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Research paper

Maximal velocity of fetal pulmonary venous blood flow

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Abstract

Introduction: Doppler imaging of foetal pulmonary veins plays a crucial role in prenatal cardiology centres. Therefore, we established reference ranges for maximal fetal pulmonary venous blood flow velocity for our unit.
Material and methods: A database of fetal ultrasound and echocardiographic examinations was analysed retrospectively. Healthy fetuses with no evidence of heart defect or any abnormality at the time of examination were selected as a study group. Fetuses with functional or morphological anomalies were excluded. The obtained data included: gestational age of pregnancy according to last menstrual period, maximal velocity of blood flow through pulmonary veins (V_{max} for PVs), prenatal cardiological diagnosis, extracardiac anomalies, and extracardiac abnormalities.
Results: Ultrasound data were collected at 18–39 weeks of gestation in singleton pregnancies. The study group contained 184 healthy fetuses. Scatter graph and reference ranges for their V_{max} for PVs during pregnancy were prepared. The regression equation for V_{max} for PVs as a function of gestational age (GA) in days was:
V_{max} for PVs (cm/sec) = 0.1 x GA (in days) + 5.5 (r = 0.45, CI 0.95).
Conclusion: We presented normal ranges for pulmonary vein Doppler flow for the 18th–38th week of gestation in fetuses with normal heart anatomy, showing a steady increase towards the term in statistical analysis. However, each case should be approached individually because interpretation of the calculated values might not be very easy or straightforward.

Key words: fetal echocardiography, fetal heart, pulmonary veins, maximal velocity.

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Introduction

Colour-coded imaging of fetal pulmonary veins was described for the first time in 1992 by DeVore. Now it is possible to detect the pulmonary veins with their blood flows as early as week 12 of gestation and to trace them in detail as far as the distal end with advancing age [1].

According to Polish Prenatal Cardiology Society and American Ultrasound Institute of Medicine, examination of fetal pulmonary venous blood flow is not compulsory during basic obstetrical ultrasound, but it is an essential part of advanced examination in prenatal cardiology referential centres [2–3].

The purpose of this research was to establish reference ranges for maximal fetal pulmonary venous blood flow velocity for our unit.

Material and methods

The database of fetal ultrasound and echocardiographic examinations performed by experienced fetal cardiologists in the referential centre of prenatal cardiology was analysed ret-

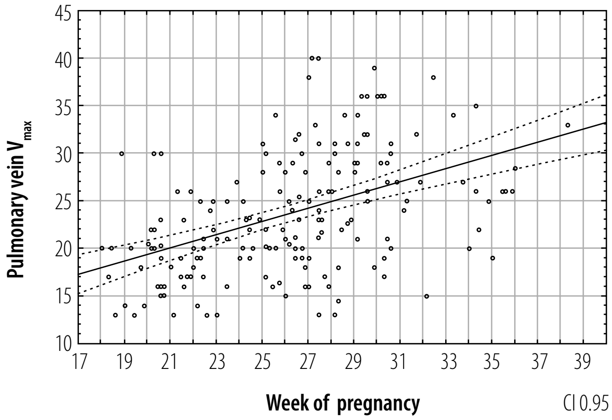

Figure 1. Scatter graph of fetal V_{max} for PVs in the course of pregnancy with regression line

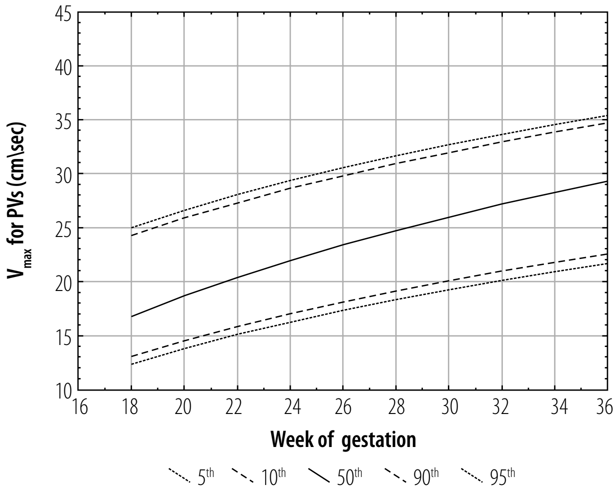

Figure 2. Percentile graph of V_{max} for PVs between 18th and 36th week of gestation

