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Sonographic Evaluation of Fetal Growth and Well-Being

John W. Seeds

The Department of Obstetrics and Gynecology, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina 27514

INTRAUTERINE GROWTH RETARDATION

Intrauterine growth retardation (IUGR) is not itself a discrete disease process but an abnormality of fetal growth common to a variety of different conditions (1–4). The clinical significance of IUGR is well-established, but variation in definition, applicable birthweight (BW) standards, and primary etiologies of strikingly different significance can make it difficult to discuss IUGR with practical clarity (1). The most commonly used definition is a birthweight less than the tenth percentile for gestational age (1,5). By definition, therefore, the incidence of the condition is 10%. Affected infants face a 30% to 50% likelihood of intrapartum hypoxic distress and a 50% risk of neonatal complications that may include hypoglycemia, meconium aspiration pneumonia, or long-term growth impairment (6–10). Although inconsistency in the definition of IUGR chosen by individual investigators and variability of birthweight standards used to judge growth lead to a measure of confusion in reported clinical data on growth retardation, the greatest source of difficulty when comparing the outcomes of growth retarded infants is the variability of etiology of IUGR (5,11,12).

IUGR (BW below 10th percentile) may be the result of (a) constitutional influences (40%), (b) environmental factors (10%), (c) specific genetic disorders (10%), or (d) utero-placental insufficiency (40%) (Fig. 1) (1–3,12–20). Each of these categories of fetal growth impairment shows a typical anthropomorphic pattern as well as characteristic outcome. Furthermore, within each of these broad categories of etiology, there are many different specific disorders, each with a different long-term prognosis.

Etiology

Inevitably, the natural frequency distribution of birthweight will result in a group of babies small-by-weight standards who are not diseased or in danger, but rather

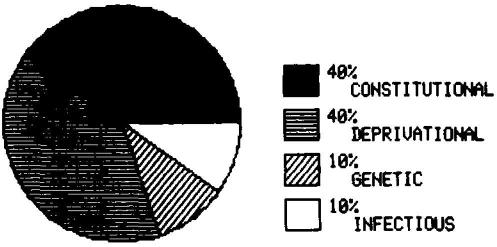

FIG. 1. IUGR (BW below the 10th percentile) may be the result of several broad categories of etiology.

are simply small because of constitutional influences, such as familial growth patterns (11). Such infants do not necessarily face long-term developmental problems. Another group of babies are small because of toxic environmental factors such as maternal alcohol abuse (17,18). Evidence suggests that such infants do show long-term growth and neurobehavioral abnormalities, but the impact of obstetrical management on these problems is limited. IUGR on the basis of specific genetic abnormalities such as renal agenesis or trisomies is of minor importance when compared to the serious implications of the primary condition (16,20). Finally, IUGR resulting from utero-placental deprivation occurs most often with an otherwise normal fetus. Long-term follow-up has shown that the single perinatal factor most closely associated with later development is the presence or absence of perinatal asphyxia (7,10,21). Prenatal detection of fetal growth impairment offers the opportunity to apply methods of perinatal intensive care and possibly to prevent asphyxia. Furthermore, when Kurjak (22) studied 260 IUGR infants, he found that perinatal mortality was three-fold higher in cases where the diagnosis of IUGR was not made prior to labor. It is these normal infants, growth-retarded on a deprivational basis, who are most likely to benefit from prenatal diagnosis and intensive perinatal care.

Prenatal Sonographic Diagnosis

The sonographic evaluation of fetal growth and well-being is based on simple empirical observations. The larger the fetus, the larger will be the sonographic dimensions. Using this principle, fetal growth standards may be established from uncomplicated pregnancies, and these standards may be used to judge the quality of fetal growth in the individual case (22,23). The comparison of dimensions from the same fetus allows evaluation of the symmetry of growth, and the integration of selected dimensions may be used to estimate fetal weight *in utero* (24–27). The observation of dynamic events on real-time ultrasound offers important information about fetal well-being (28). Finally, deep Doppler ultrasound techniques, which are capable of evaluating fetal cardiovascular dynamics, seem able to identify those fetuses who are reacting to acute deprivation (29–31).

