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A new method for the measurement of pre-ejection period in the human fetus

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Summary. The pre-ejection period (PEP) of the cardiac cycle was measured in the human fetus using pulse Doppler in association with transabdominal ECG. The technique permitted the exact localization of the aortic valve, a good recording of its opening and the exact measurement of PEP. Between 32 and 42 weeks of pregnancy there is a strong correlation between PEP and gestational age. This new method seems to be an easy and reliable tool for measuring the PEP during intrauterine life.

The systolic time intervals of the fetal cardiac cycle have been analysed by several authors in the past, both in animals (Organ *et al.* 1973; Murata *et al.* 1978*a*) and man (Goodlin *et al.* 1972; Murata *et al.* 1978*b*). Particular importance has been given to the study of the pre-ejection period (PEP), which is defined as the time between the onset of the QRS complex of the electrocardiogram (ECG) and the beginning of ventricular ejection, timed from the opening of the aortic valve.

Up to now, the opening of the aortic valve in the human fetus has been detected by phonocardiography (Goodlin *et al.* 1972) or a suitably filtered Doppler ultrasound signal (Murata *et al.* 1978*b*). As shown in Fig. 1, the signal S_2 represents the opening of the aortic valve and is used for the measurement of PEP.

Notwithstanding the importance and the predictive value (Murata *et al.* 1978*b*) of monitoring fetal myocardial function, the study of systolic time intervals has not been widely applied in clinical practice. This may be explained by the difficulty in obtaining simultaneously a reliable fetal ECG and a Doppler tracing, with current equipment.

We propose a new and simplified technique for the evaluation of PEP by means of a cardiotocograph for recording fetal ECG in association with a real time echotomograph with pulse Doppler for the detection of the cardiac sounds.

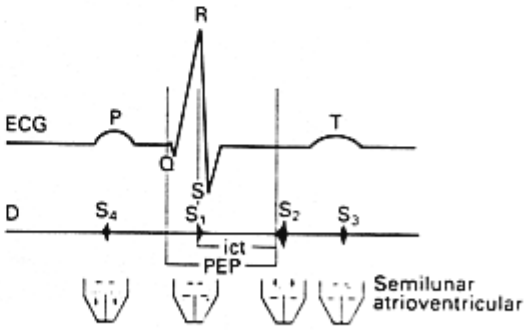

Fig. 1. Schematic representation of the pre-ejection period as the interval between the Q wave of ECG and the opening of aortic valve.

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Fig. 2. Ultrasound scan displaying the aorta (parasternal long axis).

Subjects and methods

Thirty-four healthy women with pregnancies of between 32 and 34 weeks were studied. After informed consent has been obtained, an ultrasound scan confirmed the gestational age and a normal fetal growth.

Recordings were then performed with patients in the left semirecumbent position in a quiet room. An echotomograph of Advanced Technology Laboratories MARK 500 (ATL 500), fitted with a pulse Doppler module of varying depth and a 3·5 MHz sectional sectorial transducer, was used together & Hewlett-Packard 8040 cardiotocograph arranged to record the fetal ECG through the maternal abdominal wall. The two pieces of equipment were connected to allow the fetal ECG to appear on the echotomograph display, after suitable decodification, filtering and voltage step-down (1 V output cardiotocograph to 1 mV input echotomograph).

After identification by real time ultrasonic scanning of the fetal position *in utero*, electrodes to record the fetal ECG were applied on the maternal abdomen along the fetal electrical axis. Once a satisfactory fetal ECG was clearly displayed a longitudinal scan of the fetal heart was performed by a two-dimensional ultrasonic technique. When the aortic bulb and its ascending part were recognized, the sample volume was set in the middle of the vessel immediately above the valve (Fig. 2) for the pulse Doppler registration. In this way we obtained, simultaneously, the pulse Doppler tracing and the fetal ECG on the echotomograph display. The abscissa of the oscilloscopic tracing was subdivided into 40 ms periods. The intervals between the ECG and pulse Doppler tracings were easily detected when the image ran at the highest possible speed (100 mm/s). After freezing the image on the display (Fig. 3), the PEP was measured as the distance between the onset of the Q wave of the fetal ECG and the beginning of the S_2 signal of the Doppler tracing.

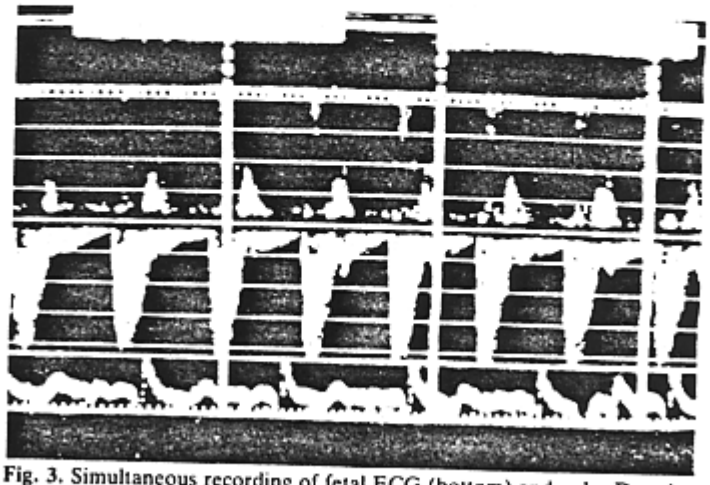

Fig. 3. Simultaneous recording of fetal ECG (bottom) and pulse Doppler tracing (top).

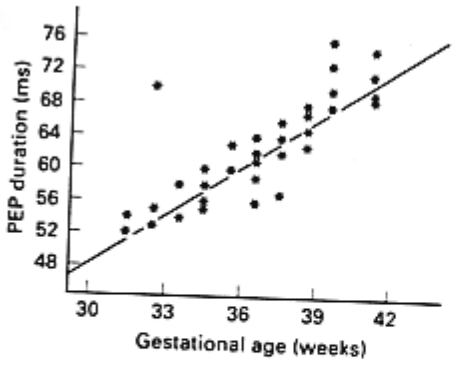

Fig. 4. Correlation between gestational age and PEP duration ($y = 17{\cdot}05 + 2{\cdot}14x$), $r = 0{\cdot}89$; $P<0{\cdot}001$.

Statistical analysis was performed by means of linear regression.

Results

The mean gestational age of the patients studied was 34·5 (SD 3·78) weeks, and we were able to record fetal ECG and Doppler tracings in all those studied.

PEP values obtained ranged between 52 and 76 ms, similar to those obtained by other authors with different techniques (Organ *et al.* 1973; Murata & Martin 1974; Murata *et al.* 1978*b*).

In line with previous reports (Wolfson *et al.* 1977; Murata *et al.* 1978*b*), we have found a strong positive linear correlation between PEP and gestational age ($r = 0{\cdot}89$; $P<0{\cdot}001$, Fig. 4).

There was no correlation between fetal heart rate and PEP.

Discussion

The method described, thanks to the precise localization of the aortic valves, allows an optimum imaging of the S_2 signal. The simultaneous display of the fetal ECG and Doppler tracing enables the immediate reading of the systolic time intervals devoid of the distortion caused by paper print-outs. Furthermore the bidimensional display of the fetal heart allows the exact localization of the aortic valve, thus differentiating it from the pulmonary valve. A difference between the PEP of the right and left ventricles has been shown recently in the fetal lamb (De Muylder *et al.* 1984).

We consider that this new method will simplify the study of the fetal heart cycle, especially of PEP, and make it more reliable for the clinical assessment of fetal well being.

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