Ultrasound Obstet. Gynecol. 4 (1994) 294–303

The effect of an abnormal umbilical artery Doppler on the management of fetal growth restriction: a survey of maternal–fetal medicine specialists who perform fetal ultrasound

G. R. DeVore

The Department of Obstetrics and Gynecology, LDS Hospital, Salt Lake City, Utah and Alfigen, The Genetics Institute, Pasadena, California, USA

Key words: INTRAUTERINE GROWTH RETARDATION, DOPPLER, BED REST, ANTEPARTUM TESTING, ULTRASOUND

ABSTRACT

The purpose of this survey was to determine if an abnormal Doppler ultrasound scan of the umbilical artery alters the management of patients with fetuses with varying degrees of asymmetrical growth restriction remote from term. A survey was conducted of Maternal Fetal Medicine specialists who practiced in the United States. Three cases of increasing severity of asymmetrical growth restriction (abdominal circumference > 2 standard deviations below the mean) were presented, each with a normal or abnormal Doppler of the umbilical artery. The estimated fetal weights were between the 15th and 25th centiles (Case 1), 10th and 15th centiles (Case 2), and less than the 10th centile (Case 3). Each physician was asked to respond to questions regarding the frequency (none, 2 weeks, 3 weeks, 4 weeks) of repeat ultrasound scans, the recommendation for maternal bed rest and its duration (none, 5 hours, 12 hours), and the choice of antepartum testing (none, non-stress test, non-stress test plus amniotic fluid index, contraction stress test, biophysical profile).

A completed survey was returned by 199 of 900 (22%) Maternal–Fetal Medicine specialists who practiced in 33 of 50 states. Of respondents, 95% performed fetal ultrasound. Over 98% of respondents repeated the ultrasound examination irrespective of the degree of growth restriction. Comparing the effect of a normal versus an abnormal Doppler for Ca. ° 1, there was a significant increase in the following: repeat ultrasound at the 2-week interval (46 vs. 68%, $p < 0.00002$); recommendation for maternal bed rest (55 vs. 80%, $p < 0.00002$); the duration of bed rest for 12 h (17 vs. 46%, $p < 0.000001$); recommendation for antepartum testing (82 vs. 96%, $p < 0.00002$); utilization of the contraction stress test (1 vs. 7%, $p < 0.004$); and the biophysical profile (17 vs. 27%, $p < 0.02$). Comparing the effect of a normal versus an abnormal Doppler on management for Case 2, there was a significant increase in the following: recommendation for maternal bed rest (80 vs. 89%, $p < 0.02$); duration of bed rest for 12 h (34 vs. 63%, $p < 0.000001$); and the recommendation for antepartum testing (95 vs. 99%, $p < 0.04$). Comparing the effect of a normal versus an abnormal Doppler on management for Case 3, the only significant increase was the recommendation for 12 h of bed rest (72 vs. 84%, $p < 0.006$). Comparison of the trends in management as the cases became more severe (Case 1 through Case 3) in the normal Doppler group demonstrated a significant increase in recommendation for repeat ultrasound at the 2-week interval (46 to 76%, $p < 0.000001$); recommendation for bed rest (55 to 92%, $p < 0.000001$); the duration of bed rest for 12 h (17 to 72%, $p < 0.000001$); recommendation for antepartum testing (82 to 100%, $p < 0.000001$); use of the contraction stress test (1 to 10%, $p < 0.0004$); and the biophysical profile (17 to 46%, $p < 0.00009$). Comparison of the trends in management as the cases became more severe (Case 1 through Case 3) in the abnormal Doppler group demonstrated a significant increase in recommendations for bed rest (80 to 96%, $p < 0.000007$); the duration of bed rest for 12 h (46 to 84%, $p < 0.000002$); and use of the biophysical profile (27 to 55%, $p < 0.000001$).

An abnormal Doppler ultrasound scan of the umbilical artery appears to alter the recommendations for management of fetuses with varying degrees of growth restriction.

Correspondence: Dr G. R. DeVore, 4155 South Parkview, Salt Lake City, Utah, 84124, USA

Received 10–8–93
Revised 8–11–93
Accepted 15–12–93

INTRODUCTION

Ultrasound examination of the viable fetus remote from term may demonstrate a spectrum of growth restriction. Although a fetus may not have intrauterine growth retardation, as defined by an estimated fetal weight below the 10th centile, asymmetrical growth failure (abdominal circumference > 2SD below the mean with an estimated fetal weight greater than the 10th centile) may be present[1-6]. This survey was undertaken to ascertain how specialists in Maternal–Fetal Medicine manage patients with asymmetrical growth failure remote from term, with or without an abnormal Doppler of the umbilical artery, compared to the fetus with asymmetrical intrauterine growth retardation. (In the United States a Maternal–Fetal Medicine specialist requires 2 additional years of training beyond the 4-year training program in Obstetrics and Gynecology.)

METHODS

A mailing list was obtained from the Society of Perinatal Obstetricians and a questionnaire was prepared and mailed to 900 specialists in Maternal–Fetal Medicine who were asked to respond to three cases of increasing severity of asymmetrical growth restriction in which the Doppler ultrasound scan of the umbilical artery was either normal or abnormal. The following clinical history was provided.