Fetal Adaptions

In the study of fetal biometry, it should be remembered that an important fetal mechanism for coping with acute and chronic deprivation is redistribution of cardiac output (32,33). The fetus responds to deprivational insults with vasoconstriction in most visceral and musculoskeletal beds in order to maintain flow to the cerebral, coronary, and adrenal circulations. The result is fetal hypertension, slowing of the heart rate (at least temporarily), the maintenance of brain growth, and therefore, cranial growth well into any deprivational sequence. This preferential redistribution on a chronic basis leads to an asymmetry of growth favoring cranial growth and delaying abdominal growth (22,25). Furthermore, hemodynamic flow characteristics are altered, including maximum blood flow rate, diastolic flow, and mean flow velocity in those vessels serving vasoconstricted vascular beds (29,30).

In this chapter, I shall briefly discuss the efficacy of clinical methods for the diagnosis of IUGR and the possible role of routine early pregnancy ultrasound examinations in screening for altered fetal growth. I shall evaluate the utility of static dimensions both individually and in combination to judge the quality and the symmetry of fetal growth and to estimate fetal weight. Important real-time observations related to monitoring fetal well-being, and Doppler techniques reflecting the status of fetal hemodynamics, will then be examined.

CLINICAL DIAGNOSIS OF IUGR

The clinical diagnosis of fetal growth retardation is typically expected to have a sensitivity of about 50% and may also have an accuracy of only 50% (34,35). Clinical diagnosis is based on both the serial measurement of uterine growth and on a high index of suspicion for IUGR in pregnancies complicated by maternal conditions known to be associated with impaired fetal growth (36). Although clinical methods are relatively imprecise, the only alternative to clinical screening of low-risk pregnancies as a basis for referral for more sophisticated and expensive technical evaluations is the routine serial sonographic evaluation of all pregnancies. Although routine ultrasound screening is practiced in many parts of the world, it is not part of standard care in the United States.

Fundal Growth

The uterus measured from the pubic symphysis to the top of the fundus between 20 and 34 weeks gestation is about equal in centimeters to the gestational age in weeks. Belizan (37–39) and other investigators have found that with a reasonable attention to consistency, determination of this index of growth may identify IUGR with 60% to 89% sensitivity. These observers have reported that the tenth percentile for fundal growth is approximately 4 cm less than the gestational age in weeks. Fundal growth delay in the low-risk prenatal population may therefore be a good clinical screening test for impaired fetal growth and should offer the possibility of detecting at least two-thirds of the affected infants in this group. It is estimated that one-third of the babies whose birthweight is below the tenth percentile come from the 65% of pregnancies that are otherwise low-risk (3,40).

TABLE 1. *Maternal risk factors for IUGR*

Previous history of growth retarded infant
Chronic or acute hypertension
Congenital or acquired heart disease
Chronic renal disease
Prepregnancy weight below 45 kg
Total pregnancy weight gain under 5 kg
Severe anemia
Advanced maternal age
Alcohol abuse
Heavy smoking

IUGR, intrauterine growth retardation.

Maternal High Risk Factors

The family of historical and clinical factors known to be associated with an increased risk of the birth of a growth-retarded infant (Table 1) includes maternal conditions associated with constitutional, deprivational, environmental, and genetic growth delay (3,40,41).

Low prepregnancy maternal weight and low weight gain certainly identify pregnancies that include a large number of constitutionally small infants (3,40). A large proportion of those women delivering successive pregnancies with IUGR are also only expressing familial tendencies. Acute and chronic maternal hypertension, maternal heart disease, and maternal renal disease are more often associated with deprivational fetal growth delay because of relative utero-placental insufficiency (41–43). Increased maternal age is associated with an increase in the likelihood of aneuploidy, which is associated with fetal growth retardation. The presence of any of these historical or clinical factors is sufficient indication for early ultrasound referral to establish or confirm gestational age and generate dimensional data as the basis for future evaluation of growth. Up to two-thirds of growth-retarded infants are born to the one-third of patients with one or more of these high-risk factors (40).

