Acceleration time in the aorta and pulmonary artery measured by Doppler echocardiography in the midtrimester normal human fetus

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SUMMARY The time to peak velocity was measured by Doppler echocardiography in the pulmonary artery in 102 normal human fetuses (gestational age 16-30 weeks). Time to peak velocity in the aorta was measured in 72. In 58 both measurements could be made in the same fetus. The time to peak velocity was shorter in the pulmonary artery than in the aorta. This difference was statistically significant. This suggests that in the midtrimester fetus mean pressure in the pulmonary artery is higher than in the aorta.

Cross sectional echocardiographic examination of the normal fetal heart has become well established in recent years.¹⁻³ The intracardiac structures can be readily identified and the Doppler sample volume accurately positioned to allow the characteristics of the blood flow velocity waveform through each cardiac valve to be evaluated.⁴

The prediction of pulmonary artery pressure by non-invasive methods in children and adults has been reported recently. Studies using Doppler echocardiography in pulmonary hypertension have shown a good correlation between the acceleration time and the mean pressure measured by cardiac catheterisation.^{5,6} As pulmonary artery pressure increased the time from the onset of ejection to peak velocity became shorter.

We compared the acceleration time in the pulmonary artery and aorta in a series of normal fetuses to assess the relative mean arterial pressures in fetal life.

Patients and methods

One hundred and two pregnant women were selected for fetal echocardiographic examination between 16 and 30 weeks' gestation. The study group were referred to us because of a previous family history of congenital heart disease or they came as volunteers from the routine antenatal clinic. All the

fetuses were examined by a Hewlett-Packard 722020A phased array sector scanner with a 5 MHz transducer. The fetal heart was first examined by cross sectional echocardiography to establish that its structure was normal. Those with any abnormality of pregnancy or of the fetal heart were excluded. Singleton pregnancies only were examined. Gestational age was estimated from the fetal biparietal diameter and the femoral length or both. The pulmonary artery or the aorta was imaged in a suitable

Fig 1 The Doppler sample volume is positioned in the main pulmonary artery just distal to the valve leaflets. Note that the angle of interrogation is very close to the direction of blood flow.

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Fig 2 The heart is imaged in the long axis of the left ventricle (lv). The Doppler sample volume is then placed in the correct orientation for interrogation of the aortic valve. ao, aorta.

orientation with the Doppler sample volume positioned distal to the valve leaflets. Only those tracings where the direction of the ultrasound beam was $< 30^\circ$ from the direction of blood flow were considered to be acceptable (figs 1 and 2). The blood flow velocity was displayed on the strip chart at paper speed of 100 cm/s and recorded on videotape.

After the examination the measurements were made from the videotape. The measurement was made on screen by positioning one calliper at the onset of ejection and the other at the peak of velocity on a frozen frame tracing from the respective valve (figs 3 and 4). The interval between the callipers was then displayed on the screen. Only clear complexes were used and the acceleration time was the average of 10–20 cardiac cycles.

Results

The time to peak velocity in the pulmonary artery was measured in all 102 patients and aortic measurements were obtained in 72. In 58 fetuses both measurements were made in the same patient. In

Fig 3 The blood flow velocity waveform through the pulmonary artery. The callipers are positioned at the onset of ejection and at the peak of velocity. The time between the two measurements is shown on the screen.

Fig 4 The blood flow velocity waveform through the aortic valve.

Fig 5 The time to peak velocities plotted against gestational age for both the pulmonary artery (a) and the aorta (b). There was no association with gestational age. The values for the pulmonary artery (a) vary slightly more than the aortic values (b).

these 58 we compared the time to peak velocity in the great arteries.

Figures 3 and 4 show that the shape of the velocity tracings was similar in the two arteries. The time to peak velocity was shorter in the pulmonary artery than in the aorta (mean (SD) pulmonary artery 0.0321s (0.0085), vs mean (SD) aorta 0.0437s (0.0088)) ($p = < 0.0000001$ by an unpaired t test). There was no detectable change with gestational age in the time to peak velocity in either of the great arteries (fig 5).

Discussion

Fewer measurements of aortic velocity were obtained because at the start of the study we found it more difficult to achieve a small angle between the direction of the beam and the direction of flow in this vessel. Later in the study measurements in both the aorta and pulmonary artery were readily achieved in the correct orientation.

Kitabatake *et al* described the close correlation between pulmonary artery pressure and time to peak velocity in 33 adult patients studied by Doppler and cardiac catheterisation.⁵ These results were

confirmed by Serwer *et al* in a study of 33 children⁶ and by Kosturakis *et al* in a study of 17 children with structural heart disease undergoing cardiac catheterisation.⁷

On the basis of these studies we expect that fetal results will also reflect the relative mean arterial pressures found prenatally. Our results suggest that between 16–30 weeks' gestation the mean pressure in the pulmonary artery is higher than that in the aorta and that this reflects a difference in resistance between the two circuits.

Thus when there is a restrictive ventricular septal defect in a fetus there may be a right to left shunt. Because the pressure difference between the two sides of the heart is probably small, however, the shunt is not expected to be large. We have been unable to detect shunting in prenatal life through a ventricular septal defect by direct Doppler interrogation. Some workers who have had the opportunity to examine such cases with colour Doppler have suggested that there is a left to right shunt.⁸ This does not accord with our findings.

It is perhaps surprising that there was no detectable change in pulmonary artery time to peak velocity estimations with increasing gestation. Placental resistance is known to fall as pregnancy advances^{9 10} and this might be expected to affect the results of time to peak estimation in the pulmonary artery.

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