

FETAL AND NEONATAL MEDICINE

Prediction of fetal acidaemia in intrauterine growth retardation: comparison of quantified fetal activity with biophysical profile score

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ABSTRACT

Objective To study the relation between quantified fetal movements and fetal activity assessed by the biophysical profile score and the pH in umbilical arterial blood at elective caesarean section.

Design Fetal activity was assessed within 24 h prior to caesarean section for decelerative fetal heart rate patterns both by quantification (% of time spent moving) and by applying the biophysical profile score (BPS) criteria.

Setting Department of Obstetrics, University Hospital.

Subjects Nineteen growth retarded fetuses.

Main outcome measures Fetal generalised movements (FGM%), fetal breathing movements (FBM%), total fetal activity (TFA% = FGM% + FBM%); FGM, FBM and tone as assessed according the biophysical profile score (BPS); umbilical arterial pH.

Results In all 11 acidaemic fetuses (pH <7.20) TFA% was below the 10th centile for normal fetuses; nine had decreased FGM% and eight decreased FBM%. Absence of FGM or tone according to the biophysical profile score was only seen in two acidaemic fetuses.

Conclusion TFA% <11.7% was a better predictor of acidaemia at birth than either reduced FGM%, FBM%, or absence of FGM, FBM and tone as defined in the biophysical profile score. The two methods of assessing FBM were identical in predicting acidaemia, suggesting that in presence of acidaemia the decrease of FBM may be an all-or-none phenomenon. Furthermore, the data indicate that reduction in body movements may precede reduction in breathing movements.

In the assessment of fetal well-being, the importance attributed to fetal activity is reflected in the biophysical profile score (BPS), where activity is apportioned 60% of the total score (Manning *et al.* 1980). However, in the BPS fetal activity is considered as an all-or-none phenomenon. The aim of the present study is to examine whether quantification of fetal movements can provide more accurate information on fetal acidaemia.

Subjects and methods

Videotape recordings of real time ultrasound examination in 19 intrauterine growth retarded fetuses (IUGR) at 29 to 37 (median 31) weeks of gestation were made

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within 24 h before elective caesarean section and cord blood sampling at birth. In all cases gestational age was determined by Naegele's rule or by an ultrasound scan in early pregnancy. The diagnosis of IUGR was based on the demonstration of a fetal abdominal circumference below the 5th centile for gestation and this was subsequently confirmed by the birthweight (median 930 g, range 620–1535 g) which was always below the 10th centile for gestational age and sex (Kloosterman *et al.* 1970). The amniotic fluid volume was subjectively assessed ultrasonographically as being reduced in 18 cases; in seven of these oligohydramnios was present (i.e. largest pocket < 1 cm). The velocity waveform pattern of the umbilical artery was abnormal (Pulsatility Index > 2 SD above mean for gestational age) in all fetuses except the one delivered at 37 weeks. All infants were chromosomally and morphologically normal. At the time of fetal assess-

ment seven mothers were receiving sympatholytic drugs (labetalol) for pregnancy induced hypertension.

Fetal generalised body movements (FGM) and fetal breathing movements (FBM) were visualised using a linear array ultrasound scanner, and 60 min recordings were made between 8:00 and 21:00 h with the women in a semirecumbent position. The mothers were requested to refrain from eating or smoking for 1 h before and during the actual recording. All recordings were analysed by the same investigator (LSMR) who marked the onset and end of FGM, and each breathing movement using an event recorder. An episode of FBM was defined by the presence of at least two breathing movements within an interval of 6 sec. In each case, the amount of time the fetus spends moving (FGM%) and breathing (FBM%) as well as total fetal activity (TFA% = FGM% + FBM%) were calculated and expressed as a percentage of observation time. Additionally, in each case the first 30 min of recording was examined for the presence or absence of FGM, FBM and tone as defined by the Manning criteria for the BPS (Manning *et al.* 1980). Thus, FGM or FBM were considered to be absent if there were less than three body movements or no sustained breathing lasting at least 30 s or more, respectively.