SONOGRAPHIC EVALUATION OF FETAL GROWTH

Sonographic tracking of fetal growth is based on two possible normative standards. First, an accurate knowledge of gestational age, either from an accurate history of the last menstrual period or early sonographic confirmation of gestational age, allows the comparison of fetal dimensions at one ultrasound examination to the expected values, so that diagnostic conclusions may be drawn regarding growth. But if early confirmation of gestational age was not accomplished or accurate menstrual data are not available, then sonographic information must be recorded at two examinations no closer than two weeks apart. The growth rate may then be evaluated. During the interval between examinations, ultrasonic or electronic fetal heart rate monitoring should be used to monitor fetal well-being.

TABLE 2. *Sonographic methods: diagnosis of IUGR*

Fetal dimensions alone
BPD
AC
Analysis of symmetry
HC/AC
AC/FL
Estimation of fetal weight
From AC alone
From BPD and AC
From BPD, AC, and FL

IUGR, intrauterine growth retardation; BPD, biparietal diameter; AC, abdominal circumference; HC, head circumference; FL, femur length.

The sonographic indices of growth include individual fetal dimensions (22,23), comparison of selected dimensions intended to evaluate symmetry of growth (25,44), and the integration of certain dimensions in the estimation of fetal weight (Table 2) (26,27).

Fetal Dimensions

The widely varying accuracy and sensitivity in the detection of IUGR shown by several investigators (Table 3) for biparietal diameter by itself, serial biparietal diameter (BPD), abdominal circumference (AC), and head circumference (HC) to abdominal circumference ratio, probably reflect the variability in the growth characteristics of infants who are small because of deprivation compared to those who are small for constitutional reasons (22,45–47).

Asymmetrical growth is typical of deprivational growth retardation (44). In the deprivationally small infant, the biparietal diameter alone is not sensitive to the condition because of the sparing of brain growth secondary to redistribution of blood flow. It appears that abdominal circumference, both alone and in combination with

TABLE 3. *Relative sensitivity*[a]

Dimension	Sensitivity (%)
Single BPD	49
Serial BPD	50
AC	83
HC/AC ratio	80

[a]See Table 2 for explanation of abbreviations.

head circumference, offers the greatest sensitivity for diagnosing IUGR (22,47). Since the liver at the level where AC is measured constitutes about two-thirds of the area of the trunk image at that level, it is no surprise that this dimension appears to be a sensitive measure of the quality of fetal growth. The fetal liver is affected early and severely in cases of fetal deprivation. Furthermore, the AC will also be small in IUGR occurring on the basis of consitutional, genetic, and toxic factors, and is thus a valuable measurement in symmetric as well as in asymmetric IUGR. Mean abdominal diameter (MAD), as a fixed relative of abdominal circumference, may be substituted in most methodologies where AC is used.

Symmetry

The ratio of HC to AC in normal pregnancies follows a pattern which illustrates the gradually changing relationship of the head to the body (25). Normally the fetal head circumference in early gestation is larger than the abdominal circumference. The ratio slowly decreases until about 36 weeks gestation when the circumferences are approximately equal. Near to term the abdominal circumference becomes larger (Table 4).

An abnormality of this ratio suggests an abnormality of growth (25,44). An increased HC:AC ratio would suggest growth delay. A decreased ratio would be consistant with increased growth or macrosomia. Even in the case of deprivation, however, head growth will eventually be affected, and greater apparent symmetry will be noted late in the deprivational sequence (48).

In addition to the symmetry of growth of the fetal head and abdomen, a study of the comparative growth of the abdomen and the femur appears to offer possibilities in the diagnosis of IUGR (49,50). Vintzileos (49) and Seeds (50) have both reported that aberrations in the ratio of the abdominal circumference to femur length (FL), or of the mean abdominal diameter to femur length, can identify the IUGR infant with a sensitivity of about 80% (Figure 2 shows MAD:FL in graphic form, while Table 5 shows AC:FL in tabular form.).

