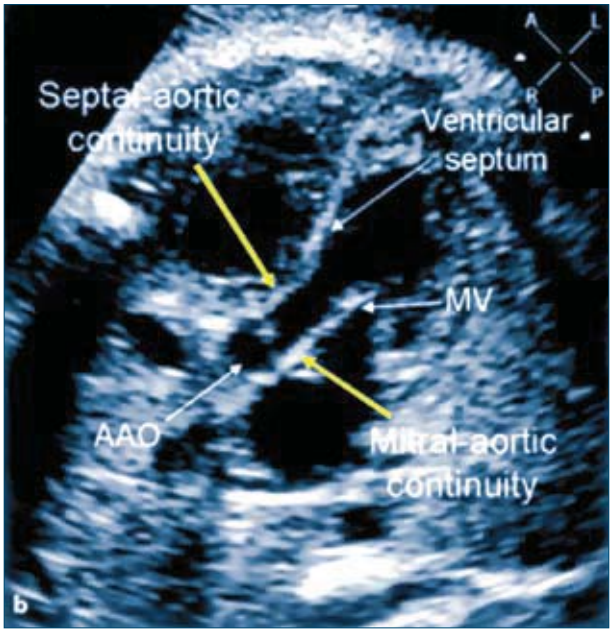

Figure 2. Five chamber view

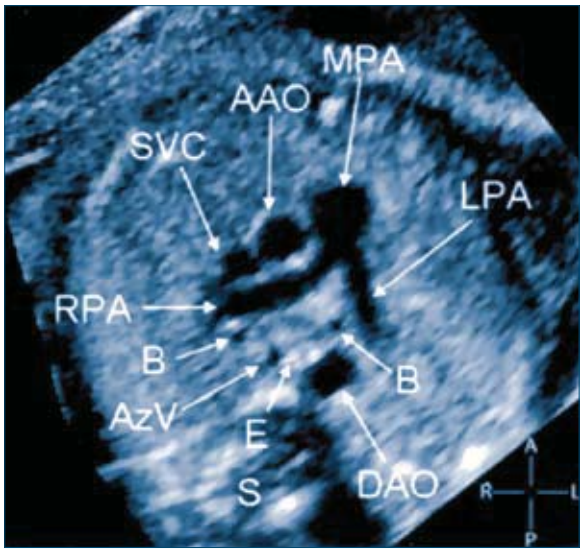

Figure 3. Three vessels image

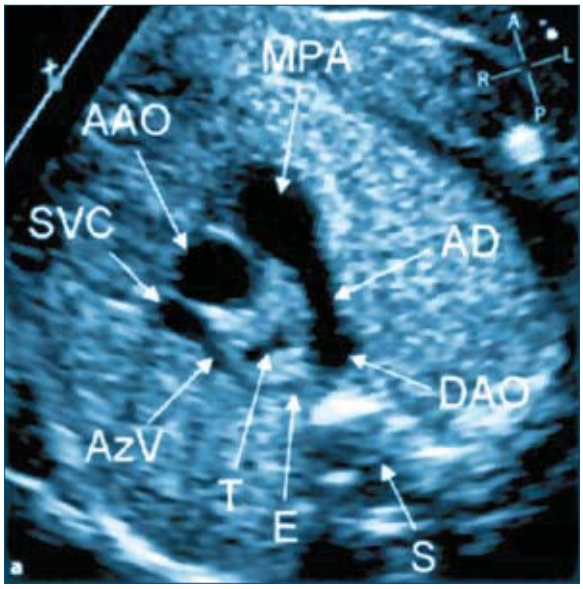

Figure 4. Three vessels and trachea view

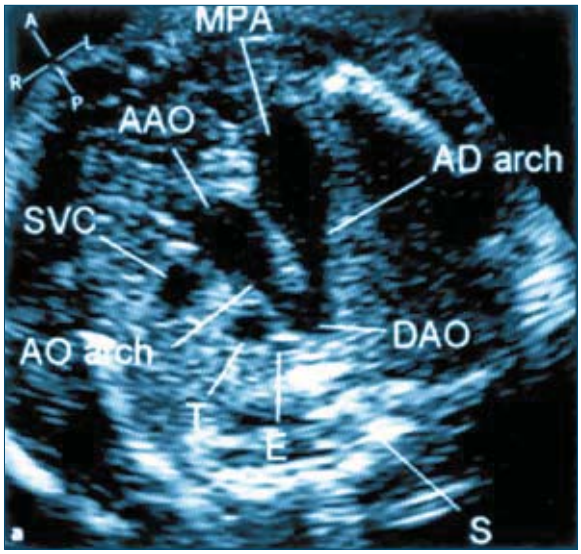

Figure 5. Transversal section of arterial ductus and aortic arch (in V)

aorta is situated in front and to the left of spine, inferior vena cava is more anterior and to the right of the spine. Second plane is the most important plane of the fetal heart examination: four-chamber view (figure 1). Third plane is traditionally named five-chamber view, and represent the image of aorta leaving left ventricle with continuity from interventricular septum to aorta[13] (figure 2). The fourth transversal plane is called the image of three vessels and contain the crossroad of the trunk of pulmonary artery into 2 branches, situated in front, aorta behind this and superior vena cava situated behind aorta[14] (figure 3). The fifth transversal plane is called three vessels and tracheae view, is the most cranial plane at the level of mediastinum and contain the continuity between the trunk of pulmonary artery and ductus arteriosus to the level of descendent aorta, than ascendant aorta and then superior vena cava (from the front to the back) (figure 4).

This method proposed by Yagel has been imposed in screening echocardiography examination due to its major advantage: examination starts with superior abdominal section and moving gradually cranial the transducer, with a continuously and slowly movement, we will include all mentioned sections. An extensive study of the fetal heart may include other sections: transversal section of aortic arch localized superior from the image of 3 vessels and trachea (include the short aortic arch which bind ascendant aorta with descendent aorta, having at left superior vena cava, trachea and esophagus), transversal section of ductus arteriosus and aortic arch (which include the image in V of confluence between ductus arteriosus and aortic arch, including