> Three patients present for diagnostic ultrasound because the referring physician suspects intrauterine growth retardation. All three fetuses demonstrate a biparietal diameter (8.1 cm), head circumference (29.5 cm) and femur length (6.2 cm) which are appropriate for 32 weeks of gestation and equivalent to the menstrual age. The Doppler ultrasound scan of the umbilical artery is normal or abnormal (diastolic flow present). However, the abdominal circumference ranges from just below 2 SD to 5.8 SD below the mean. In all cases the head circumference/abdominal circumference ratio is abnormal, suggesting growth disproportion observed with asymmetrical growth restriction. The estimated fetal weights, however, range from below the 10th centile to just below the 25th centile (Figure 1). The clinical question is *How do you manage each of the three cases?* Place an X in the box for each case for *Repeat ultrasound, Antepartum testing*, and *Bed rest.*

The severity of asymmetrical growth restriction increased from Case 1 to Case 3 (Figure 1). Cases 1 and 2 represent *growth failure* (estimated fetal weight > 10th centile) but not intrauterine growth retardation, while Case 3 is intrauterine growth retardation (estimated fetal weight < 10th centile). The Maternal–Fetal Medicine specialist was requested to return the questionnaire (Table 1) in a pre-addressed envelope to the author's address. Physicians who responded to the questionnaire were not identified by name, nor was information elicited regarding their age, or place of training. However, they were asked whether they personally performed fetal ultrasound. The state from which the response was mailed was tabulated to determine the geographical distribution of the respondents. The normal and abnormal Doppler scan responses were analyzed by χ^2 analysis (True Epistat, Richardson, TX) to determine whether an abnormal Doppler scan influenced management for Cases 1, 2 or 3. Cases 1, 2 and 3 for both normal and abnormal Doppler groups were examined using χ^2 analysis to determine if increasing degree of growth restriction influenced the frequency of repeat ultrasound examination, the recommendation for maternal bed rest and its duration, and the frequency and type of antepartum testing. A p value < 0.05 was considered significant.

RESULTS

From 900 questionnaires, 199 (22%) questionnaires were returned for analysis. Ninety-five percent of respondents personally performed diagnostic ultrasound. The respondents were from 33 of 50 states which included all regions of the United States.

Table 1 Questionnaire sent to Maternal–Fetal Medicine specialists

Frequency of repeat ultrasound	*Recommendation for bed rest*	*Antepartum testing*
Normal Doppler of the umbilical artery		
(1) None	(1) None	(1) None
(2) 2 weeks	(2) 5 hours*	(2) Non-stress test
(3) 3 weeks	(3) 12 hours†	(3) Contraction stress test
(4) 4 weeks		(4) Non-stress test plus amniotic fluid index
		(5) Biophysical profile
Abnormal Doppler of the umbilical artery		
(1) None	(1) None	(1) None
(2) 2 weeks	(2) 5 hours*	(2) Non-stress test
(3) 3 weeks	(3) 12 hours†	(3) Contraction stress test
(4) 4 weeks		(4) Non-stress test plus amniotic fluid index
		(5) Biophysical profile

*Represents part-time bed rest during the day in addition to overnight bed rest; †represents full-time bed rest during the day in addition to overnight bed rest

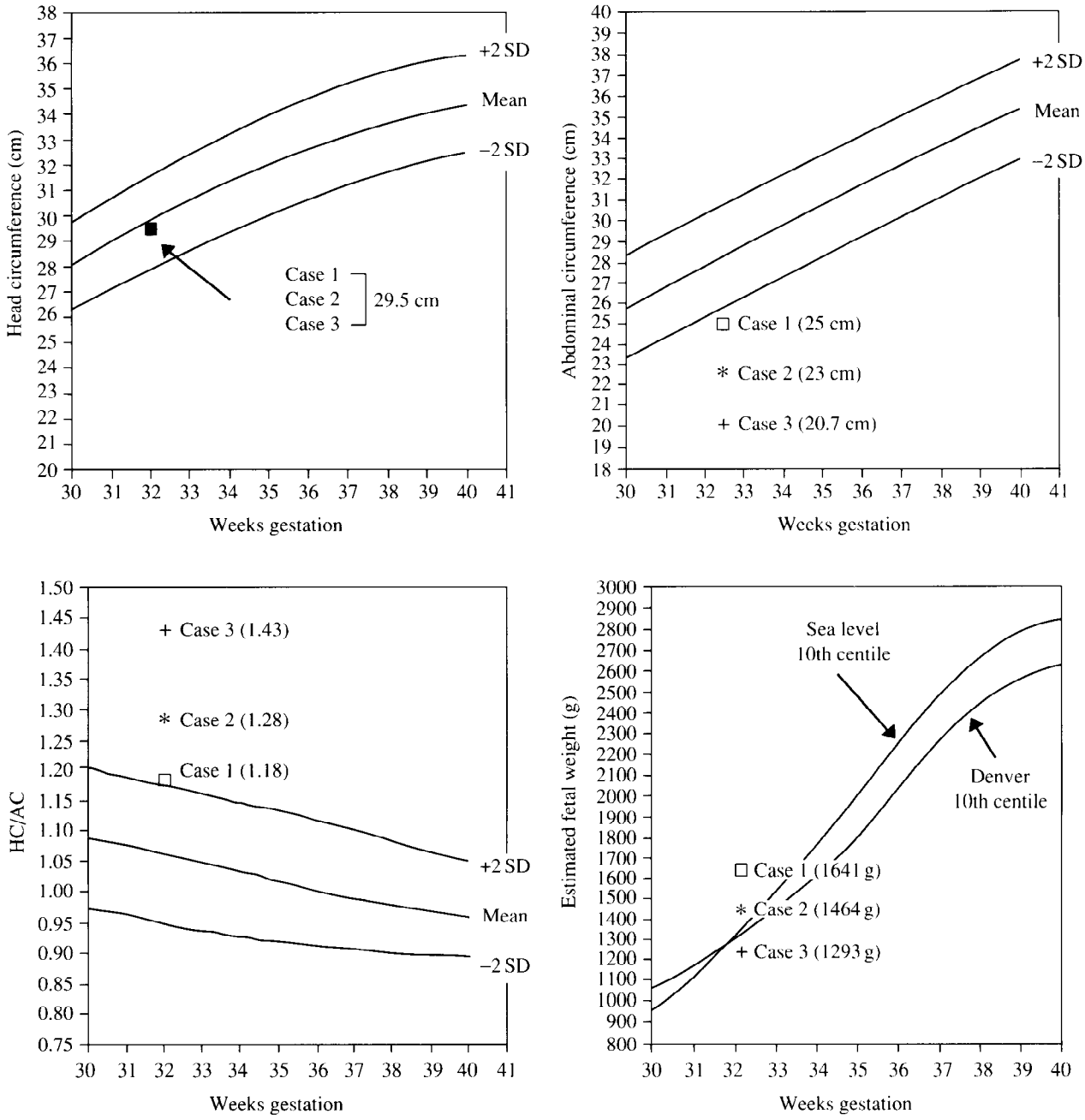

Figure 1 Growth curves for the head circumference, abdominal circumference, head/abdominal circumference (HC/AC) ratio, and estimated fetal weight in grams for Cases 1, 2 and 3