More important is the observation that these ratios appear to detect selectively the

TABLE 4. *Head circumference/abdominal circumference*

Gestational age	− 2 SD	Mean	+ 2 SD
28	0.99	1.08	1.18
30	0.97	1.07	1.16
32	0.95	1.05	1.14
34	0.94	1.03	1.13
36	0.92	1.01	1.11
38	0.90	1.00	1.09
40	0.89	0.98	1.08

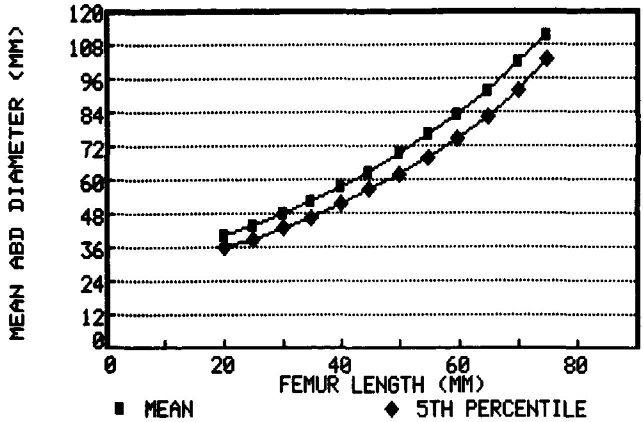

FIG. 2. Mean abdominal diameter in relation to femur length.

fetus with deprivational growth impairment. This suggests that in the intrinsically normal infant suffering only from nutritionally inadequate circumstances, the liver mass and therefore abdominal circumference will show growth impairment before—and to a greater extent than—the femur. Furthermore, the detection of an anomaly of this relationship does not require accurate knowledge of gestational age since the data are not indexed to gestational age.

Estimation of Fetal Weight

The essential clinical measurement of IUGR is birthweight. An accurate knowledge of fetal weight, therefore, would be an ideal element of the accurate diagnosis.

TABLE 5. *Abdominal circumference (AC)/femur length (FL)*

	AC	
FL (mm)	Mean (cm)	5th percentile (cm)
20	12.9	11.3
25	14.0	12.3
30	15.1	13.5
35	16.5	14.8
40	18.2	16.3
45	19.8	17.9
50	22.0	19.6
55	24.0	21.4
60	26.2	23.6
65	28.9	26.1
70	32.0	28.9
75	35.2	32.4

TABLE 6. *Formulas for estimation of fetal weight*

1. $\log(BW) = 1.599 + 0.144(BPD) + 0.032(AC) - 0.111(BPD^2 \times AC)/1{,}000$	
2. $BW = -299.076 + 9.337(BPD \times AC)$	(under 34 weeks only)
3. $BW = 10.1(AC \times BPD) - 481$	(under 2000 g only)

BW, birthweight; BPD, biparietal diameter; AC, abdominal circumference.

A wide variety of sonographic systems for the estimation of fetal weight have been reported since 1977 (Table 6) (26,27). These methods rely on the proportional growth of the fetus. Investigators simply determine selected dimensions of a group of fetuses shortly before birth and draw regression relationships between the selected dimensions and the recorded birthweight. Published systems include both simple linear relationships and logarithmic transformations (51,52).

Single dimension methods have used fetal abdominal circumference, while multiple dimension systems have shown improved accuracy using at least two dimensions, most often abdominal circumference and biparietal diameter (26). Other observers claim greater accuracy with at least three dimensions including AC, BPD, and femur length (53).

Clearly, differences in fetal proportionality will contribute to inaccuracy in estimation of fetal weight derived from only a limited number of dimensions. Furthermore, disproportionality is more often characteristic of the IUGR infant. It might thus be expected that these popular techniques would fall short in detection of growth impairment. Ott (54), however, in studying estimated fetal weight (EFW) methods in the care of pregnancies at risk of IUGR, found a sensitivity of 89%. He used his own normal fetal estimated weight data and the tenth percentile to achieve this level of detection (Table 7) (27). There was a false positive rate of 40%.

