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EXAMINATION OF THE FETAL HEART WITH TWO-DIMENSIONAL ECHOCARDIOGRAPHY

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The methodology of the two-dimensional fetal echocardiography is described by the basic of the accepted international nomenclature. By their opinion it is necessary that on the 18-20th weeks of gestation the high risk pregnants in aspect congenital heart disease examined by well-trained specialists. The indications of the echocardiography are listed, too.

INTRODUCTION

The frequency of congenital heart disease is 0.3-0.6 % /5, 6, 8, 9, 11, 17, 21, 24, 25/. The development of the method of ultrasound examination gives more possibilities to discover the sick fetuses just on the 16th-20th weeks of pregnancy. So the parents have been informed about the status of their fetus in time and after a well-founded consideration they can make a decision about the future of the pregnancy. As the number of ultrasound equipments are increasing continuously and the routine screenings are made by more and more colleagues, it seems to be necessary to review the methodology of the examination of the fetal heart.

MATERIAL AND METHODS

As this Department is one of the examining centers - there are only four centers in the Federal Republic Germany - the number of patients is very large and varied. Within the district,

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the colleagues sent all the "suspect" cases to our center for examination and in these cases the fetal heart has been studied, too. From the point of view of congenital heart disease (Table I) the high risk pregnancies must be examined by a colleague who worked earlier as a cardiologist.

TABLE I

Indication for fetal echocardiography

A. Familial cause:
1. Congenital heart disease
2. Genetic disease
3. Anomaly syndrome

B. Maternal cause:
1. Heart disease (congenital, acquired)
2. Drug exposure (narcotics, lithium, amphetamin, contraceptives, sexual hormones, trimethadion, hydantoin)
3. Alcohol, heroin
4. Viral infection (rubeola, cytomegalia, Coxsackie, mumps)
5. Metabolic disease (diabetes mellitus, phenylketonuria)
6. Rh isoimmunisation
7. Hydramnion (oligo-, poly-)
8. Collagen vascular disease (SLE)
9. Elderly gravida
10. EPH gestosis
11. High dose ionize radiation
12. Toxoplasmosis

C. Fetal cause:
1. Intrauterine growth retardation (IUGR)
2. Fetal arrhythmia
3. Somatic anomalies
4. Decreased fetal movement
5. Abnormal genetic screen (Patau-, Edwards-Turner-, Klinefelter syndrome)
6. Hydrops fetalis

All of the examinations were performed with a high resolution real-time sector scanner (Acusion 128, Acuson GmbH, Erlangen, GFR). If it was necessary M-mode, pulsed Doppler or colour Doppler ultrasound examinations were done, too. But this paper discusses only the two-dimensional echocardiography (2DE), because this method has been used most frequently.

Of course the procedure of the examination was the same as other obstetrical ultrasound examinations. We have been informed about the position of the fetus, the adhesion of the placenta, the quantity of amniotic fluid, the fetal kinetic activity and the biometrical measurements were performed (biparietal, frontooccipital, abdominal diameter, femur length).

2-DE echocardiography

Characteristics of the examination of the fetal heart

Fetal echocardiography cannot be directly compared with the newborn study /1, 3/. There are several reasons:

1. The fetal heart lies in a different position than after birth. The apex is pressed up by the large fetal liver, so it is in a more horizontal position.
2. The size of the right ventricle is equal to the left ventricle. The right ventricle lies just below the chest wall. In the newborns its position is more inferior.
3. It is possible to observe the patent foramen ovale and ductus arteriosus.
4. The lung fields are unaerated and fluid-filled.

Nomenclature

In 1980 "The Committee of the American Society of Echocardiography" recommended for the standards of the nomenclature used in the two-dimensional echocardiography /13/. The main point of this suggestion is that we get always the same information about the heart when transsecting the heart in the different planes (these planes are defined). Three main planes are distinguished (Fig. 1).

