generalisation of the results of this study should be carefully restricted to interventions of the type and duration examined here. Specifically, this refers to a combined preventive and therapeutic intervention, delivered to an unselected population of children with chronic illnesses over a period of six months.

In contrast to the encouraging results from the Rochester lay family counsellor experiment,[12] and the home-care programme in New York,[15] the findings from this study prevent us from endorsing the routine provision of social-work services of the type and duration studied here to children with chronic illnesses. It could be argued that a longer, more intensive social-work intervention focusing on children at risk for maladjustment within individual clinics, would be beneficial. However, we do not know how to identify individual children at greatest risk. Drotar[3] argues that "the mere inclusion of a psychologist or mental health professional in a comprehensive care team without a well-defined salient role in clinical decision-making does not necessarily facilitate psychosocial support". Controlled evaluation of such currently popular team-based interventions, involving the participation of psychologists, nurses, or others, has not yet been attempted in hospital-centred specialty-care clinics. More generally, clinical trials of social work in child health care should be seen as an important and constructive means of appraising traditional modes of practice and of obtaining greatest benefit from the potentially valuable resource that social work represents for the prevention and treatment of psychosocial disorder.

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INTRAUTERINE GROWTH RETARDATION: PREDICTION OF PERINATAL DISTRESS BY DOPPLER ULTRASOUND

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Summary To investigate the ability of umbilical artery Doppler findings to identify true cases at risk of fetal distress among 51 pregnancies clinically judged to be compromised by intrauterine growth retardation (IUGR) Doppler data were related to pregnancy outcome, which was classified into three groups—group 1, healthy babies with normal placental function (16 fetuses), group 2, fetuses with definite signs of placental failure (30), and group 3, non-classifiable pregnancies (5). Group 2 was subdivided into 2A, placental failure with manifest perinatal distress (19), and 2B, placental failure without perinatal distress (11). All 19 compromised and distressed fetuses (group 2A) had extremely pathological Doppler findings, even several weeks before fetal distress became apparent by cardiotocography. The Doppler findings in the 11 small-for-dates fetuses without perinatal distress (group 2B) were inconsistently normal or slightly pathological. All 16 normal infants (group 1) had normal antenatal Doppler data. The Doppler technique thus allows accurate and early recognition of those fetuses who will become distressed perinatally. It also helps to identify which fetuses clinically suspected of IUGR have an adequate placental circulation.

Introduction

BECAUSE of the lack of direct information on placental function, fetal growth is taken to reflect placental adequacy. Fetuses clinically suspected of having intrauterine growth retardation (IUGR) are considered to require intensive obstetric care. Accurate knowledge of gestational age is necessary for the detection of IUGR. However, even when this information is available, the differentiation between suboptimum fetal growth and adequate growth of a genetically small infant is difficult. Consequently, some true growth-retarded fetuses remain undetected while some normally growing ones are unnecessarily treated because of

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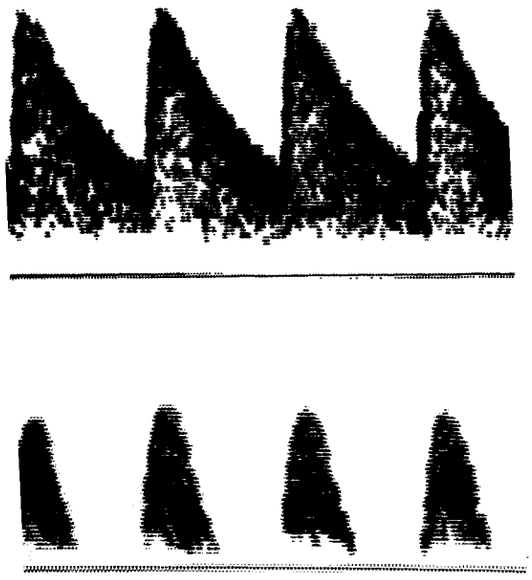

Fig 1—Doppler sonograms from the umbilical arteries showing blood velocity against time.