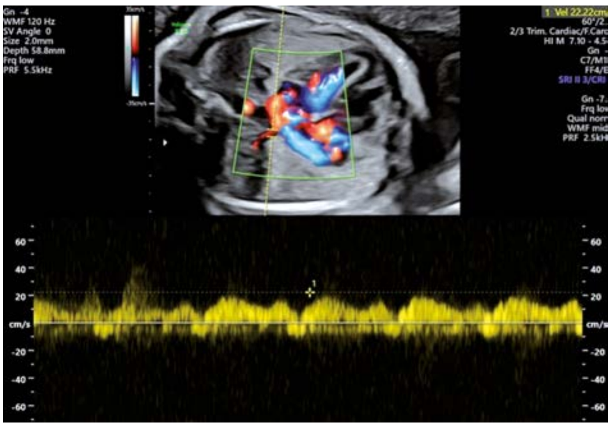

Figure 3. Measurement of blood flow through pulmonary vein (30 hbd)

rospectively. Obtained data included: gestational age of pregnancy according to last menstrual period, maximal velocity of blood flow through pulmonary veins (V_{max} for PVs), prenatal cardiological diagnosis, extracardiac anomalies, and extracardiac abnormalities. In our centre, visualisation of two PVs is a standard. V_{max} for PVs was measured for left and right pulmonary veins at their entrance to the left atrium separately, using the transducer position to obtain almost zero degree for blood flow. A correction angle was not used. The final result was the mean of these two measurements. Healthy fetuses with no evidence of heart defect or any abnormality at the time of examination were selected as a study group. In our database they had labels of normal heart anatomy, no extracardiac malformations, and no extracardiac anomalies. Fetuses with functional or morphological anomalies, oligo- or polyhydramnios, bright spot, arrhythmias, and umbilical cord around the neck and/or 2 vessel cord were excluded. For statistical analysis Statistica 13.1 software was used.

Results

Ultrasound data were collected at 18–39 weeks of gestation in singleton pregnancies. The study group contained 184 healthy fetuses. A scatter graph for their V_{max} for PVs during pregnancy was prepared using Pearson correlation (CI 0.95) (Figure 1). The regression equation for V_{max} for PVs as a function of gestational age (GA) in days was:

V_{max} for PVs (cm/sec) = 0.1 × GA (in days) + 5.5 ($r = 0.45$, CI 0.95).

The 5th, 10th, 50th, 90th, and 95th percentiles of V_{max} for PVs between 18th and 35th week of gestation were calculated. For consecutive percentiles a logarithmic dispersion line was created, and they were combined into a graph (Figure 2).

Discussion

As fetal lung parenchyma develops, so does the pulmonary vasculature. Its development starts by 34 days of gestation. Fetal pulmonary blood flow increases with gestation, from an initial low to almost 50% of the combined ventricular output by term [4]. Only a small amount of blood reaches the fetal pulmonary veins, which is caused by preferential shunting of oxygenated blood from the right to left side of the fetal heart and high vascular resistance in fetal lungs. Nevertheless, visualisation of fetal pulmonary veins connecting to the left atrium plays a crucial role in prenatal cardiology centres (Figure 3).

Many studies show normal fetal pulmonary venous blood flow pattern and velocity [1, 5–7]. Fetal pulmonary venous internal diameters were also evaluated [8]. Considering socioeconomic, environmental, and behavioural changes in the contemporary population, it is essential to re-evaluate this data. Normal ranges for pulmonary vein blood flow require continuous elaboration. We estimated ranges of normal V_{max} for PVs in our region, for our own centre as a reference value for this and subsequent analyses, but it may be used by other obstetrical/cardiac centres. According to Paladini et al., normal V_{max} for fetal PVs differs from our results marginally [5]. Differences in ranges may be caused by various regions of study or different ultrasound devices used. Pulmonary blood flow velocity and its pattern should always be evaluated during fetal echocardiographic examination in a referential centre. Proper fetal cardiopulmonary circulation yields better outcomes after delivery.

Haemodynamic changes in the lung veins may occur in utero as early as in the second trimester and could explain reports of chronic changes in the lung veins complicating neonatal or postoperative outcome in some heart anomalies [9]. An abnormal pattern may be seen in anomalous pulmonary venous connection or obstructed left atrium and restrictive foramen ovale [10, 11]. In the case of fetal critical aortic stenosis, a double reverse pattern in the pulmonary veins is associated with a poor prognosis [12]. In the IUGR population and in fetuses of diabetic mothers, we can observe higher pulsatility, which is lower during fetal respiratory movements [13–15]. That is why velocity measurement of blood flow through pulmonary veins is of great value.

Mother hyperoxygenation is considered to be a potential therapy in some cases of prenatal congenital heart defects [16–18]. Such a new way of treatment requires the response of pulmonary veins to a high concentration of oxygen. It is used also in our centre. Nonetheless, its precise role should be carefully evaluated [19].

Conclusions

We present normal ranges for pulmonary vein Doppler flow for the 18^{th}– 36^{th} week of gestation in fetuses with normal heart anatomy, showing a steady increase towards term in statistical analysis. However, the scattered graph of V_{max} for PVs suggested that for an individual case the proper interpretation of the calculated values might not be very easy or straightforward.

Conflict of interest

The authors declare no conflict of interest.

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