descendent aorta at the left of the spine, left branch of V beeing composed by pulmonary artery with continuity of ductus arteriosus and right branch by aortic arch) (figure 5), longitudinal section of ductus arteriosus, longitudinal section of aortic arch, longitudinal bicava section (at the level of right atrium), coronary section[15].

It is very important to understand normal anatomy and blood circulation at the level of fetal heart. If we want to establish if there is a cardiac defect, we must analyzed the main three segments ant its connections: 2 atrium, 2 ventricles and great vessels and veno-atrial connection, atrio-ventricular connection and ventricle-arterial connection[16]. Veno-atrial connection can be evaluate on the four-chamber view (for pulmonary veins) and on bicava longitudinally image (for cava veins). Atrio-ventricular connection can be evaluated on four chamber view. Left ventricle-aorta connection can be obtain beginning from four-chamber view with a slightly angulations of transducer to the right shoulder, and right ventricle-pulmonary artery connection can be obtain beginning to four-chamber view also, but with an angulation of transducer to the left shoulder. We can use color Doppler which helps us to identify this connections and the circulation of blood between them[16].

Normal circulation of fetal blood, shortly, is the next one: blood with O_2 from the inferior vena cava goes to right atrium and foramen ovale straight to left atrium, while blood without oxygen from superior vena cava goes straightly to right ventricle through tricuspid valve. Than nonoxygenated blood is sent by right ventricle through

Table 1 Prenatal diagnose of isolated CHD[1]

Disease	Nomber of cases	Prenatal diagnosis (%)
Left heart hypoplasia	72	63
Unic ventricle	16	44
Tricuspidian atresia	5	40
Pulmonary atresia	16	5
Ebstein anomaly	17	59
Stenosis of pulmonary artery	70	9
Stenosis of aorta	32	3
Coarctation of aorta	57	16
Pulmonary veins anomalies	10	0
Intricates	186	30
Unspecifics	74	15

Table 2 Prenatal diagnose of CHD in Europa[1]