In all cases delivery was performed by caesarean section for fetal distress (decelerative fetal heart rate patterns with decreased variation). At caesarean section, after routine maternal preoxygenation, the umbilical cord was double clamped and arterial blood was aspirated into heparinised syringes for blood pH measurements (AVL 945 Automatic Blood Gas System, Austria). In a previous study in 45 normally grown fetuses born by elective cae-

Table 1. Fetal activity according to the biophysical profile score (BPS) and as percentage of observation time (%) in 19 growth retarded fetuses with decelerative fetal heart rate patterns. In seven cases there was oligohydramnios (*). The cases are ranked according to the pH in the umbilical artery. FGM = Fetal generalised body movements; FBM = fetal breathing movements; TFA = total fetal activity.

Case	FGM	FBM	TONE	BPS	FGM%	FBM%	TFA%	pH
1	0	0	0	0	0.2	0.0	0.2	7.01
2	2	0	2	4	1.8	0.0	1.8	7.04
3	2	0	2	4	2.9	0.7	3.6	7.06
4	0	0	0	0*	0.2	0.0	0.2	7.07
5	2	0	2	4*	4.7	0.4	5.1	7.09
6	2	2	2	6	1.1	5.3	6.4	7.12
7	2	2	2	6*	1.5	8.2	9.7	7.13
8	2	2	2	6	2.7	3.4	6.1	7.15
9	2	0	2	4*	7.1	0.4	7.5	7.17
10	2	0	2	4*	2.5	0.2	2.7	7.18
11	2	0	2	4*	2.1	0.9	3.0	7.19
12	2	2	2	6*	18.0	6.4	24.4	7.20
13	2	0	2	4	3.0	4.9	7.9	7.23
14	2	2	2	6	2.8	8.1	10.9	7.24
15	2	2	2	6	1.9	10.4	12.3	7.24
16	2	2	2	6	7.4	8.5	15.9	7.24
17	2	0	2	4	13.1	18.7	31.8	7.26
18	2	2	2	6	2.8	8.1	10.9	7.26
19	2	2	2	6	6.3	47.0	53.3	7.27

sarean section the 10th centile for umbilical arterial pH was found to be 7.20 (Bekedam *et al.* 1987). Therefore in the present study acidaemia was diagnosed if the umbilical arterial pH was less than 7.20.

In a cross sectional study of 74 normal third trimester pregnancies, the incidence of FGM%, FBM% and TFA% did not change significantly with gestation and the respective values for the 10th centile were 3.6%, 2.9% and 11.7%.

Results

The umbilical arterial blood pH was less than 7.20 in 11 of the 19 IUGR fetuses (Table 1). Reduced TFA% was a better predictor of fetal acidaemia than either the individual components of FGM% and FBM% or the fetal tone and activity as defined in the BPS (Table 2). The associations between blood pH and fetal activity are shown in Fig. 1 and 2. Ingestion of sympatholytic drugs had no significant effect on these associations (multiple regression analysis; $P > 0.20$). TFA% and activity according to the BPS (score 0–6) showed a similar correlation with pH at birth (Fig. 2). However, with a BPS of 6 there were three acidaemic fetuses whereas with a normal TFA acidaemia was always absent.

Discussion

This study deals with small-for-gestational-age fetuses without congenital malformations in which abnormal flow velocity waveform patterns, reduction in amniotic fluid volume, and abnormal fetal heart patterns are indicative of growth restriction because of impaired utero-placental perfusion (intrauterine growth retardation).

Abnormal antepartum fetal heart rate patterns are primarily associated with fetal hypoxaemia, whereas fetal acidaemia may or may not yet be present (Henson *et al.* 1983; Bekedam *et al.* 1987; Smith *et al.* 1988; Visser *et al.* 1990; Ribbert *et al.* 1991). This study has confirmed that in growth retarded fetuses the presence of abnormal fetal heart rate patterns necessitating caesarean delivery can be found in the absence of fetal acidaemia. However, acidaemic fetuses have decreased total activity whereas non-

Table 2. Prediction of fetal acidaemia (pH <7.20) by reduced percentage of time spent in generalised body movements (FGM%), breathing movements (FBM%) and total fetal activity (TFA%), or by absence of movements and tone according to the biophysical profile score.

