EFFECTS OF EXTRADURAL ANAESTHESIA ON UMBILICAL AND UTEROPLACENTAL ARTERIAL FLOW VELOCITY WAVEFORMS

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SUMMARY

Flow velocity waveforms were recorded from the umbilical artery and uteroplacental arterial circulations of 15 women undergoing elective Caesarean section under extradural anaesthesia. The systolic:diastolic ratios of the flow velocity waveform were determined before and after extradural block. Extradural block did not alter fetal or maternal heart rates; however, umbilical artery systolic:diastolic ratio decreased from a mean (SD) of 2.4 (0.42) to 2.26 (0.38) (P = 0.049). There were no significant changes in the uteroplacental systolic:diastolic ratios. These results were compared with those from a control group in which no statistically significant changes in maternal and fetal systolic:diastolic ratios or heart rates were observed. The application of a pulse correction factor to standardize the data to fixed maternal and fetal heart rates had little effect on the significance of the findings. Extradural block in normal pregnant women during late gestation was associated with a small reduction in umbilical artery systolic:diastolic ratios, suggesting a decrease in downstream fetoplacental vascular resistance.

KEY WORDS


Extradural anaesthesia has become a widely used technique for Caesarean section. It allows the woman to remain awake, enabling immediate contact with her infant and minimizing her risk of pulmonary aspiration. The fetus also may benefit from reduced exposure to anaesthetic drugs [1].

Recent advances in ultrasonography have allowed study of the uteroplacental and fetoplacental circulations. Several preliminary investigations of the effects of extradural anaesthesia on the uteroplacental and fetoplacental circulations have been published, reporting conflicting results [2-6]. The technique used most frequently utilizes continuous wave Doppler ultrasound to obtain a flow velocity waveform of the blood flow through an umbilical or uteroplacental artery. By determining the ratio of peak flow in systole to least flow in diastole, an assessment of the downstream vascular resistance is obtained. Increased systolic:diastolic ratios have been correlated with increased placental vascular resistance caused by a decrease in the small arteries in placental tertiary stem villi [7] and have been reproduced in experimental animals by microsphere embolization of the umbilical circulation [8]. The purpose of this study was to use flow velocity waveform analysis to investigate the effects of extradural block on uteroplacental and fetoplacental vascular bed resistance. As systolic:diastolic ratios have negative correlations with their corresponding heart rates, allowance was made for the effect of pulse interval by adjustment of ratios to standard heart rates [9]. A control group also was included, to assess any changes in systolic:diastolic ratios which may have resulted solely from enforced rest.
PATIENTS AND METHODS

We studied 15 women undergoing elective Caesarean section between 38 and 41 weeks gestation. All were ASA grade I with no history of problems during their pregnancy; in particular, none had any features of pre-eclampsia, diabetes, antepartum haemorrhage, abnormal amniotic fluid volume, uterine abnormality or altered fetal growth.

Informed consent was obtained from the patients and approval from the hospital Ethics Committee. The flow velocity waveforms were obtained with a Doppler spectrum analyser 9000 with a 4-MHz continuous wave Doppler transducer using methodology outlined elsewhere [10]. Briefly, ultrasound imaging was used to establish the site of the umbilical cord and placenta. The arterial waveforms were obtained by directing the Doppler beam and searching for the characteristic waveform. Systolic:diastolic ratios were recorded from umbilical and uteroplacental arterial waveforms and calculated from the mean of three or four consecutive waveforms. Measurements were not made during periods of fetal breathing or excessive fetal activity and at least 10 stable consecutive waveforms were required before measurements were taken. Heart rates were calculated from measurement of the average pulse interval using electronic calipers. Results of the Doppler studies were not released for clinical management.

Readings were performed by the principal author (G.T.). An analysis of within-observer variability showed a coefficient of variability of less than 5% within a series of measurements in the same patient. All measurements were made with the woman in a left lateral tilt position to avoid aortocaval compression. Baseline readings were made before preloading with Hartmann's solution 1000 ml. An extradural catheter was inserted into the lumbar extradural space through a 16-gauge Tuohy needle and anaesthesia was induced with introducing 0.5% plain bupivacaine 15 ml. Further increments of 0.5% bupivacaine were added to obtain a sensory block to the level of T3—5. Arterial pressure measurements were made at 5-min intervals. A second set of readings and recording of the height of the block were made after another 20 min.

The control patients had two sets of readings made 40 min apart while lying on a theatre trolley between the readings and were exposed to the theatre suite environment. Neither an i.v. nor an extradural catheter was inserted. Thus any change in the fetoplacental or maternoplacental flow velocity waveforms caused solely by a period of enforced rest in the operating theatre environment could be assessed.

The potential exists for uteroplacental systolic:diastolic ratios to vary with the site along the uterine arterial tree that the measurement is taken. Measurement from arteries close to the placental bed may result in smaller systolic:diastolic ratios, reflecting the low resistance of the placental vasculature, while measurements taken from a more proximal site may result in greater systolic:diastolic ratios, reflecting the low resistance placental and high resistance somatic arteries downstream. Great care was taken in the present study to ensure that measurements were taken from arteries within the centre of the placental bed and in each patient serial measurements were taken from the same site.

