Fetal Aortic and Pulmonary Artery Diameters: Sonographic Measurements in Growth-Retarded Fetuses

The small size of the head and abdomen in a growth-retarded fetus may lead to inaccurate estimates of gestational age. Therefore, we conducted a study to assess the diameters of the aortic root and pulmonary artery in such fetuses. During the study period, we measured these great vessel diameters at the level of the semilunar valves on all third-trimester obstetric sonograms in which intrauterine growth retardation was suspected. Cases were included in the study if delivery occurred within 1 week of the scan and if growth retardation was confirmed after birth. The study population consisted of 75 growth-retarded fetuses. We compared the relationships between great vessel diameters and gestational age in this study population with norms previously established in our laboratory in 403 normal fetuses. In a similar fashion, we compared the relationships between great vessel diameters and biparietal diameter in our study population with previously established norms. We found no significant difference between great vessel diameters in growth-retarded fetuses and those in normal fetuses of the same gestational age (p > .45 for aorta; p > .40 for pulmonary artery). In contrast, aortic root diameter was larger in relation to biparietal diameter in growth-retarded fetuses than it was in normal fetuses (p < .05), and there was a tendency toward the same result for the pulmonary artery.

We conclude that the diameters of the aorta and pulmonary artery remain normal in most cases of intrauterine growth retardation. The aorta and pulmonary artery may be useful predictors of gestational age when growth retardation is suspected.

Intrauterine growth retardation (IUGR) is a fetal disorder characterized by reduced growth, usually occurring in the third trimester. As commonly defined, a fetus is growth retarded if its weight is below the 10th percentile for gestational age [1–6]. The fetal abdomen and, to a lesser degree, the fetal head are small in most cases of IUGR [7–11]. Thus, a prediction of gestational age based on the size of these body parts tends to underestimate age in a growth-retarded fetus. Using our previously developed norms for diameters of the great vessels (aorta, pulmonary artery) [12], we conducted a study to determine whether these structures were smaller in growth-retarded fetuses.

Subjects and Methods

We measured great vessel diameters on all third-trimester obstetric sonograms in which the estimated fetal weight was below the 10th percentile for gestational age [13]. Weight was estimated by using a formula based on biparietal diameter (or corrected biparietal diameter [14]), abdominal circumference, and femur length [15]. All measurements were obtained by using two-dimensional real-time sonography. Measurements of the great vessels were taken from inner wall to inner wall at the level of the semilunar valves. Using an approach that has been described previously [12], we made aortic measurements with the aorta in cross section, and we obtained measurements of the pulmonary artery from images showing the artery in either a cross-sectional or a longitudinal orientation. The aorta and pulmonary artery were both measured at least twice in each fetus. If the initial pair of measurements of one of the vessels differed by more than 0.1 mm, additional measurements were obtained.
until a single reproducible value was achieved. Equipment used to obtain measurements included a phased- or linear-array Acuson scanner (Mountain View, CA), a phased-array Hewlett-Packard scanner (Andover, MA), and a linear-array or mechanical-sector ATL scanner (Advanced Technology Laboratories, Bothell, WA).

In addition to measurements of the great vessels, we recorded the gestational age and the biparietal diameter (or the corrected biparietal diameter [14], if both the width and length of the skull could be measured). Gestational age was assigned by using the first available item from the following list: (1) previous first-trimester sonogram (via crown-rump length [16]), (2) reliable clinical estimates of gestational age, (3) earliest second- or third-trimester sonogram (via biparietal diameter or corrected biparietal diameter [14]).

The fetuses whose measurements were recorded were included in the study only if (1) delivery occurred within 1 week of the scan, (2) IUGR was confirmed after birth (i.e., birth weight was at or below the 10th percentile for gestational age [13]), (3) no major anomaly was detected either by prenatal sonography or after birth. The study population consisted of 75 growth-retarded fetuses.

We compared the relationship between great vessel diameter and gestational age in this study population with that in a normal population (i.e., the population we used previously to establish norms for great vessel size [12]). We also compared the relationship between great vessel diameter and biparietal diameter in this study population with that in the normal population. All comparisons were examined for statistical significance by using the F-test.

Results

Figure 1A shows the relationship between fetal aortic root diameter and gestational age in our study population of 75 growth-retarded fetuses. Superimposed on the 75 data points are the 5th, 50th, and 95th percentile lines for aortic root diameters in normal fetuses, derived in a previous study [12]. The data points are centered about the 50th percentile line, and most fall within the 5th–95th percentile range, suggesting that aortic root diameter in growth-retarded fetuses does not differ from that in normal fetuses of the same gestational age. This is confirmed by statistical analysis: No significant difference was found between fetuses with IUGR and normal fetuses in respect to the relationship between mean aortic diameter and gestational age (p > .45, F-test).