Upper tracing, a normal sonogram, and lower tracing showing pathological diastolic zero-flow.

an erroneous diagnosis of IUGR.[1] Ultrasonic Doppler investigations have been reported to give direct information on placental circulation.[2-4] We have conducted a blind prospective study to evaluate the impact of umbilical artery Doppler examinations on the clinical management of pregnancies suspected of IUGR.

Patients and Methods

Patients

51 patients with singleton pregnancies admitted for IUGR were studied. In our hospital the criteria for suboptimum fetal growth are fundal growth delay of 4 weeks and/or deviation of the sonographic fetal abdominal area from the reference curves to beneath the 2·3 centile. All pregnancies were well dated. At hospital admission, the gestational age ranged from 24–40 weeks. In 25 patients there were concomitant complications such as pregnancy-induced hypertension (23 cases) and/or blood loss (4 cases), or occurrence of abruptio placentae (2 cases).

Our clinical management is aimed at appropriate timing of delivery, as assessed by daily cardiotocographic monitoring and taking into account the gestational age, growth assessment, obstetric history, and other complications of pregnancy. Bed-rest, but no

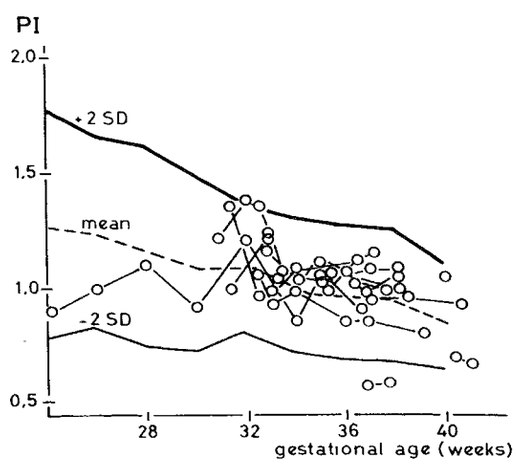

Fig 3—Serial PI values in fetuses clinically suspected of IUGR, which was not substantiated after birth (group 1).

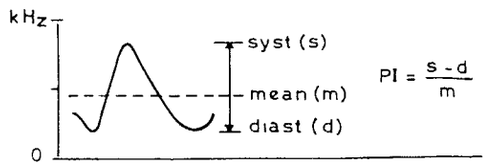

Fig 2—Definition of the pulsatility index (PI).

specific treatment, was prescribed. During the hospital stay, Doppler examinations (see below) were done weekly, always by one operator who had nothing to do with the patient's treatment. The Doppler data were rigidly withheld from the obstetricians and neonatologists. The patients were informed about the blind nature of the Doppler study and gave their consent.

Assessment of Pregnancy Outcome

Pregnancy outcome was evaluated and classified without knowledge of the Doppler data. The assessment took the following variables into account:

Fetal—hypoxic late decelerations or non-reactive cardiotocogram with positive stress-test which prompted caesarean section;

Neonatal—birthweight centile (P), ponderal index, Apgar scores, umbilical cord blood gases, and a paediatrician's definite assessment based on physical findings and neonatal complications related to growth retardation;

Placental—weight and pathological examination.

The pregnancies were classified into three groups—group 1, with normal placental function: group 2, with manifest placental insufficiency; and group 3, with possible suboptimum placental function. Group 2 was subdivided into—2A, with manifest perinatal distress, and 2B, without perinatal distress.

The criteria for group 1 (normal placental function) were birthweight $\geq$P5 (fifth centile), a normal ponderal index, and absence of perinatal problems. Group 2 (manifest placental insufficiency) had to have birthweight $<$P5 and/or ponderal index