Effect of an abnormal Doppler scan on clinical management

Case 1 Mild growth failure

Table 2 lists the responses. Irrespective of whether the Doppler scan was normal or abnormal, 99% of physicians repeated the ultrasound examination. When the Doppler scan was abnormal, there was a significant increase in the percentage of specialists requesting repeat ultrasound at the 2-week interval (normal Doppler, 46%; abnormal Doppler, 68%) and a significant decrease at the 3-week interval (normal Doppler, 46%; abnormal Doppler, 28%). When the Doppler scan was normal, 55% recommended bed rest which increased significantly to 80% when the Doppler scan was abnormal. The significant increase was due to the recommendation of bed rest for 12 h (normal Doppler, 17%; abnormal Doppler, 46%). The number of physicians recommending antepartum testing when the Doppler scan was normal (82%) significantly increased when the Doppler scan was abnormal (96%). There was no significant difference in the number of specialists recommending a non-stress test or a combination of the non-stress test and amniotic fluid index between the normal and abnormal Doppler groups. When the Doppler scan was abnormal, there was a significant increase in the number recommending a biophysical profile (normal Doppler, 17%; abnormal Doppler, 27%) or a contraction stress test (normal

Table 2 Number of responses from the survey for Case 1

	Normal Doppler	*Abnormal Doppler*	χ^2 *(2-way analysis)*
Total responses	199	194	
Recommended diagnostic ultrasound	195	192	NS
2 weeks	92	132	$p < 0.00002$
3 weeks	92	54	$p < 0.002$
4 weeks	14	6	NS
Recommended bed rest	109	155	$p < 0.00002$
5 hours	76	66	NS
12 hours	34	89	$p < 0.000001$
Recommended antepartum testing	163	186	$p < 0.00002$
non-stress test	32	29	NS
non-stress test and amniotic fluid index	96	91	NS
contraction stress test	2	14	$p < 0.004$
biophysical profile	34	52	$p < 0.02$

NS, non-significant

Table 3 Number of responses from the survey for Case 2

	Normal Doppler	*Abnormal Doppler*	χ^2 *(2-way analysis)*
Total responses	195	194	
Recommended diagnostic ultrasound	194	192	NS
2 weeks	129	144	NS
3 weeks	64	47	NS
4 weeks	1	2	NS
Recommended bed rest	156	173	$p < 0.02$
5 hours	90	50	$p < 0.00004$
12 hours	66	122	$p < 0.000001$
Recommended antepartum testing	185	192	$p < 0.04$
non-stress test	21	12	NS
non-stress test and amniotic fluid index	94	87	NS
contraction stress test	8	12	NS
biophysical profile	62	81	NS

NS, non-significant

Table 4 Number of responses from the survey for Case 3

	χ^2 *Normal Doppler*	χ^2 *Abnormal Doppler*	χ^2 *(2-way analysis)*
Total responses	198	190	
Recommended diagnostic ultrasound	192	184	NS
2 weeks	150	150	NS
3 weeks	40	32	NS
4 weeks	2	2	NS
Recommended bed rest	182	182	NS
5 hours	40	23	$p < 0.04$
12 hours	143	160	$p < 0.006$
Recommended antepartum testing	198	190	NS
non-stress test	8	4	NS
non-stress test and amniotic fluid index	79	65	NS
contraction stress test	20	17	NS
biophysical profile	91	86	NS

NS, non-significant

Doppler, 1%; abnormal Doppler, 7%). The most frequently recommended antepartum test when the Doppler scan was abnormal was the combination of the non-stress test and amniotic fluid index (48%).

Case 2 Moderate growth failure

Table 3 lists the responses. Over 99% of specialists repeated the ultrasound examination, irrespective of the Doppler scan findings. An abnormal Doppler scan did not alter the time interval between repeat ultrasound

examinations compared to when the Doppler scan was normal. The most frequent time interval between ultrasound examinations was 2 weeks (normal Doppler, 66%; abnormal Doppler, 74%). When the Doppler scan was normal, 80% recommended bed rest. This percentage increased significantly to 89% when the Doppler scan was abnormal. There was a significant decrease in the number of specialists recommending bed rest for 5 h (normal Doppler, 46%; abnormal Doppler, 26%) and a significant increase in those recommending bed rest for 12 h (normal Doppler, 34%; abnormal Doppler, 63%). While not clinically significant, the number recommending antepartum testing when the Doppler scan was normal (95%) increased when the Doppler scan was abnormal (99%). There was no significant difference in the number of specialists recommending a non-stress test, a combination of the non-stress test and amniotic fluid index, a contraction stress test, or a biophysical profile when the Doppler scan was normal or abnormal. The two most frequently recommended antepartum tests, irrespective of the Doppler scan, were the combination of the non-stress test and amniotic fluid index (normal Doppler, 48%; abnormal Doppler, 45%), and the biophysical profile (normal Doppler, 32%; abnormal Doppler, 42%).