The sonographic dimensions used for the estimation of fetal weight are measured in a standard way. The BPD is the same BPD as that used for estimating gestational age, and the AC is also determined at the same level and with the same methods as

TABLE 7. *Mean estimated fetal weight and expected gain*

Gestational age (weeks)	Mean EFW (g)	5th percentile (g)	Expected gain in 2 weeks (g)
28	1,130	918	305
30	1,435	1,166	333
32	1,768	1,436	343
34	2,111	1,715	329
36	2,440	1,982	286
38	2,726	2,211	213
40	2,939	2,377	—

EFW, estimated fetal weight.

for gestational dating. The BPD is the largest diameter of the fetal cranium, outer edge to inner edge. This dimension is most often obtained at the level of the thalami. The AC is measured from a transverse image of the fetal trunk at the level of the umbilical vein within the liver mass. This is one of the most variable of fetal dimensions and requires considerable care in producing an image as close as possible to perpendicular to the fetal trunk (55). Once the correct image is generated at the level of the fetal liver, at right angles to the fetal spine, the circumference may be measured in two ways. Most modern ultrasound equipment offers electronic perimeter measurement systems. Infidelity to the true fetal skin curvature, however, introduces a positive error of up to 3% and the possibility of increased variability based on this error (56). The determination of two perpendicular diameters, and the estimation of circumference from the average diameter avoids much of this potential error.

From the normal estimated fetal weight data, expected growth rates may be derived, and at any given weight an expected weight gain in two weeks can be calculated (27). This manipulation gives the opportunity in the pregnancy of unknown gestational age to track fetal weight gain over the minimal two-week interval (Table 7) (54,55).

Amniotic Fluid Volume

The blood flow redistribution already mentioned that characterizes the fetal response to utero-placental insufficiency can, if sustained and severe enough, lead to reduced amniotic fluid volume because of reduced renal cortical flow and reduced fetal urine output.

Manning and others (57) reported that severe oligohydramnios itself suggests an element of immediate fetal distress, since they found perinatal mortality to be increased tenfold when IUGR was combined with greatly reduced amniotic fluid (a pocket less than 1 cm in greatest dimension). There may be difficulty in discriminating IUGR with severe oligohydramnios from IUGR with renal agenesis in the case of a patient first seen late in gestation. Careful anatomic examination may clarify the case, but can be difficult because image clarity is diminished by oligohydramnios. Maternal furosemide treatment might produce a fetal diuresis and establish the presence of a fetal urinary tract (58), but failure to produce a diuresis does not prove absence of fetal kidneys (59).

Routine Screening

Since imprecision in clinical assessment of gestational age or even complete absence of reliable clinical data complicates and compromises the diagnosis of IUGR, several investigations have focused on the efficacy of routine sonographic screening for IUGR. Warsof et al. (60) reported an 85% sensitivity and accuracy using a two-stage screen. Their approach utilized an early examination to establish or confirm gestational age, followed by a second examination at 32 weeks to evaluate fetal growth.

Doppler Evaluation

Sound echoes originating from a moving object have a higher frequency if the object is moving toward the observer and a lower frequency if the object is moving away. This is the Doppler effect. If either a pulse-echo or continuous wave ultrasound beam is directed at blood within a vessel, the frequency shift of the echoes reflected from moving red cells is proportional to the velocity of the cells, and inversely related to the beam angle (29). Computer analysis of the frequency shift results in a spectrum of individual data points, since individual echoes from blood cells of differing velocities will produce a spectrum of related proportional Doppler shifts and not a single uniform shift (29). The shape of the maximum velocity profile offers important information about the vascular resistance of the circulation served by the vessel studied. The ratio of systolic peak velocity (S) to the diastolic minimum (D) is proportional to resistance. The beam angle does not directly influence this ratio, but if the angle is not sufficiently acute, technical measurement error has a greater relative impact on the result.