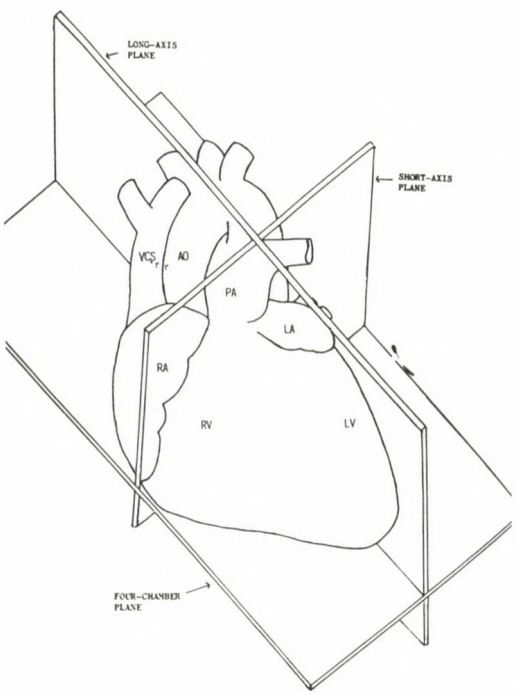

Fig. 1. Three main planes intersect the fetal heart
Explanation in detail see in the text.
(VCS=vena cava superior, AO=aorta, PA=pulmonary artery, RA=right atrium, LA=left atrium, RV=right ventricle, LV=left ventricle)

1. Long axis plane:
The plane that transsects the heart perpendicularly to the

dorsal and ventral surface of the body and parallel to the long axis of the heart.

2. Short axis plane:
   The plane that transsects the heart perpendicularly to the dorsal and ventral surface of the body, but perpendicularly to the long axis of the heart.
3. Four-chamber plane:
   The plane that transsects the heart approximately parallel to the dorsal and ventral surface of the body.

Of course with a minimal change of the main transectional planes it is possible to study the different parts of the heart, but the knowledge of main transectional planes is enough to diagnose the healthy heart.

Four-chamber view

This plane provides information about the fetal heart in a relatively easy way (Fig. 2). This view is achieved in a

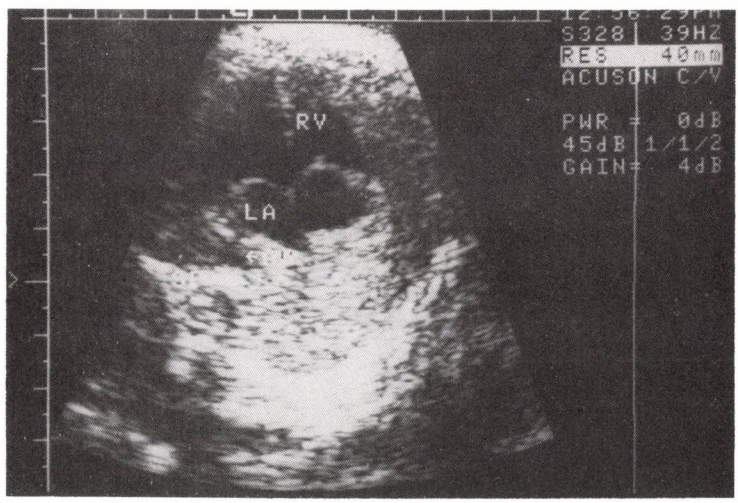

Fig. 2. Four-chamber view
Anterior to the spine (SP) is a relatively small circle is the aorta (AO). Directly opposite to it, one rib (R) should be seen and the underneath of rib is the right ventricle (RV). Between the aorta and the right ventricle the left atrium can be identified (LA). After this all of the other parts of the fetal heart are recognizable

straight cut across the fetal thorax at the base of the sternum. This section lies between the view of the abdomen and the head (the place of the measurement of the abdominal circumference and the biparietal diameter). Therefore the obstetric ultrasonographers offer to start from the well-known planes and move the transducer up and down so the four-chamber view of the heart can be achieved. The thorax appears as a circular structure and one of the points of this structure, the

spine, is easily recognized. To ensure that the section is not oblique at least one complete rib should be seen. The sternum can be located lying directly opposite to the spine in the centre of the anterior chest wall. The right ventricle lies underneath the sternum. The descending aorta, lying anterior to the spine can be seen as a circle in cross-section. It lies between the spine and left atrium. Afterwards all the other parts of the heart can easily be recognized (Fig.3).

