Non-invasive measurement of human fetal circulation using ultrasound: a new method

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Summary

We combined two ultrasound techniques to develop a safe, non-invasive, transcutaneous method of observing the circulation in the umbilical arteries and vein in the fetus. The umbilical cord can be located by standard echo ultrasound procedures, and this information can be used to direct a Doppler ultrasound beam on to the vessels in the cord. The signals can be heard through audio headphones or recorded on a tape recorder and spectrum-analysed.

The method was successful in each of 20 patients examined, whose pregnancies ranged from 12 to 40 weeks' gestational age, and was suitable for outpatient use. It should be useful in assessing such conditions as pre-eclampsia and intrauterine growth retardation.

Introduction

Due to the relative inaccessibility of the human fetus, all the current information on umbilical blood flow has been inferred from animal studies,¹ from the clearance rates of radioactive isotopes,² or from measurements taken immediately after delivery.³ Pulsed-echo ultrasound is widely used in obstetric practice to assess fetal growth, diagnose multiple pregnancy, and

FIG 1—B-scan showing umbilical cord (UC) of 12-week-old fetus and displaying the echoscan depth-markers (EM).

FIG 2—Sample sonograms of arterial (a) and venous (b) blood-velocity signals obtained from the cord shown in fig 1. Signals may sometimes be mixed (c), but fine movements of the probe angle can usually separate artery and vein.

determine placental position. During these examinations the umbilical cord is often visible. The position of the umbilical vein, where it curves under the fetal liver, is now used as a reference in fetal abdominometry.⁴ Continuous-beam Doppler-shift ultrasound is used for observing blood velocity in arteries and veins.^{5 6} By combining these two techniques we were able to monitor the circulation in the umbilical vessels transcutaneously from 12 weeks' gestation to full term.

Method

We used a Dasonograph NE 4102 (Nuclear Enterprises) at a frequency of 2.5 MHz to obtain transverse displays of the fetal abdomen (technique of Campbell and Wilkin⁴), and to identify the position of the umbilical vein where it entered the fetal abdomen. The pulsed ultrasound beam was then directed through the centre of the displayed segment of umbilical vein, held at right angles to it, and the distance from the probe to the vessel measured with the electronic calipers of the Dasonograph. As it is difficult to recognise the umbilical vein before 22 weeks' gestation, a segment of the umbilical

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cord was located by performing a series of longitudinal scans, and the above-mentioned procedure was performed. A 5-MHz probe, attached to a Doppler velocity flowmeter (Model 806 C; Parks Electronics), was placed to one side of the pulsed-echo probe, and the continuous beam of ultrasound was directed in the same plane as the pulsed beam, with an angle of approximately 30° between it and the umbilical vessel. The Doppler probe, which was hand-held, required slight angular manipulation to obtain optimum Doppler-shift signals, which were monitored through headphones. The position of the probe was held, and the signals recorded on a tape recorder. The recorded signals were then processed through an audiofrequency analyser (Kay Sonagraph 6061) to produce a display (sonagram) of red-cell velocity in real time. The density of the signal in the sonagram is proportional to the number of red cells travelling at a particular velocity at a particular time.

The angle of the Doppler probe is held at approximately 30° to the vessels, and positioning is made possible by using the B-scan to place the pulsed-echo probe at right angles to the vessels. This serves as a guide to position the Doppler probe. Experience in collecting Doppler signals also helps in obtaining the optimum angle of the probe to the vessel.⁶ The audiofrequency analyser displays the signals in terms of frequency against time, and there is a linear relation between frequency and velocity at these levels.⁷ These signals are records of blood velocity, however, and do not represent volume flow.

Results

Twenty patients, whose pregnancies ranged from 12 to 40 weeks' gestational age, were referred for ultrasonic examination either to confirm gestational age or to locate the placenta before amniocentesis. Using the method described above Doppler signals were obtained from the umbilical cord in each patient examined. By small movements of the direction of the ultrasound beam venous and arterial signals could be detected. These were sometimes mixed, but could be separated by careful changes of the beam direction. The position of the umbilical cord in a 12-week-old fetus as detected by the echoscan is shown in fig 1. Sonagrams of venous and arterial blood-velocity signals from the cord are shown in fig 2. The sonagram is com-

posed of the spectrum of red-cell velocities passing through the ultrasound beam. An example of artery (a), vein (b), and artery and vein mixed (c) is shown. There is a clear difference in the shape of the two signals, which can also be discerned while listening to the signals. Re-examination of the patient three or four times at intervals during the same session gave reproducible signals, of which the illustrations are representative examples.

Discussion

This technique is safe and non-invasive, and allows fetal umbilical blood-flow patterns to be observed from as early as 12 weeks' gestation. It required no elaborate preparation, and was thus suitable for use as an outpatient procedure. The technique is basically simple and easy to learn, and can be used throughout pregnancy. The shape of the blood-velocity waveform will change with conditions affecting the efficiency of blood supply,⁶ and the method should be useful in assessing such conditions as pre-eclampsia and intrauterine growth retardation.

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Active management of labour: care of the fetus

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Summary

A prospective study of 1000 consecutive primigravidae was conducted to assess the relevance of the colour of the liquor to the welfare of the child. The results showed that clear liquor early in labour virtually ensures the birth of a healthy infant, provided the duration of labour is limited and delivery is effected without trauma; and, conversely, that meconium—or no liquor—marks the fetus who may suffer death or brain damage during normal labour. Special techniques were reserved for the second group of cases.

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Introduction

A policy of active management of labour was adopted in this hospital 10 years ago with the aim of reducing maternal stress by restricting the duration of exposure.¹ This policy has been successful to the extent that delivery is usually completed within 12 hours. Several additional benefits have accrued to mothers: these include a personal nurse for every patient, reduced demand for analgesia, a low rate of operative intervention, and elimination of trauma.² Initially we feared that the use of oxytocin to ensure effective uterine action might prove detrimental to infants, but this has not been the case. We report on the method of supervision of the fetus, based on colour of liquor, which has evolved in this hospital during the past decade. Good results can be achieved in a busy delivery unit when special techniques are used selectively.

Patients and methods

A prospective study of 1000 consecutive primigravidae was conducted between 1 June and 12 October 1976. Management of labour was directed to ensure delivery within 12 hours. The fetus was supervised by simple auscultation when clear liquor was shown early in labour. Special techniques were reserved for cases in which meconium