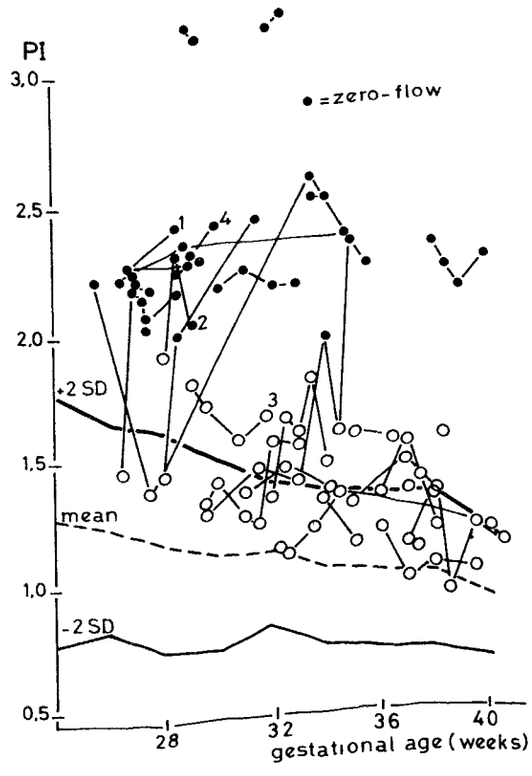

Fig 4—PI values of all 30 pregnancies judged postpartum to have had placental insufficiency (group 2).

Cases 1 and 2 IUD, case 3 IUD and chromosomal XXXXY, case 4 postnatal death.

beneath 2·32[5] and be judged clinically by the neonatologist to have IUGR. The pregnancy was classified as subgroup 2A if obstetric intervention was required for fetal distress or if the fetus died in utero, and as subgroup 2B when no obstetric intervention was required for fetal distress and no neonatal resuscitation or intensive care was needed. Group 3 (possible suboptimum placental function) consisted of those infants who could not be classified as group 1 or group 2.

Only after pregnancies had been classified were the Doppler data revealed.

Doppler Recordings

Blood flow velocity signals from the umbilical arteries were recorded with a bidirectional 4 MHz continuous wave Doppler device. Spectrum analysis ('Doptek 9000') yielded pulsatile flow velocity wave forms (fig 1). The recording was accepted if it showed 5 uniform heart-beats. The pulsatility of the spectrum outline was quantified by calculating the pulsatility-index (PI), which was defined as systolic peak minus diastolic peak divided by the mean deviation from the baseline (fig 2). The PI reflects the fetoplacental impedance (resistance) to umbilical blood flow.[6] The PI of one examination was taken as the average of the PIs of at least three steady state recordings. If diastolic flow was absent—that is, below the high pass filter of 150 Hz—this feature was explicitly noted (fig 1).

PI Reference Values

PI reference values related to gestational age were established in a previous study[7] of 70 uneventful pregnancies with normal outcome that had been examined every 2 weeks from the 24th post-menstrual week onwards.

Results

Group 1

16 pregnancies were judged to have had normal placental function and normal outcome. The mothers had been in hospital for 39 days on average (range 4–118). All PI values turned out to be in the normal range (fig 3).

Group 2

30 pregnancies were associated with manifest placental failure. The antenatal Doppler data are shown in figure 4. Of the 19 in group 2A, 16 had fetal distress requiring obstetric intervention in the perinatal period, and 3 died in utero, while in the 11 group 2B infants the only indication of placental failure was their small size ($P<5$) in relation to gestational age.

Group 2A

3 fetuses died in utero. A chromosomal abnormality (XXXXY) identified antenatally in one of the babies justified non-intervention (patient 3 in figs 4 and 5), and in the other 2 the postnatal prognosis was judged to be so poor that caesarean section was not done (patients 1 and 2 in figs 4 and 5).

Of the 16 liveborn babies, only 1 was delivered vaginally, by forceps extraction because of severe bradycardia (case 5 in fig 5); the other 15 were delivered by caesarean section because of fetal distress before the onset of labour. All 16 required intensive neonatal care; 15 survived without major handicap and 1 baby boy (660 g at 31 weeks) died at day 16 from severe and persisting respiratory insufficiency and perforation of the ileum (patient 4 in fig 4 and 5).

All 19 distressed fetuses had extremely raised PIs, in most cases with diastolic zero flow (fig 5). Significantly raised PIs were consistently present at least 9 days before the cardiotocographic signs of fetal distress, in most cases even several weeks earlier (fig 5). Only in 2 cases was diastolic zero flow not observed, although PI values were significantly raised. 1 of these was the baby delivered by forceps (case 5 in fig 5) and the other (case 6 in fig 5) was delivered by emergency caesarean section because of an abruptio placentae.