Case 3 Intrauterine growth retardation

Table 4 lists the responses. Irrespective of the Doppler scan finding, over 97% of specialists repeated the ultrasound examination. There were no significant differences in the time intervals between ultrasound examination when the Doppler scan was normal or abnormal. The most common interval of time between examinations was 2 weeks (normal Doppler, 76%; abnormal Doppler, 79%). There was no significant difference between the normal (92%) and abnormal Doppler (96%) groups for the recommendation of bed rest. When the Doppler scan was abnormal, a significant increase in the number recommending bed rest for 12 h (normal Doppler, 72%; abnormal Doppler, 84%) was paralleled by a significant decrease in the number recommending bed rest for 5 h (normal Doppler, 20%; abnormal Doppler, 12%). The number recommending antepartum testing was 100% for both groups. There was no significant difference between the types of antepartum tests when the Doppler scan was normal or abnormal. The most frequently recommended antepartum test was the biophysical profile (normal Doppler, 46%; abnormal Doppler, 55%). The least frequently ordered tests were the non-stress test and contraction stress test, which were ordered by less than 10% of specialists.

Effect of increasing severity of growth restriction on clinical management

The data were analyzed to determine if there was a significant difference between the responses as related to an increasing severity of growth restriction (Case 1 vs. Case 2 vs. Case 3) in the normal and abnormal Doppler groups.

Normal Doppler

The frequency of specialists repeating the ultrasound scan was not significantly different between the three cases. However, there was a significant increase in the number who recommended a repeat ultrasound at 2-week intervals as the severity of growth restriction increased (Figure 2). This was paralleled by a significant decrease in the number who recommended an ultrasound at 3- and 4-week intervals (Figure 2). The number who recommended bed rest significantly increased as the severity of growth restriction increased (Figure 3). The number recommending 5 h of bed rest significantly decreased and the number recommending 12 h of bed rest significantly increased (Figure 3). There was a significant increase in the number who recommended antepartum testing when growth restriction became progressively more severe (Figure 4). The number of non-stress tests significantly decreased, the number of contraction stress tests significantly increased as did the number of biophysical profiles (Figure 4). There was no change in the number recommending the combination of the non-stress test plus amniotic fluid index.

Abnormal Doppler

The frequency of repeat ultrasound and the interval between ultrasound examinations were not significantly different between the three cases (Figure 5). This suggested that when the Doppler scan of the umbilical artery is abnormal, the fetus with less severe growth failure undergoes repeat ultrasound at a time interval similar to the fetus with intrauterine growth retardation. There was a significant increase in the number recommending bed rest (Figure 6). This was associated with a significant decrease in those recommending 5 h of bed rest and a significant increase in the number recommending 12 h of bed rest (Figure 6). There was no significant difference in the number recommending antepartum testing between the three cases. However, the number of non-stress tests significantly decreased as did the combination of the non-stress test and amniotic fluid index (Figure 7). The number of biophysical profiles significantly increased (Figure 7).

DISCUSSION

The results would suggest that specialists in Maternal–Fetal Medicine who responded to this survey do not wait until the fetus demonstrates intrauterine growth retardation before initiating fetal surveillance and treatment. The importance of this concept is supported by a study reported by Myers and Ferguson in 1989 who examined 850 000 birth records between 1980 and 1984[7]. Their data suggested that a fourfold increase in fetal death occurred

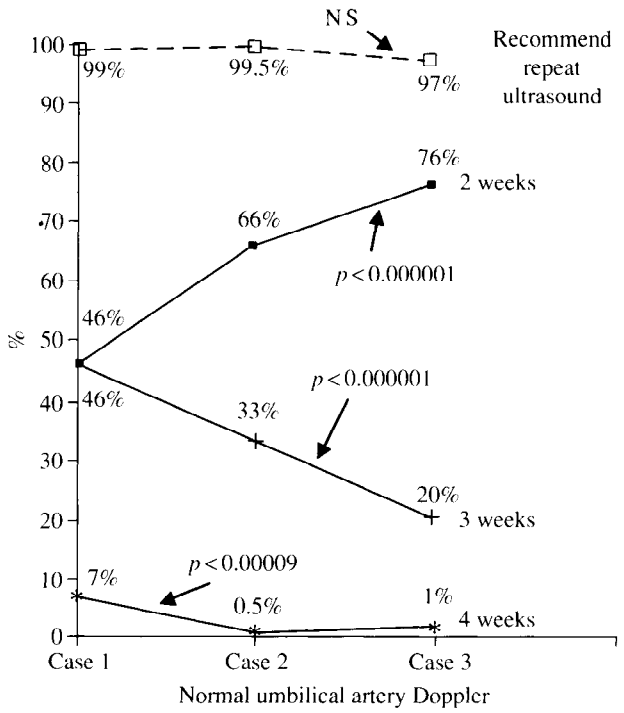

Figure 2 Recommendation for repeat ultrasound examination with a normal umbilical artery Doppler. χ^2 analysis of Cases 1, 2 and 3. The numerical counts from the χ^2 analysis are represented as percentages (see Tables 2, 3 and 4). The solid line represents significant trends; the interrupted line represents non-significant trends

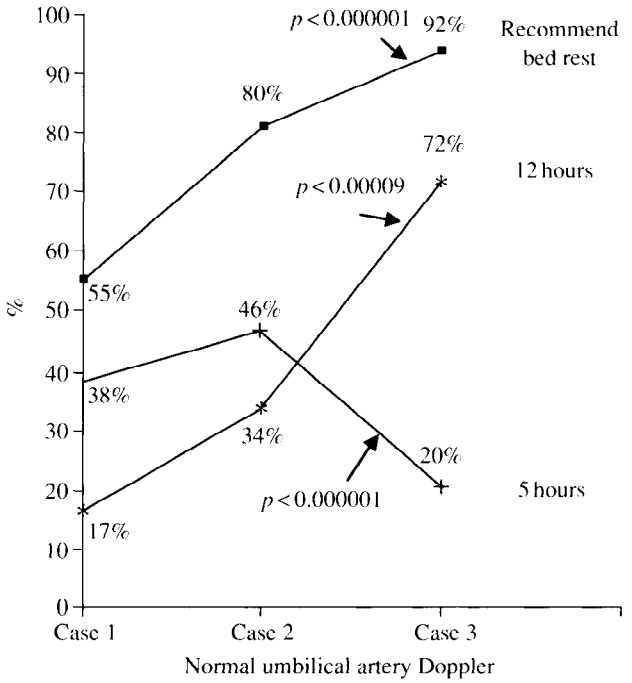

Figure 3 Recommendation for bed rest with a normal umbilical artery Doppler. χ^2 analysis of Cases 1, 2 and 3. The numerical counts from the χ^2 analysis are represented as percentages (see Tables 2, 3 and 4). The solid line represents significant trends