Pulse Doppler systems built into real-time sector machines as well as independent continuous wave (CW) Doppler devices both seem to provide adequate data for resistance measurements, but there are important differences in cost and in the acoustic power used. Duplex pulse Doppler systems range in cost up to $70,000.00, compared to continuous wave Doppler machines, which cost less than $15,000.00. Duplex pulse Doppler may require a temporal peak/spatial peak intensity of 1,000 mw/cm^2 to produce useful data, compared to the typical continuous wave intensity of 1 mw/cm^2. There are no reported adverse effects of the higher intensity of pulsed Doppler energy, but the significant difference in both cost and power may result in greater application of the CW types of systems.

Shulman (29) has studied the Doppler S:D ratio from fetal umbilical vessels using continuous wave equipment in both the normal and the IUGR pregnancy and found that in the normal case, the S:D ratio averages 2.8 at 25 weeks, dropping to 2.2 at term. In IUGR, the ratio was found to average 3.8 at 29 weeks and drop to 3.0 at term. Diagnostic sensitivity and power of discrimination are yet to be clearly established for Doppler methods, but this technique does offer insight into the fetal physiological response to stress and may prove to be a useful adjunct to the other methods presented.

Summary

Careful evaluation of these many points allows the conclusion that with careful clinical monitoring of low-risk pregnancies, including measurement of fundal height and ultrasonic evaluation of pregnancies with uncertain dating or fundal growth discrepancies, and with sonographic evaluation of high risk pregnancies, up to 90% of IUGR infants may be detected prior to labor (55). Such examinations should include BPD, AC, and FL, as well as estimation of fetal weight and amniotic fluid volume. The false positive rate may approach 40%, but if intensive perinatal surveillance is the appropriate response to such a diagnosis, sensitivity is the more valuable result. Neither routine ultrasonic screening of all pregancies nor Doppler methods have yet shown a higher rate of diagnostic sensitivity than this, although Doppler studies do offer a greater understanding of the pathophysiology of the condition.

SONOGRAPHIC EVALUATION OF FETAL WELL-BEING

The surveillance of fetal condition is an integral feature of the care of the pregnancy at risk for IUGR or one in which the diagnosis is already made. The diagnosis of IUGR is by itself insufficient to justify the delivery of a premature infant (55), and evidence of immediate fetal distress is the additional element necessary to proceed to delivery. Electronic fetal heart rate monitoring, in the form of the non-stress test (NST) and the contraction stress test (CST), is the standard approach to this surveillance (61–63). These tests record fetal heart rate without (NST) and with (CST) uterine contractions using Doppler techniques for detecting fetal heart movement. Heart rate accelerations indicate normal fetal midbrain function and well-being, while absence of these accelerations suggests compromise. Uterine contractions can be spontaneous and of sufficient frequency (3 per 10 min) to constitute a contraction stress test. Alternatively, dilute pitocin or nipple stimulation may be required to stimulate contractions. Late decelerations after two or three contractions during a CST suggest fetal hypoxia (64).

Non-stress tests demonstrate a low false negative rate, but a high rate of false positive results. The risk of fetal death within one week of a reactive (normal) non-stress test is as low as 3:1,000 in a high-risk population, but if the test is abnormal (non-reactive), as it is in up to 18% of tested cases, only 3% to 5% of these are truly in danger, either judged by the results of a contraction stress test or behavior in labor (61). A normal CST also has a good record of predicting a normal outcome, but a 50% false positive rate if abnormal, judged by labor performance (64).

Biophysical Profile

The empirical observation that a higher rate of fetal or perinatal death was seen in pregancies demonstrating decreased fetal breathing movements led to the development of a combination of dynamic observation on real-time ultrasound in addition to the NST, to produce a scoring system called the biophysical profile (28). The biophysical profile uses fetal breathing movements, trunk movements, limb movements, amniotic fluid volume, and the results of a non-stress test (Table 8).