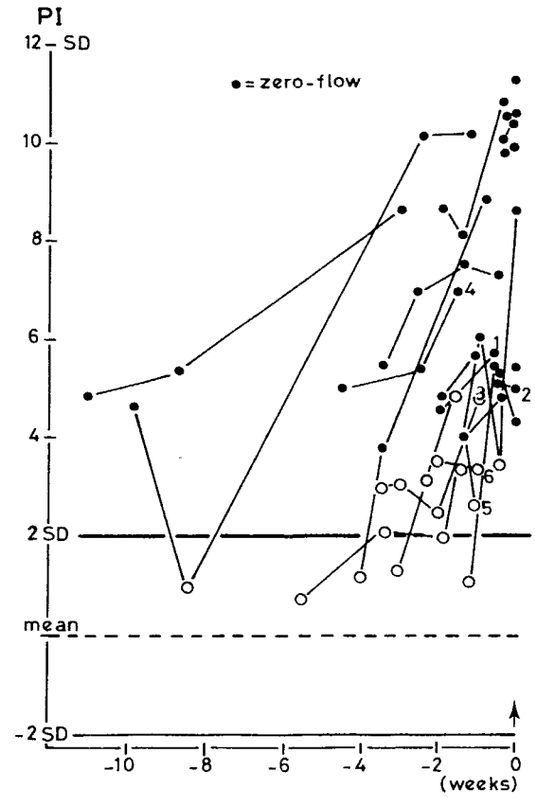

Fig 5—PI values, expressed as standard deviations from the mean, of the truly compromised fetuses (group 2A).

Horizontal axis: weeks preceding the time (arrow) of obstetric intervention or intrauterine death (IUD). Cases 1 and 2 IUD; case 3 IUD and chromosomal XXXXY; case 4 postnatal death; case 5 only liveborn, delivered vaginally (forceps); case 6 abruptio placentae.

Group 2B

3 of the 11 group 2B babies were delivered by elective repeat caesarean on the basis of the poor obstetric history and doubt about further intrauterine growth. The others were delivered uneventfully per vaginam. Most group 2B babies were born near term (fig 4).

The Doppler data varied inconsistently between normal and abnormal (fig 6) but no patient showed diastolic zero-flow.

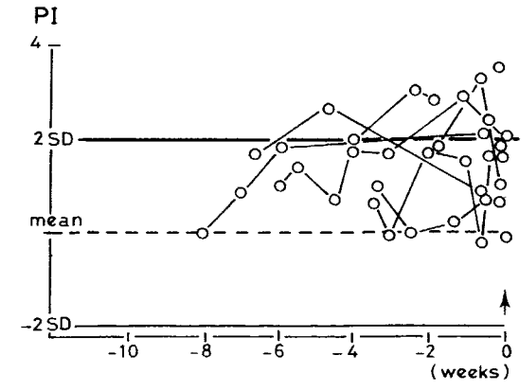

Fig 6—PI values, expressed as standard deviations from the mean, of growth retarded infants without any perinatal distress (group 2B).

Horizontal axis: weeks preceding time of birth (arrow).

Group 3

Of the 5 patients in this group 2 had a birthweight <P5 but normal ponderal index; 1 had a birthweight at P10 but low ponderal index. None of these 3 had problems in the perinatal period and the paediatrician's assessment of growth retardation was inconclusive. 1 baby was born by emergency caesarean section because of abruptio placentae; at birth he was of appropriate size for gestational age (P25) but asphyxiated. The 5th baby was a growth retarded and triploidic infant.

All Doppler observations in group 3 patients were normal. The patient with an abruptio placentae had abnormal PI 3 days earlier.

The severely growth retarded but chromosomally abnormal infant (triploidy) had normal PIs of 0·9 to 1·0 from the 29th to the 31st week. At that time the chromosomal diagnosis became available and the pregnancy was terminated. The placenta was classified by the pathologist as normal.