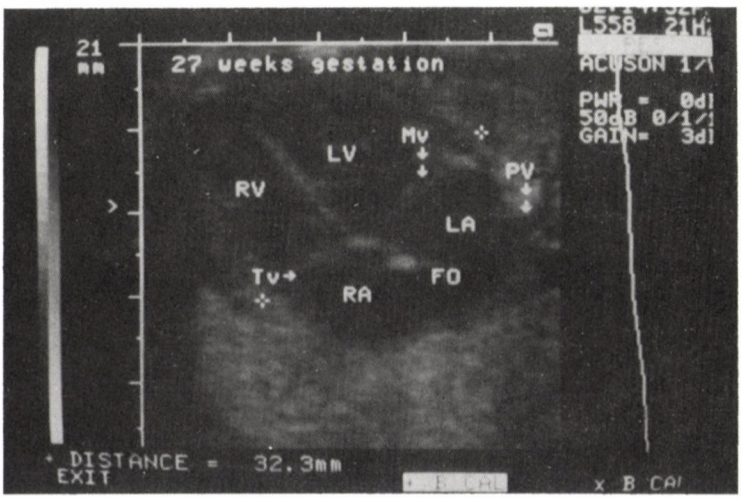

Fig. 3. Four-chamber view in the 27th week of pregnancy
Beside the main four-chamber of the fetal heart (RV=right ventricle, LV=left ventricle, RA-right atrium, LA=left atrium) it can be identified the tricuspid valve (TV), mitral valve (MV), and the patent foramen ovale, too. The pulmonary vein can also be recognized, running into the left atrium (PV). The distance of the meeting points of the tricuspid valves (TV) and bicuspid valves (BV) and the myometrium (marked with a " + " at the level of the anulus fibrosus), mean the cross section size of the heart

Studying the four-chamber view and making a decision that there is a healthy and normally developed heart, all of the following points must be noted:

1. The heart fills about 1/3 of the fetal thorax.
2. The right and left atrial chambers are similar in size.
3. To measure the right and left ventricular cavities just below the atrioventricular valve; they must be approximately equal in size.
4. The posterior walls of the right and left ventricles and the interventricular septum are approximately equal in thickness.
5. The atrioventricular valves open with each cardiac cycle.
6. The atrial and ventricular septa and atrioventricular valves

meet at the crux of the heart in an offset cross.
7. The normal atrial defect (foramen ovale) can be seen.
8. The ventricular septum appears intact.

Short axis plane

This view is important because it shows the relation of the great vessels to each other (Fig. 4). On the transsect, the right atrium (possibly with the streaming inferior vena cava), the tricuspidal valve, the right ventricle, the pulmonary valve, the main pulmonal artery, and the ductus arteriosus would be seen. The ductus arteriosus joins the descending aorta anterior to the spine. The main pulmonary artery and the right pulmonary artery wrap around the ascending aorta creating an image that looks like a "sausage". The middle of the picture, as it is written above could be compared to a "doughnut", too.

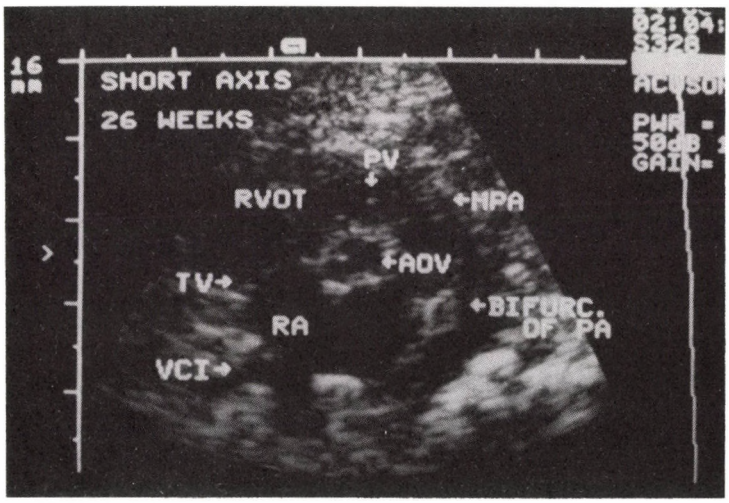

Fig. 4. Short axis plane
In the middle of the circular structure it can be seen the aorta and the aortic valve (AOV). It can be recognized on the right side of the picture the right atrium (RA) with the streaming inferior cava vein (CVI), the tricuspidal valve (TV), the right ventricle and the right ventricle outflow tract (RVOT), respectively. These structures together with the pulmonary valve, with the main pulmonal artery as well as the bifurcation of the pulmonary artery (Bifurc. of PA) make the picture look like a "doughnut".