Variables	pHa <7.20 n=11	pHa ≥7.20 n=8
Movement incidence (%)		
FGM (<3.6%)	9	4
FBM (<2.9%)	8	0
TFA (<11.7%)	11	3
Biophysical profile score		
FGM absent	2	0
FBM absent	8	2
Tone absent	2	0

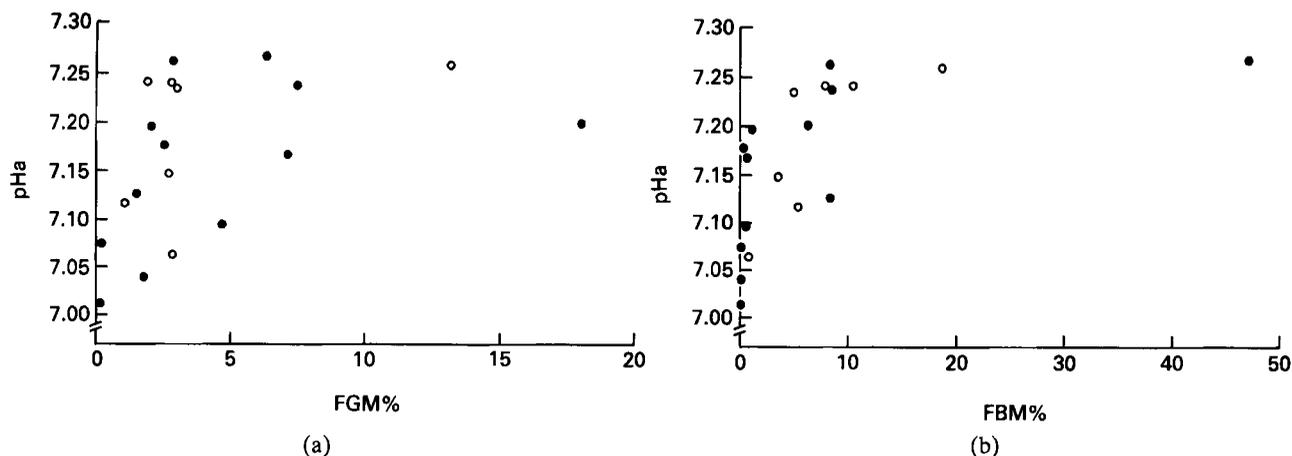


Fig. 1. The association between umbilical arterial blood pH and percentage of time spent in (a) generalised body movements (FGM%; $r=0.43$, NS) and (b) breathing movements (FBM%; $r=0.57$, $P<0.05$). Maternal ingestion of sympatholytic drugs (\circ) had no significant effect on these associations.

acidaemic fetuses continue to breathe. These data are compatible with the findings of previous studies that in compromised fetuses development of fetal heart rate abnormalities precedes the cessation of fetal movements (Bekedam *et al.* 1987; Vintzileos *et al.* 1987a; Vintzileos *et al.* 1987b; Ribbert *et al.* 1990, 1993).

In the BPS, fetal tone and activity are defined as being present or absent (Manning *et al.* 1980). The findings of this study and those of previous reports that examined the relation between BPS and blood gases at cordocentesis or at delivery, demonstrate that although absence of FGM, FBM and tone is indicative of fetal acidaemia, their presence (as defined for the BPS) does not reassure that fetal blood pH is normal (Vintzileos *et al.* 1987a; Vintzileos *et al.* 1987b; Ribbert *et al.* 1990). In contrast, decreased TFA% identified all acidaemic fetuses, while normal TFA% was always indicative of nonacidaemia.

In the prediction of fetal acidaemia, TFA% ($<11.7\%$) is more accurate than the individual components of either FGM% or FBM%. Similarly, Roberts *et al.* (1991) have demonstrated that in the diagnosis of intrauterine infection, TFA% is more discriminative than FGM% or FBM% alone, or than the BPS. The main reason for the

observed differences between the BPS and TFA% in the study by Roberts and in the present study, was in FGM. Thus, the results for breathing movements were identical in the two tests which implies that in the presence of acidaemia, decrease in FBM may indeed be an all-or-none phenomenon. In contrast, although decreased FGM% was present in nine of the 11 acidaemic fetuses, absence of FGM, according to the BPS definition of less than three movements in 30 min was found in only two of our most severely acidaemic fetuses.