at a birth weight greater than the 10th centile after 34 weeks of gestation for the Illinois population, and after 33 weeks for the Denver population[7]. They concluded that 'if assessment of risk is to be inferred based on the relationship between birth weight and gestational age, then tenth centile (whether Denver, Illinois, or elsewhere) does not predict stillbirth accurately'[7]. In a recent review by Zimmer and Divon in 1992, they recognized the progressive nature of growth restriction and stated, 'Newborns who appear to be malnourished but whose birth weight is at or slightly above the tenth centile for gestational age may present with abnormal indirect indices indicating growth retardation (i.e. head circumference/abdominal circumference, femur length/abdominal circumference, Doppler velocimetry or oligiohydramnios) despite a normal estimate of fetal weight'[8]. Therefore, it is not surprising that the majority of respondents to the survey interpreted growth failure (Cases 1 and 2) as a clinical concern, and initiated fetal surveillance and treatment with bed rest.

For some obstetricians, Doppler examination of the umbilical artery may be controversial. In November 1992, the American College of Obstetricians and Gynecologists published a *Committee Opinion* (Number 116) entitled, *Utility of Antepartum Doppler for Estimating Fetal Umbilical and Uterine Artery Flow*, in which they stated, 'It remains unclear what the role of this technique (Doppler of the umbilical artery) may be in clinical management.' However, the majority of specialists in Maternal–Fetal Medicine who responded to this survey appear to interpret an abnormal Doppler scan of the umbilical artery as identifying a fetus at increased risk, given similar growth patterns. The response of those surveyed is supported by a number of studies which have suggested that an abnormal Doppler scan of the umbilical artery often precedes conditions associated with an increased risk for perinatal morbidity and mortality. In 1988 Anyaegbunam and colleagues reported that, for fetuses at increased risk for intrauterine growth retardation, an abnormal Doppler examination of the umbilical artery preceded abnormal antepartum testing by an average of 3 weeks[9]. In 1990, Bekedam and colleagues reported their findings from 29 fetuses with intrauterine growth retardation in which the umbilical artery Doppler pulsatility index became abnormal in 93% of the fetuses 17 days (range 0–60 days) prior to the development of late decelerations of the fetal heart[10]. Pattinson and associates also reported in 1990 that an abnormal Doppler scan of the umbilical artery preceded an abnormal non-stress test and found that patients with a normal non-stress test and an abnormal Doppler examination had a significantly ($p < 0.001$) increased incidence of Cesarean sections for fetal distress (16.7%) when compared to fetuses with a normal non-stress test and a normal Doppler (2.1%)[11]. In 1992, James and colleagues examined the relationship between the umbilical artery Doppler scan, abdominal circumference, and biophysical profile to determine if there was a temporal relationship between the three ultrasonographic parameters[12]. The order of deterioration was, first, the umbilical artery Doppler scan, followed by the abdominal circumference, and finally the biophysical profile[12]. The

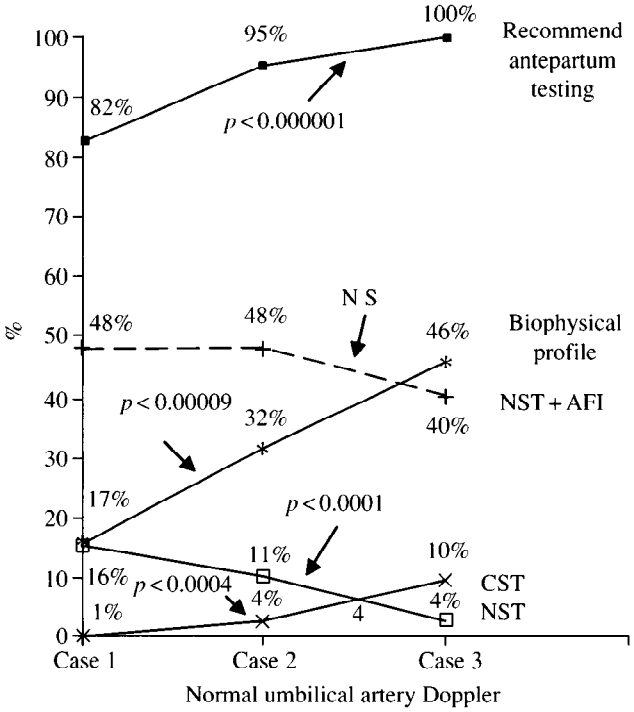

Figure 4 Recommendation for antepartum testing with a normal umbilical artery Doppler. χ^2 analysis of Cases 1, 2 and 3. The numerical counts from the χ^2 analysis are represented as percentages (see Tables 2, 3 and 4). The solid line represents significant trends; the interrupted line represents non-significant trends. NST, non-stress test; CST, contraction stress test; AFI, amniotic fluid index

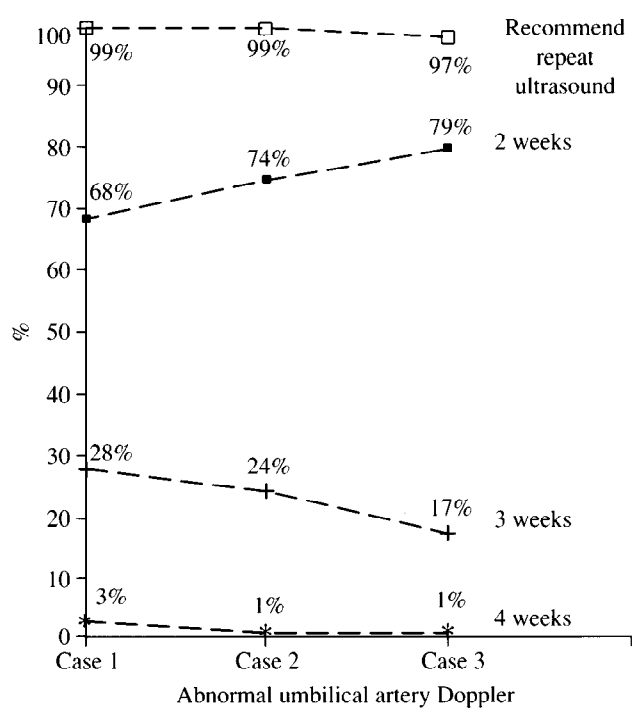

Figure 5 Recommendation for repeat ultrasound examination with an abnormal umbilical artery Doppler. χ^2 analysis of Cases 1, 2 and 3. The numerical counts from the χ^2 analysis are represented as percentages (see Tables 2, 3 and 4). The interrupted line represents non-significant trends