Country	Number of cases	Prenatal diagnose (%)
Estern Europe	439	8
Holland	151	11
Denmark	28	11
Italy	151	19
Swiss	110	22
Austria	85	26
Great Britain	247	35
Germany	98	40
Spain	152	45
France	348	48

Table 3 Postnatal incidence of CHD at children with Down syndrome

Study	New born with trisomy21 (no.)	CHD (%)
Tubmann (1991)	81	42.01
Khoury (1992)	532	33.1
Wells (1994)	118	48.3
Freeman (1998)	227	44.0
McElhiney (2002)	114	65.8
Nisli (2008)	1042	39.5
Total	2114	42.5

pulmonary artery and the most quantity goes to *ductus arteriosus* in aorta and further to placenta and to the inferior part of the fetus. A little part of the nonoxygenated blood sent by right ventricle goes to the lungs and from here returns through pulmonary veins in left atrium, after that in left ventricle and from here into aorta.

Leaving from Yagel's five basic sections we can see that is "SOMETHING" abnormal in the structure of fetal heart, than we diagnose the type of heart disease and what is the obstetrical attitude. We can identify the following anomalies:

- abdominal section: *situs inversus*, isomerism;
- four chamber view: disproportion between the fourth chambers, ventricular septal defect, atrial septal defect, anomalies of atrio-ventricular connection;
- five chamber view: aorta " overriding " interventricular sept, transposition of great vessels, aortic stenosis;
- three vessels view: pulmonary stenosis or atresia, syndrome of absence of pulmonary valve;
- three vessels and trachea view: coarctation of aorta, discontinuity of aortic arch, right aortic arch , right subclavicular aberrant artery.

This article hasn't the purpose to analyze each fetal heart disease, but to keep in mind that using the five basic plans Euroscan study[1] state that prenatal ultrasound screening between 20-22 weeks (including echocardiography) diagnose a great part of severe fetal heart diseases (table 1). A few cases are diagnosed if echocardiography is performed only proceeding from indications (table 2). Purpose of ultrasound fetal heart screening is to get the suspicion of a CHD, while the diagnose can be put in other specialized centers.

Association from CHD with trisomy 21 have been discovered 50 years ago, cardiac anomalies have remaining one of the most frequent postnatal pathology at children with Down syndrome. Echocardiography performed in second trimester contributes beside blood screening of trimester 2, blood screening of first trimester, ultrasound screening of first trimester,r at diagnosis of Down syndrome.

Postnatal incidence of CHD at children with Down syndrome is around 41,5% (table 3)[17].

Prenatal incidence of CHD at children diagnosed with trisomy 21 through amniocentesis is about 18,66%[18].

The most using screening test for trisomy 21 are:

a) nuchal translucency combined with blood screening of first trimester;

b) nuchal translucency combined with blood screening of first trimester plus quadruple test (Quad test) of second trimester (Quad test consist of adding inhibine-A as a fourth marker to other 3 markers of triple test;

c) blood screening of first trimester plus blood screening of second trimester;

d) Quad test. In this way, using fetal echocardiography plus screening fetal ultrasound of second trimester, as a helping element, and using relative risk of cardiovascular markers and non-cardiovascular markers proposed by DeVore, we can diagnose almost 90% of fetuses with Down syndrome[19]. Thus ventricular septal defect has a relative risk of 12.45; disproportion of the heart right-left has a relative risk of 88.29; pericardic fluid has a relative risk of 10.02; tricuspidian insufficiency has a relative risk of 5.89.

Conclusions

Most of congenital cardiac anomalies can be diagnosed by prenatal ultrasound on four chamber view, but general screening of low risk population for CHD shows an incidence of diagnose by 56%[1]. If screening echocardiography include the extensive examination of the heart than the incidence of diagnose of CHD reach 60-70%.

Fetal echocardiography of second trimester together with other ultrasound markers, can identified almost 90% from fetuses with Down syndrome and can be compare with nuchal translucency associated with blood screening of first trimester.

Fetal echocardiography of second trimester when it is used together with screening of first or second trimester for trisomy 21, can increase the incidence of diagnose of fetuses with Down syndrome till 94%. ■

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