Clearly then the conclusion, reached by us and others (Vintzileos *et al.* 1987a; Vintzileos *et al.* 1987b; Ribbert *et al.* 1990), that FGM and fetal tone, are the last to respond to acidaemia is not a physiological phenomenon but rather the consequence of the arbitrary definitions given for the BPS which falsely imply that no change in fetal generalised movements is present before their abolition. Indeed, the data of the present study indicate that reduction in body movements may precede reduction in breathing movements. The latter was also found in a recent study in which we followed IUGR fetuses longitudinally (Ribbert *et al.* 1993). In these cases FHR variation was reduced first and this was followed by a gradual decrease in

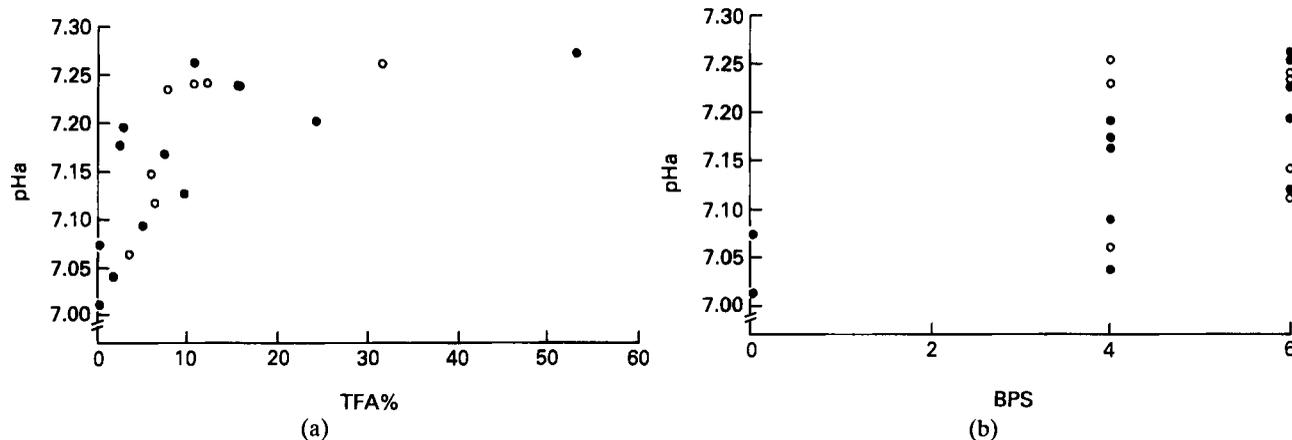


Fig. 2. The association between umbilical arterial blood pH and percentage of time spent in (a) total fetal activity (TFA%; $r=0.63$, $P<0.01$), or by (b) the biophysical profile score (BPS; two points each for generalised and breathing movements and tone; $r=0.61$, $P<0.01$). Maternal ingestion of sympatholytic drugs (\circ) had no significant effect on these associations.

FGM%. FBM% stayed within the normal range until the last two days prior to CS and fell together with the 'final' decrease in FHR variation. In view of the chronic and progressive reduction in placental function, it has been found that the reduction in FHR variation coincides with the onset of hypoxaemia. As in the longitudinal study FHR variation remained stable during the progressive decrease of FGM%, it may be postulated that the decrease in FGM% marks a continuing adaptation to impaired oxygen delivery. FBM% only falls with the onset of acidemia. Both in human and in sheep it has been found that there is a temporary reduction of FBM following acute hypoxaemia (Bekedam & Visser 1985, Koos *et al.* 1988). However, with chronic hypoxaemia and normal pH, in fetal sheep breathing movements return to normal values (Koos *et al.* 1988).

In the antenatal assessment of the growth retarded fetus, a pathological FHR pattern identifies a group likely to be hypoxaemic (Henson *et al.* 1983, Bekedam *et al.* 1987, Smith *et al.* 1988, Visser *et al.* 1990, Ribbert *et al.* 1991). However, a further antenatal test might be necessary to distinguish between acidaemic and non-acidaemic fetuses. This is of particular importance in those cases with equivocal fetal heart rate patterns and at early gestations when further maturation *in utero* is desirable. The present study indicates that more accurate distinction may be achieved by quantitation of fetal activity rather than by applying the all-or-none criteria of the traditional BPS.

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