Each normal observation allows 2 points, while absence results in 0 points. A re-

TABLE 8. *Biophysical profile*

Observation	Score 2 Points	Score 0 Points
Fetal breathing	30 sec/30 min	Absent
Trunk movements	3/30 min	Absent
Limb movements	3/30 min	Absent
Heart rate acceleration on NST	15 BPM × 15 sec × 2/40 min	Absent
Amniotic fluid	One pocket 1 × 1 cm	Absent

NST, non-stress test; BPM, beats per minute.

active NST gives 2 points, while a non-reactive result gives 0 points. A score of 8 to 10 is normal. A score of 4 to 6 requires re-evaluation within 24 hr, and a score under 4 suggests the need for delivery.

Careful randomized comparison between the biophysical profile and the non-stress test in large series of high-risk pregnancies shows that the NST and the BPD are comparable in predicting a normal outcome, but that the BPD is significantly superior in the prediction of the compromised fetus (28). These results indicate that the NST remains a reasonable primary surveillance tool, and that the BPD, together with the contraction stress test, is useful in the case of the abnormal NST.

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DISCUSSION

Dr. Toubas: I would just like to comment how things are changing. Ten years ago, when attending deliveries, neonatologists used to make jokes about how obstetricians predicted birthweight. Weight discrepancies between predicted weight and birthweight were sometimes enormous. Neonatologists nowadays do not laugh anymore. Due to technical advances in ultrasound imaging, such discrepancies are now rare when pregnant women receive regular prenatal care from well-equipped centers with qualified staff.

Dr. Bossart: When there is very little amniotic fluid, what is its specific gravity? Do you think it may be necessary under some circumstances (for example, if the baby has a severe degree of hemoconcentration for some reason) that less fluid of high specific gravity may maintain the fetus's internal milieu? In other words, production is low to maintain its specific gravity and osmotic pressure.

Dr. Seeds: It sounds logical that this would be the situation in pre-renal azotemia, for example, but I cannot comment further.

Dr. Chessex: Your biophysical scoring system is interesting, but aren't you being rather over-restrictive in your assessment of fetal breathing movements by only looking at them for 30 min? I have heard recently that there can be periods of up to 4 hr with no breathing movements at all in an absolutely normal fetus. I suppose you restrict your observation period on grounds of practicality?

Dr. Seeds: I agree that you could clearly have a false positive biophysical profile if you were to look at breathing movements alone, but if you have a non-compromised fetus who is simply taking a nap then the other measures of our 5-point scale will be normal (reactive non-stress test, good amniotic fluid volume, and so on). We do not use the biophysical profile for primary surveillance in high-risk pregnancies because it is far too labor-intensive. The non-stress test alone is an adequate discriminator of the normal or not immediately threatened high-risk pregnancy. We use the profile as a back-up to the non-stress test, and then we go on to ultrasound, and even then we will not normally deliver a preterm baby on this evidence alone without a contraction stress test.

Dr. Kuletharn: What is the significance of fetal gasping movements which you sometimes see?

Dr. Seeds: I don't know what their significance is in the absence of other indications of fetal distress, though during fetal distress they may clearly result in meconium being drawn deeper into the tracheo-bronchial tree, which makes the obstetrician gasp too. Gasping can be confused with gagging sometimes. A fetus with nasopharyngeal anomalies can be seen gagging when he tries to swallow amniotic fluid. We saw this clearly on real-time ultrasound in a fetus with a pedunculated meningomyelocele.

Dr. Toubas: In animal experiments it has been shown that one isolated gasp or deep breath of -20 cm H_2O is of no significance, but when there is repetitious gasping it usually means there is some degree of asphyxia (1,2).

Dr. Wharton: What proportion of growth-retarded fetuses with non-reactive cardiotocography would be regarded as normal or not at immediate risk after doing your biophysical profile?

Dr. Seeds: Around 15% to 18% of non-stress tests will be unreactive in our high-risk obstetric population, and in about one-third of these the fetus will turn out to be in serious difficulty. The biophysical profile is capable of picking up the vast majority of these.

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