When aortic root diameter is plotted against biparietal diameter (BPD) (Fig. 1B), the data points for fetuses with IUGR are centered above the 50th percentile line, and the number of points above the 95th percentile is disproportionate to sample size. This suggests that aortic root diameter is larger in relation to BPD in IUGR fetuses than in normal fetuses, a result confirmed by statistical analysis: The relationship between aortic root diameter and BPD is different in IUGR fetuses than in normal fetuses (p < .05, F-test). This finding reflects the fact that growth-retarded fetuses have aortas that are the appropriate size for the gestational age and heads that are small for the gestational age.

The findings were similar for the pulmonary artery. As shown in Figure 2A, there is no significant difference between growth-retarded fetuses and normal fetuses in respect to the mean pulmonary artery diameter as a function of gestational age (p > .40, F-test). In the relationship between pulmonary artery diameter and biparietal diameter (Fig. 2B), the pulmonary artery diameter in growth-retarded fetuses tends to be above the 50th percentile line and a disproportionate number of points are above the 95th percentile line, although this difference between fetuses with IUGR and normal fetuses was not statistically significant (p = .19, F-test).

Discussion

IUGR is a disorder that is associated with considerable risk to the fetus. The perinatal mortality rate of growth-retarded fetuses is 8–10 times that of normal fetuses, and the prevalence of serious morbidity is 50–75% [2–4]. These risks underscore the importance of developing a better understanding of IUGR.

Head and abdominal sizes of growth-retarded fetuses have been studied extensively [7–11]. Abdominal growth in these fetuses is consistently small. Head size is also diminished, although most often to a lesser degree than abdomen size (leading to the term “asymmetric IUGR” to describe the most common form of this disorder). Therefore, a prediction of gestational age that is based on the size of the head or abdomen generally will be less than the true age; head and abdominal measurements carry a systematic bias as predictors of gestational age in growth-retarded fetuses.

We have previously shown [12] that the diameter of the great vessels grows linearly with gestational age in normal fetuses. These measurements can be obtained reliably in 84–
90% of cases. The difference between systolic and diastolic measurements and between M-mode and two-dimensional measurements are small (2.2–4.6%). The accuracy of age prediction by using aortic root diameter is similar to that obtained by using the BPD in normal third-trimester fetuses: a 95% confidence range of ±3–4 weeks.

The current study indicates that great vessel size is no different in growth-retarded fetuses than in normal fetuses of the same gestational age. Therefore, predictions of gestational age based on great vessel diameter will, on average, neither underestimate nor overestimate the true age in growth-retarded fetuses. In contrast to head and abdominal measurements, great vessel diameters will yield unbiased estimates of gestational age in growth-retarded fetuses.

Our study also shows that a disproportion exists between great vessel size and head size in growth-retarded fetuses: biparietal diameter is small relative to the great vessels, as is evidenced by Figures 1B and 2B. This reflects the fact that growth-retarded fetuses tend to have great vessels that are the appropriate size for the gestational age and heads that are small for the gestational age. However, the disproportion that occurs, on average, in fetuses with IUGR is of little value in predicting IUGR in the individual fetus. Although Figure 1B shows a statistically significant shift of data points above the 50th percentile line (a similar trend is shown in Fig. 2B), most individual points are within the normal (5th–95th) percentile range.

We cannot determine whether our findings apply to both symmetric and asymmetric IUGR because our study population included only three cases that could be clearly classified as symmetrically growth retarded (a head size that was at least two standard deviations below that which was expected on the basis of reliable estimates of gestational age, and a head-to-abdominal circumference ratio that was within normal limits). This sample was too small to allow us to reach distinct conclusions on that subtype of IUGR. However, all three of these fetuses had great vessel sizes that were large relative to their biparietal diameters, the same finding as that in the overall group.

In summary, our study adds to the current knowledge of how fetal body parts are affected by IUGR. Whereas the abdomen and head are diminished in size (the former to a greater extent than the latter), the size of the great vessels remains normal in most cases of growth retardation. A disproportion tends to exist between head and abdominal size (head is large relative to abdomen); the opposite disproportion exists between head and great vessel size (head is small relative to great vessels). In practical terms, the diameters of the aorta and pulmonary artery provide an unbiased estimate of gestational age in both normal and growth-retarded fetuses, and thus these measurements may be useful age predictors when IUGR is suspected.

REFERENCES