worst prognosis was when all three parameters were abnormal. They concluded that the Doppler scan of the umbilical artery was useful because it preceded additional abnormal findings[12].

An abnormal Doppler scan of the umbilical artery is often associated with increased perinatal morbidity and mortality. In 1991, Gudmundsson and Marsal reported that fetuses at risk for intrauterine growth retardation with an abnormal Doppler scan of the umbilical artery had a higher risk for intrauterine growth retardation, Cesarean section, and low 1-min Apgar scores (≤ 7)[13]. In 1991, Trudinger and colleagues reported results from 2178 high-risk patients, of whom 794 were followed serially[14]. In this group of patients, they found that, if the umbilical artery Doppler resistance was increasing, in contrast to decreasing with time, there was a significantly greater risk for intrauterine growth retardation and an increase in time spent in the neonatal care unit[14]. In 1992, Devoe and associates reported that rising values of the umbilical artery Doppler systolic/diastolic ratio, although in the 'normal range', were associated with a significant increase in perinatal mortality, Cesarean delivery for fetal distress, acidosis, and admissions to the newborn intensive care unit, when compared to fetuses in which the systolic/diastolic ratio decreased as a function of increasing gestational age[15].

The results of this survey demonstrated that an abnormal Doppler scan was associated with an increased number of specialists recommending maternal bed rest. Although maternal bed rest has been employed by obstetricians for a number of years for treatment of preterm labor, vaginal bleeding, and pre-eclampsia, there have been few reports relating to the treatment of fetal growth restriction. In 1990, DeVore and Hebertson reported decreasing the fetal death rate in a community hospital by 62% using maternal bed rest as the primary form of treatment once abnormalities of the umbilical artery Doppler scan and growth restriction were identified[16]. Recently, Sengupta and colleagues reported their findings in which 128 patients with an abnormal umbilical artery Doppler systolic/diastolic ratio were placed on bed rest for 4.5 h per day in addition to overnight bed rest[17]. Of the 128 patients, 41% had intrauterine growth retardation. Forty-eight percent of the intrauterine growth-retarded fetuses responded to bed rest as manifested by the abnormal systolic/diastolic ratio becoming normal. When they compared abnormal outcome between those fetuses in which the systolic/diastolic ratio improved due to maternal bed rest versus those in which it remained abnormally elevated, there was a significant difference in the incidence of severe pre-eclampsia (4.5 vs. 40.3%), spontaneous labor (71.2 vs. 12%), Cesarean section for fetal distress (0 vs. 24.2%), gestational age at birth (37.3 vs. 32.8 weeks), diagnosis to delivery interval (63 vs. 26 days), birth weight (2916 vs. 1481 g), fetal growth retardation (6 vs. 71%), admission to the newborn intensive care unit (12 vs. 77.4%), stillbirth (0 vs. 6.4%), and neonatal death (6.4%)[17].

The results of the survey suggested a hierarchy in the choice of antepartum testing, depending upon the sever-

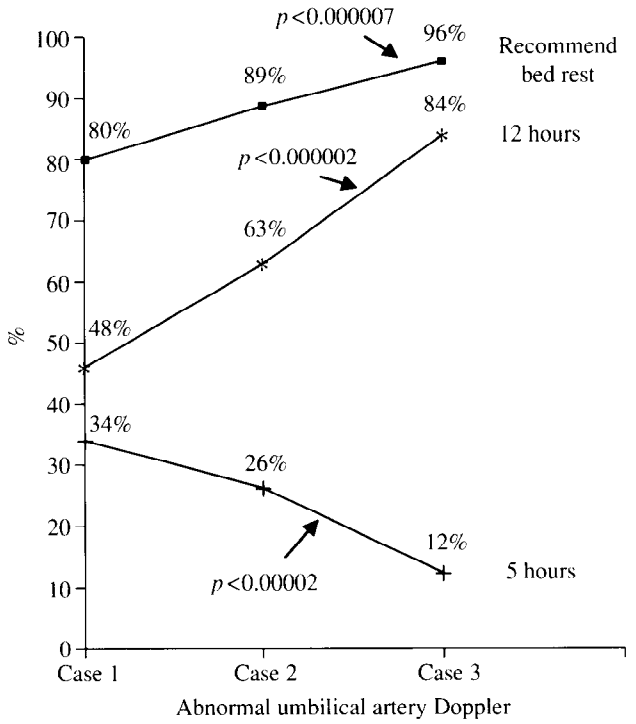

Figure 6 Recommendation for bed rest with an abnormal umbilical artery Doppler. χ^2 analysis of Cases 1, 2 and 3. The numerical counts from the χ^2 analysis are represented as percentages (see Tables 2, 3 and 4). The solid line represents significant trends