The effects of extradural anaesthesia on heart rates and flow velocity waveform systolic:diastolic ratios were tested by paired Student's t tests. Logarithmic (base 10) transformations were performed if systolic:diastolic ratios were not normally distributed.

RESULTS

There were 15 patients in the extradural group and seven patients in the control group, matched for maternal and gestational age. Mean maternal ages were 29.2 yr and 29.3 yr, for the control and extradural groups, respectively; mean gestational ages were 38.8 weeks and 39.2 weeks, respectively. Mean maternal systolic arterial pressure before and after extradural block were 109.2 (SD 10.9) and 109.3 (9.3), respectively. No vasopressors were required by any of the patients during the period of the post-extradural observations.

The effects of extradural anaesthesia on umbilical artery systolic:diastolic ratios are shown in table I. Extradural anaesthesia was followed by a reduction in umbilical artery systolic:diastolic ratios from mean (sd) 2.40 (0.42) to 2.26 (0.38) ($P = 0.049$). Although there was a mean reduction in umbilical artery systolic:diastolic ratio, the effect of extradural anaesthesia was variable, with an increase in four patients, no change in five patients and a decrease in six. Umbilical artery systolic:diastolic ratios at corresponding times in the control group were not altered ($P = 0.16$).
Fetal heart rates before and after extradural anaesthesia were similar. After adjustment of the ratios to a standard rate of 140 beat min⁻¹, mean (sd) ratios decreased from 2.32 (0.61) to 2.20 (0.61) (P = 0.054). The relative magnitude of this decrease was not significantly different from that observed when the systolic:diastolic ratios had not been adjusted for heart rate.

Maternal uteroplacental systolic:diastolic ratios are shown in table I. Extradural anaesthesia was not associated with an alteration in uteroplacental systolic:diastolic ratios or maternal heart rates. Adjustment of the systolic:diastolic ratios to a standard rate of 80 beat min⁻¹ did not affect the significance of this response.

**DISCUSSION**

The use of Doppler ultrasound has permitted in vivo assessment of flow through the uteroplacental and fetoplacental vascular beds. Spectrum analysis of the Doppler shift provides an assessment of the velocity of the red blood cell mass moving through the vessel. With the continuous wave Doppler technique used in the present study, systolic:diastolic ratios from the flow velocity waveform are calculated to provide an assessment of downstream vascular resistance. Actual flow rates cannot be calculated, as the angle of insonation is unknown. The results of the present study indicate that, after extradural anaesthesia was established, there was a reduction in mean umbilical artery systolic:diastolic ratios which suggests a decrease in downstream fetoplacental vascular resistance. However, other factors also may have contributed to this decrease in umbilical artery systolic:diastolic ratios. Flow rates through a given vessel vary inversely, not only with the resistance of the downstream vascular bed, but also with the viscosity of the perfusing fluid. Nevertheless, Steel and colleagues [11] found that changes in viscosity contributed only 10% to the
variability in flow velocity waveforms obtained from the uteroplacental circulation. Similarly, Giles and Trudinger [12] were unable to demonstrate that alterations in flow velocity waveforms were caused by changes in whole blood viscosity. Therefore it is difficult to attribute the decreased systolic:diastolic ratio in the fetoplacental circulation to haemodilution secondary to the preload of Hartmann’s solution 1000 ml. Blood flow through vascular beds also varies with perfusion pressure, which may be measured and controlled to some extent on the maternal side, but must be assumed to remain relatively unchanged in the fetal circulation.

Previous studies of the effects of extradural block on systolic:diastolic ratios have produced conflicting results [2–6]. No changes were observed in umbilical systolic:diastolic ratio after extradural block both in studies in which adrenaline was added to the local anaesthetic solution [2, 4] and in studies in which it was omitted [5]. Our results are consistent with those of Giles, Lah and Trudinger [3] which demonstrated a reduction in systolic:diastolic ratio after establishment of a block. None of the previous studies took account of the potential influence of maternal and fetal heart rates. However, adjustment of systolic:diastolic ratios to standard heart rates had minimal effect on the trend or significance of our finding, probably because maternal and fetal heart rates were little changed after extradural block.

There is evidence that the fetoplacental and uteroplacental circulations are matched to optimize nutrient and waste exchange and thus changes in one may influence the other [13]. Therefore, to analyse changes in the fetoplacental flow velocity waveforms, simultaneous recording of changes in the uteroplacental flow velocity waveforms are of interest. Of the previously cited studies, only two have taken measurements from both circulations. Giles, Lah and Trudinger [3] found that the uteroplacental systolic:diastolic ratio decreased in parallel with the umbilical systolic:diastolic ratio, while Baumann and colleagues [6] found an increase in uteroplacental resistance indices, but no changes in fetoplacental resistance. Our study provides a third combination of no change in uteroplacental systolic:diastolic ratio with a decrease in mean umbilical systolic:diastolic ratio.

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REFERENCES