Left ventricle outflow tract/long axis plane.

From the four-chamber long axis view, the transducer is angled slightly cephalad, revealing the anterior portion of the left ventricle, the aortic root, the aortic valve, and the ascending aorta (Fig. 5). A small portion of the right ventricle and right atrium is also seen. The interventricular septum is contiguous with the medial wall of the aorta. The

ascending aorta arises from the midportion of the heart and courses anteriorly and to the right within the fetal thorax.

An overriding aorta or narrowing of any portion of the ascending aorta can be determined from this view.

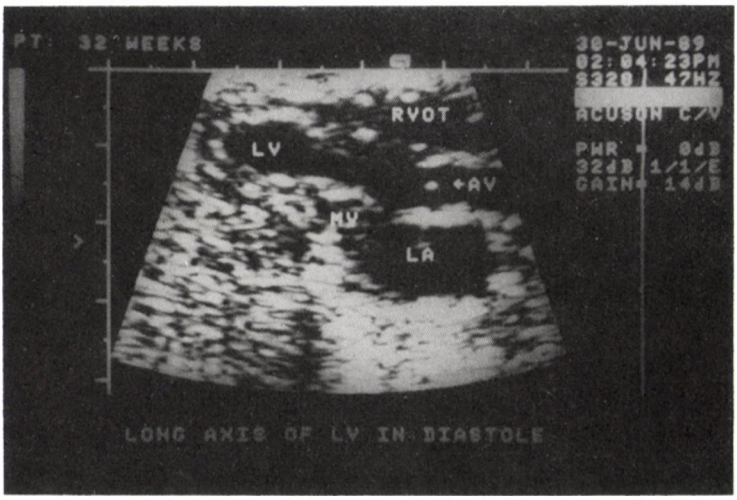

Fig. 5. Left ventricle outflow tract (LVOT)
This picture is obtained if from the four-chamber view the transducer is angled slightly cephalad. It would show the aorta - rising from the left ventricle - and the aortic valve AOV). (RVOT=right ventricle outflow tract, LA=left atrium, MV=mitral valve)

Right ventricular outflow tract/long axis plane

By sliding the transducer slightly from the position of the left ventricular outflow tract imagine towards the fetal head, the right ventricular outflow tract can be seen (Fig. 6). There can be observed the right ventricle, the pulmonary valve, the main pulmonary artery.

In both of these long axis views of the aorta and pulmonary artery, lying close to each other, it is possible to see their relation to each other by "rocking" the transducer back and forward. Transposition of the great vessels can be detected, using this maneuver. Double outler of the right ventricle, and aortic and pulmonary stenosis and atresia can also be detected by these views.

Five-chamber view

This view can be obtained by a slight caphalic tilt of the transducer from the apical view. The so-called "fifth chamber" is the aorta, separating the right and left atria (Fig. 7).

Aortic arch

The ascending aorta, arising from the left ventricle, crosses initially from left to right, passing behind the

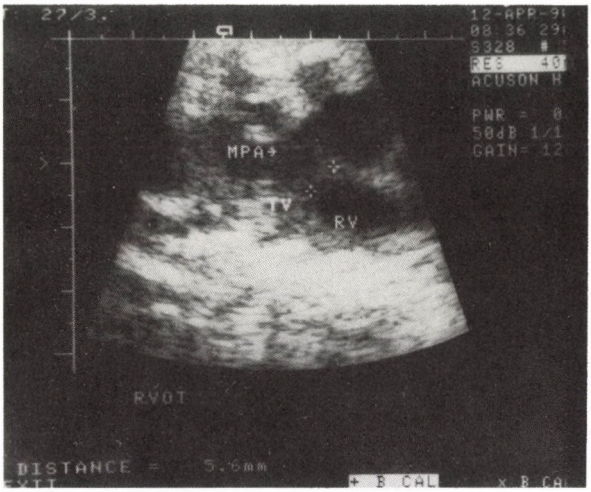

Fig. 6. Right ventricle outflow tract (RVOT)
By sliding the transducer slightly toward the fetal head from the position of the left ventricle outflow tract, the picture of the right ventricle outflow tract could be got. The main pulmonary artery (MPA) arising from the right ventricle (RV) is visible.
(TV=tricuspidal valve)