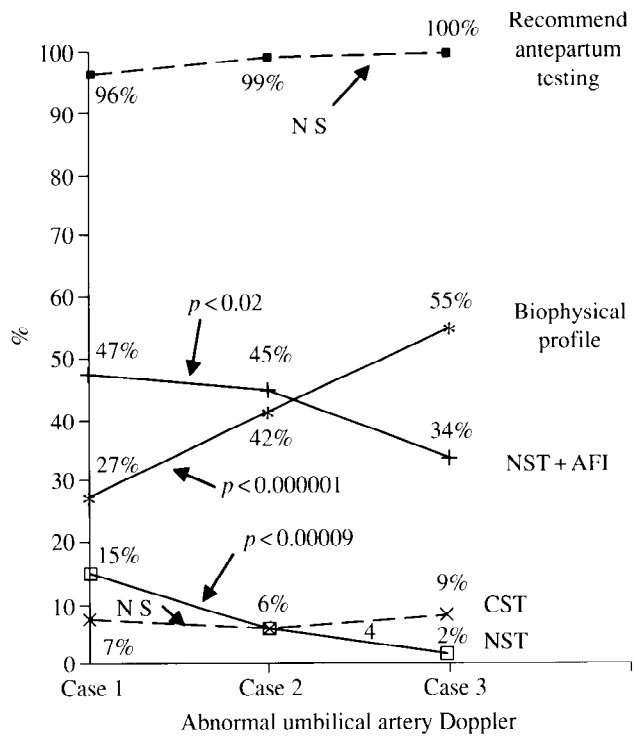

Figure 7 Recommendation for antepartum testing with an abnormal umbilical artery Doppler. χ^2 analysis of Cases 1, 2 and 3. The numerical counts from the χ^2 analysis are represented as percentages (see Tables 2, 3 and 4). The solid line represents significant trends; the interrupted line represents non-significant trends. NST, non-stress test; CST, contraction stress test; AFI, amniotic fluid index

ity of growth restriction and the presence of an abnormal Doppler scan of the umbilical artery. In this survey, the contraction stress test (1 to 10%) and the non-stress test (2 to 16%) were the least frequently used antepartum tests among the respondents. This may be due to the fact that 95% of the respondents performed ultrasound assessment of the fetus and therefore incorporate ultrasound examinations into their testing scheme (amniotic fluid index, biophysical profile). Another reason may be that the non-stress test is not specific for intrauterine growth retardation. This is suggested by a recent study from Sweden in which Almstrom and colleagues reported results from a randomized clinical trial in which fetuses who were small for gestational age were identified after 31 weeks of gestation[18]. The fetuses were assigned to antepartum surveillance using either Doppler velocimetry of the umbilical artery or cardiotocography. When compared to the non-stress test group, the Doppler group required significantly fewer antepartum tests, fewer antenatal hospital admissions, fewer inductions of labor, and fewer emergency Cesarean sections for fetal distress[18]. The authors concluded that the umbilical artery Doppler velocimetry was more specific for the small-for-gestational-age fetus than was cardiotocography[18].

This survey suggested that multiple parameters for antepartum testing were preferred by Maternal–Fetal Medicine specialists rather than an isolated non-stress test or contraction stress test. In 1987, Vintzileos and colleagues prospectively studied 124 patients prior to labor who underwent Cesarean section and identified a sequence of changes as the fetuses became progressively more acidotic[19]. They noted that with mild acidosis the non-stress test became non-reactive and fetal breathing ceased. As acidosis became more severe, there was a loss of fetal tone and movement. They suggested that the components of the biophysical profile could be used to evaluate acute hypoxia (non-stress test and/or fetal breathing) and chronic hypoxia (amniotic fluid)[19]. In 1989, Manning and associates evaluated 7000 patients at risk for adverse outcome using the four components of the biophysical profile identified with real-time ultrasound[20]. Manning's group identified a significant inverse linear relationship between the biophysical profile score and the following parameters: fetal distress in labor, admission to the newborn intensive care unit, 5-min Apgar ≤ 7, cord pH ≤ 7.20, and perinatal morbidity and mortality[20]. Therefore, the increased use of the various components of the biophysical profile as growth restriction became more severe, with or without an abnormal Doppler, is supported by the literature.

The question can be raised as to whether the number of respondents was representative of Maternal–Fetal Medicine specialists in the United States. The geographical distribution of the respondents was from all regions of the United States. Four previously published surveys of members of the Society of Perinatal Obstetricians on topics dealing with management of premature labor,

premature rupture of the membranes, diabetes, and pre-eclampsia, had between 217 and 289 respondents[21 24]. Therefore, the response rate for this survey (199 respondents) was similar in number to previously published reports[21 24]. The only potential bias might be that 95% of the respondents performed diagnostic ultrasound. Without knowing the number of Maternal–Fetal Medicine specialists in the United States who perform diagnostic ultrasound, those who responded may have had an interest in ultrasound compared to those who did not respond. For this reason, the results should be interpreted to reflect the opinions of Maternal–Fetal Medicine specialists who perform diagnostic ultrasound.

The author's interpretation of the results of the survey suggests the following principles relating to patient management:

(1) If the fetus demonstrates asymmetrical growth failure remote from term, specialists do not wait until the fetus develops intrauterine growth retardation before requesting a repeat ultrasound examination, recommending bed rest, or initiating antepartum testing.

(2) If the umbilical artery Doppler is normal, increasing severity of growth restriction (Cases 1–3) is monitored by increasing the frequency of repeat ultrasound examinations, with an interval between examinations of 2 weeks being the most commonly recommended. There is also an increase in the number of specialists who recommended 12 h of bed rest as well as fetal surveillance using the biophysical profile.

(3) If the umbilical artery Doppler is abnormal, fetuses with growth failure (Cases 1 and 2) were treated similarly to the fetus with intrauterine growth retardation (Case 3) as it related to the frequency of repeat ultrasound, and the recommendation for antepartum testing. As growth restriction became more severe, however, there was an increase in the number who recommended 12 h of bed rest, and a biophysical profile. There was a decrease in the number who ordered a non-stress test or a non-stress test and amniotic fluid index.

(4) The intrauterine growth-retarded fetus, with or without an abnormal Doppler of the umbilical artery, was treated the same as related to the frequency of repeat ultrasound, the type of antepartum testing chosen, and the recommendations for maternal bed rest. However, 12 h of bed rest was more frequently recommended when the Doppler was abnormal.