Discussion

The clinical diagnosis of placental failure is still a presumptive diagnosis based on suspicion of IUGR and cardiotocographic signs of fetal distress. However, inaccuracies may occur with intrauterine growth assessment[1] and fetal distress is an indirect and late sign of impairment of placental circulation, which is usually a gradual process. Our study substantiates the claim that umbilical artery Doppler measurements provide direct and essential information on the adequacy of the placental circulation.[6] Doppler allows an early and accurate identification of those fetuses who are really at risk of perinatal distress.

From the 51 pregnant women admitted because of suspected IUGR only 19 fetuses proved to have been truly at risk (group 2A)—ie, the pregnancy ended in intrauterine death or there were cardiotocographic signs of fetal distress prompting termination of pregnancy and requiring subsequent intensive neonatal care. All these truly distressed fetuses had significantly high PIs for several weeks, and in all but 2 cases there was diastolic zero-flow (fig 5). When the data were looked at another way, signs of distress developed in all fetuses with diastolic zero-flow; 3 of these pregnancies ended with intrauterine death and none of the others sustained a vaginal delivery. Diastolic zero-flow is thus an accurate sign of fetal stress and accurately predicts fetal distress.

Since even extremely high placental resistance, as reflected by diastolic zero-flow, may precede signs of fetal distress by several weeks or even months (fig 5), the finding does not give guidance on optimum time of delivery. Most infants with diastolic zero flow are very premature (fig 4) and could perhaps gain a crucial several weeks of gestation before cardiotocographic signs of fetal distress develop. Since gestational age is the most important factor in the prognosis of very low birthweight infants,[8] we shudder at advice to intervene[9] based solely on diastolic zero-flow without other signs of imminent danger to the fetus. In our opinion diastolic zero-flow alone is an indication for intensive cardiotocographic monitoring, but still allows expectant management taking gestational age into account. It is not a justification for repeated fetal blood sampling for pH and blood-gas analyses, except perhaps in research.

The use of the Doppler technique might have a great impact on clinical management by reducing the number of pregnancies overtreated because of a diagnosis of IUGR. Out of 51 pregnant women admitted to hospital for IUGR, 16 (32%) had completely normal babies (group 1) without signs of perinatal distress and without any sign of placental incompetence on clinical examination. All these infants had had normal PI values (fig 3), which reflected a normal competent placental circulation.[6] Admission to hospital could possibly have been avoided.

Of the 11 cases of suspected IUGR 11 infants were classified after birth as being small for dates, or of having experienced adverse placental conditions but without sign of perinatal distress or requiring intensive care in the neonatal period (group 2B). Retrospectively, the antenatal classification of "at risk of perinatal distress" could not be substantiated. The antenatal Doppler PI values were inconsistent in this group—most PI values were in the normal range, and some were high, but none showed diastolic zero-flow (fig 6). Interestingly, most of these pregnancies advanced beyond 37 weeks (fig 4) and there was sufficient placental reserve capacity to sustain a vaginal delivery. In retrospect, the necessity for the three repeat caesarean sections in group 2B seems questionable and might have been avoided had the Doppler data been available.

In the 5 unclassifiable pregnancies (group 3) the antenatal PIs were consistently in the normal range. None of the infants had problems in the perinatal period except an abruptio placentae in 1. The Doppler method was of no value in predicting abruptio placentae in this pregnancy or in the one that occurred in group 2A.

In conclusion, the identification of those growth retarded fetuses at risk of perinatal morbidity or mortality is more important than the prediction of a low birthweight. Umbilical-placental monitoring by Doppler ultrasound accurately identifies those fetuses who will become distressed and who will require intensive perinatal care. Moreover, the method indicates which of the pregnancies erroneously thought to be at risk on the basis of current diagnostic methods do in fact have adequate placental circulation. Doppler examination of the umbilical arteries may prevent overtreatment and unnecessary hospital admission. The present data justify prospective controlled trials to substantiate expectations.

We thank Mrs M. Zwinkels for performing the Doppler examinations and securing the blind character of this study.

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