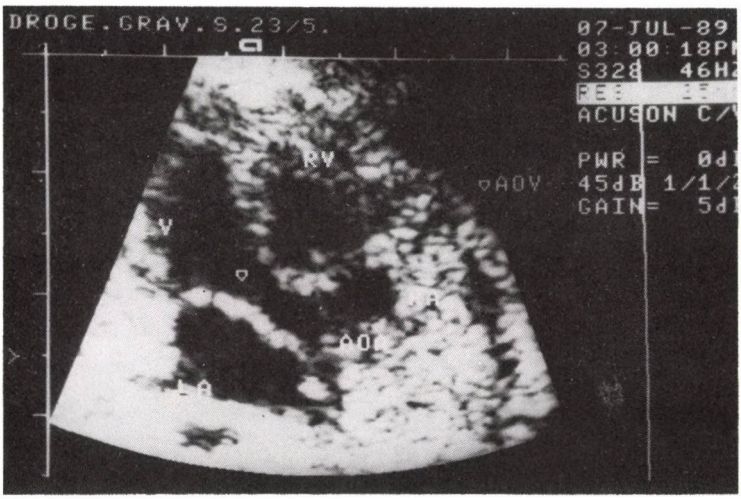

Fig. 7. Five-chamber view
Both ventricles (LV, RV) and both atria (LA, RA) would be seen on the picture. The ascending aorta (AAO) rising from the left ventricle gave the so-called "fifth chamber". (AOV=aortic valve).

pulmonary artery. It then bends from right to left and courses slightly anteriorly as it becomes the transverse arch. Then it curves posteriorly and inferiorly and becomes the descending portion of the aorta. Because of the somewhat tortuous course, the entire aorta from root to descending portion cannot be seen in one single view.

The easiest technique for examining the aortic arch and descending aorta is to place the transducer along the long axis of the fetus to the left of the fetal spine (Fig. 8). The left and right atria, and the short portion of the ascending aorta may be seen. The left subclavian artery, left common carotid artery, and the brachiocephalic trunk should be visible arising from the transverse arch.

The transposition of the great vessels and the coarctation of the aorta could be diagnosed from this view.

The image looks like a "walking stick"

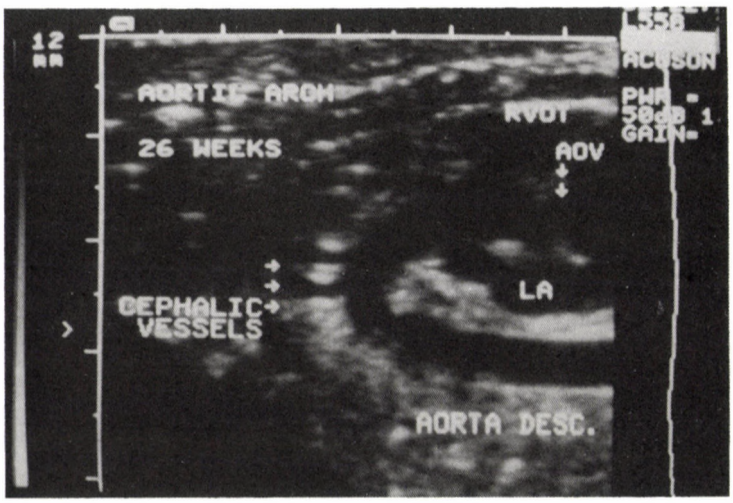

Fig. 8. Aortic arch
The aortic arch reminding of a "walking stick" can be seen in the 26th week of pregnancy with vessels arising from its cephalic vessels. The aorta would be followed from the arising (AOV=aortic valve) till the descending part of the aorta (aorta desc.). (LA=left atrium, RVOT=right ventricle outflow tract).