REFERENCES

1. Campbell, S. and Thomas, A. (1987). Ultrasound measurements of the fetal head to abdomen circumference ratio in the assessment of growth retardation. *Br. J. Obstet. Gynaecol.*, **84**, 165–84
2. Hadlock, F. P., Deter, R. L., Harrist, R. B., Roecker, E. and Park, S. K. (1983). A date-independent prediction of intrauterine growth retardation: femur length/abdominal circumference ratio. *Am. J. Radiol.*, **141**, 974–84
3. Crane, J. P. and Kopta, M. M. (1979). Prediction of intrauterine growth retardation via ultrasonically measured head/abdominal circumference ratios. *Obstet. Gynecol.*, **54**, 597–601
4. Divon, M. Y., Guidetti, D. A., Braverman, J. J., Oberlander, E., Langer, O. and Merkatz, I. R. (1988). Intrauterine growth retardation – a prospective study of the diagnostic value of real-time sonography combined with umbilical artery flow velocimetry. *Obstet. Gynecol.*, **72**, 611–14
5. Skovaran, M. L., Berkowitz, G. S., Lapinski, R. H., Kim, J. M. and Chitkara, U. (1991). Evaluation of early third-trimester ultrasound screening for intrauterine growth retardation. *J. Ultrasound Med.*, **10**, 153–9
6. Guidetti, D. A., Divon, M. Y., Braverman, J. J., Langer, O. and Merkatz, I. R. (1990). Sonographic estimates of fetal weight in the intrauterine growth retardation population. *Am. J. Perinatol.*, **7**, 5–7
7. Myers, S. A. and Ferguson, R. A. (1989). A population study of the relationship between fetal death and altered fetal growth. *Obstet. Gynecol.*, **74**, 325–31
8. Zimmer, E. Z. and Divon, M. Y. (1992). Sonographic diagnosis of IUGR-macrosomia. *Clin. Obstet. Gynecol.*, **35**, 172–84
9. Anyaegbunam, A., Langer, O., Brustman, L., Damus, K., Halpert, R. and Merkatz, I. R. (1988). The application of uterine and umbilical artery velocimetry to the antenatal supervision of pregnancies complicated by maternal sickel hemoglobinopathies. *Am. J. Obstet. Gynecol.*, **159**, 544–7
10. Bekedam, D. J., Visser, G. H., van der Zee, A. G., Sniijders, R. J. and Peolmann, G. (1990). Abnormal velocity waveforms of the umbilical artery in growth retarded fetuses; relationship to antepartum later heart rate decelerations and outcome. *Early Hum. Dev.*, **24**, 79–89
11. Pattinson, R., Dawes, G., Jennings, J. and Redman, C. (1991). Umbilical artery resistance index as a screening test for fetal well-being. I. Prospective revealed evaluation. *Obstet. Gynecol.*, **78**, 353–8
12. James, D. K., Parker, M. J. and Smoleniec, J. S. (1992). Comprehensive fetal assessment with three ultrasonographic characteristics. *Am. J. Obstet. Gynecol.*, **166**, 1486–95
13. Gudmundsson, S. and Marsal, K. (1991). Blood velocity waveforms in the fetal aorta and umbilical artery as predictors of fetal outcome: a comparison. *Am. J. Perinatol.*, **8**, 1–6
14. Trudinger, B. J., Cook, C. M. and Giles, W. B. (1991). Fetal umbilical artery velocimetry waveforms and subsequent neonatal outcome. *Br. J. Obstet. Gynaecol.*, **98**, 378–84
15. Devoe, L. D., Gardner, P., Dean, C. and Faircloth, D. (1992). The significance of increasing umbilical artery systolic-diastolic ratios in third-trimester pregnancy. *Obstet. Gynecol.*, **80**, 684–7
16. DeVore, G. R. and Hebertson, R. M. (1990). The temporal association of the implementation of a fetal diagnostic and surveillance program and decreased fetal mortality in a private hospital. *Obstet. Gynecol.*, **75**, 210–13
17. Sengupta, S., Harrigan, J. T., Rosenberg, J. C., Davis, E. and Knuppel, R. A. (1991). Perinatal outcome following improvement of abnormal umbilical artery velocimetry. *Obstet. Gynecol.*, **78**, 1062–6
18. Almstrom, H., Axelsson, O. and Cnattinguis, S. (1992). Comparison of umbilical artery velocimetry and cardiotocography for surveillance of small-for-gestational-age fetuses. *Lancet*, **340**, 936–40
19. Vintzileos, A. M., Gaffney, S. E., Salinger, L. M., Campbell, W. A. and Nochimson, D. J. (1987). The relationship

between fetal biophysical profile and pH in patients undergoing cesarean section before the onset of labor. *Obstet. Gynecol.*, **70**, 196–201

20. Manning, F. A., Harman, C. R., Morrison, I., Menticglou, S. M., Lange, I. R. and Johnson, J. M. (1990). Fetal assessment based on fetal biophysical profile scoring. IV. An analysis of perinatal morbidity and mortality. *Am. J. Obstet. Gynecol.*, **162**, 703–9
21. Taslimi, M. M., Sibai, B. M., Amon, E., Taslimi, C. K. and Herrick, C. N. (1989). A national survey of preterm labor. *Am. J. Obstet. Gynecol.*, **160**, 1352–7
22. Capless, E. L. and Mead, P. B. (1987). Management of preterm premature rupture of membranes: a lack of national consensus. *Am. J. Obstet. Gynecol.*, **157**, 11–12
23. Landon, M. B., Gabbe, S. G. and Sachs, L. (1990). Management of diabetes mellitus and pregnancy: a survey of obstetricians and maternal-fetal specialists. *Obstet. Gynecol.*, **75**, 635–40
24. Catazarite, V., Quirk, J. G. and Aisenbrey, G. (1991). How do perinatologists manage preeclampsia. *Am. J. Perinatol.*, **8**, 7–10