Ductal arch

The ductal arch looks more like a "hockey stick" than a "walking stick", because it curves much stronger than the aortic arch. The ductus arteriosus enters the descending aorta superior to the point where the transverse arch becomes the descending aorta.

The ductal arch should be focused from the ventral surface of the fetus in a longitudinal cross section (Fig. 9), since it is usually obscured by the fetal spine from the dorsal surface, especially late in gestation. The transducer is placed

in the way, that the beam enters the fetal thorax to the right of the sternum, and transsects the thorax slightly towards the left as it passes along the chest. The descending aorta is seen anterior to the spine and the ductus arteriosus enters it in a smooth curve. Of course there are no arising vessels from the ductus arteriosus.

Fig. 9. Ductal arch in the 24th week of pregnancy
The ductal arch much more reminds of a "hockey stick" because of the much broader curve compared to the aortic arch. The ductus arteriosus connected the main pulmonal artery (MPA) and the aorta (DAO) are also seen.
(RVOT=right ventricle outflow tract, PV=pulmonary valve, RPA=right pulmonary artery, AO=aorta, IVC=inferior vena cava).

Factors, influencing on the examination

By Allan /1/ there are a lot of factors which have an influence on the result of the examination. The fetal cardiac structure can be visualized from the 10th weeks of pregnancy, but the most optimal time is about the 18-20th weeks of pregnancy. In this time it is possible to get an information about the structural details of the fetal heart. Sometimes the examination is impossible to achieve because of the strong fetal body or breathing movements or the disadvantageous position of the fetus for the examination (e.g.the fetal spine is between the transducer and the fetal heart). With maternal obesity the distance between the transducer and fetal heart increases and makes it difficult to get an orientation. The cause is similar in case of polyhydramnions. In the case of oligohydramnion the favourable effect of a fluid-filled sac for optimum transmission of ultrasound is lost.

DISCUSSION

The first articles about the examination of the fetal heart by ultrasound were published about ten years ago /4, 13, 15, 23/. These were followed by a large number of other works /14, 18, 19, 22, 26/ but the checking of the fetal heart did not become general. Looking over the indications of the examination of the fetal heart (Table I), a great number of the pregnant women should get a reassuring information about the cardiological status of their fetuses. This review calls attention that not only the obstetricians but all of the colleagues who are in contact with the pregnant women (see familial and maternal causes) must be very careful that all of the pregnants, for whom it is necessary, should be checked. The acquirement of the 4-chamber-view is important fundamentally /2/. Here, at the routine obstetrical examination raises the suspicion of the congenital heart disease. The exact diagnosis is the duty of a specialist, who has a special practice in the echocardiography and pediatric cardiology, too. Recently a paper was prepared after 545 examinations during 1 year. The result was as follows: 498 negative and 45 positive cases, 1 false negative (the finest diagnosis was an atrioventricular septum defect, with a small ventricular septum defect), 1 false positive (common atrioventricular canale, but the coarctation of aortae was not diagnosed). So, the sensitivity is 98 %, specificity 99 %, positive predictive value 98 %, negative predictive value 99 %. In all of the positive cases the diagnosis was confirmed with repeated examinations. As all of the examinations were performed with a high resolution colour Doppler equipment, so it would be one of the explanation of the very low false negative and false positive cases. In a lot of cases this method made easier the orientation on the fetal heart, which would be sometimes difficult with a black-white equipment /20/. By all means, it is reasonable that at the suspicion of fetal cardiac malformation, the obstetrical ultrasound examination be followed by a consilium with pediatric cardiologist /28/. Verifying the final diagnosis and the

judgement of the further work to be done must be the result of a conclusing obstetrics-pediatric cardiologist consilium, as in pathological cases, depending on the gestational age the tasks can be various (interruption of the pregnancy, operative delivery, per vias naturales delivery). Under the review of the methodology of the fetal heart's examination we wanted to point out the necessity that the examination of high risk pregnancies, especially in congenital heart disease, should be done by well-trained specialists.

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