Individualized growth assessment: conceptual framework and practical implementation for the evaluation of fetal growth and neonatal growth outcome

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Fetal growth abnormalities can pose significant consequences on perinatal morbidity and mortality of nonanomalous fetuses. The most widely accepted definition of fetal growth restriction is an estimated fetal weight less than the 10th percentile for gestational age according to population-based criteria. However, these criteria do not account for the growth potential of an individual fetus, nor do they effectively separate constitutionally small fetuses from ones that are malnourished. Furthermore, conventional approaches typically evaluate estimated fetal weight at a single time point, rather than using serial scans, to evaluate growth. This article provides a conceptual framework for the individualized growth assessment of a fetus/neonate based on measuring second-trimester growth velocity of fetal size parameters to estimate growth potential. These estimates specify size models that generate individualized third-trimester size trajectories and predict birth characteristics. Comparisons of measured and predicted values are used to separate normally growing fetuses from those with growth abnormalities. This can be accomplished with individual anatomical parameters or sets of parameters. A practical and freely available software (Individualized Growth Assessment Program) has been developed to allow implementation of this approach for clinical and research purposes.

Key words: customized fetal growth, individualized growth assessment, Individualized Growth Assessment Program, Rossavik growth model, second trimester, third trimester, ultrasound

Beginning in the early 1800s, routine weighing of newborns began in British lying-in hospitals, with some American maternity hospitals following by midcentury.[1] By 1900, birthweight was the most common quantitative measure available for evaluating individual fetal growth, although it is actually a measure of size.[2] This availability of birthweight led to its use in establishing relationships between obstetrical, pediatric, and neurobehavioral variables beginning in the late 1940s.[1]

Birthweight as the surrogate for fetal growth was described in the classic paper of Battaglia and Lubchenco,[3] which introduced the classification system still in use today. This system categorizes neonates with birthweights below the 10th percentile for gestational age as small for gestational age (SGA), those with birth weights between the 10th and 90th percentiles as appropriate for gestational age (AGA), and those above the 90th percentile as large for gestational age (LGA).[3-12] These category boundaries were justified only by the observation that 10th percentile values were similar in different studies.[3] However, this system provided a means for relating size and preterm birth to neonatal mortality.[13-16]

Given this focus on birthweight as an indicator of fetal growth, it is not surprising that with the introduction of ultrasound into obstetrical practice in the 1970s, estimating fetal weight (because it cannot be measured directly) became a primary subject for investigation.[17-24] This has led to the development of numerous formulas for estimating fetal weight.[25-40]

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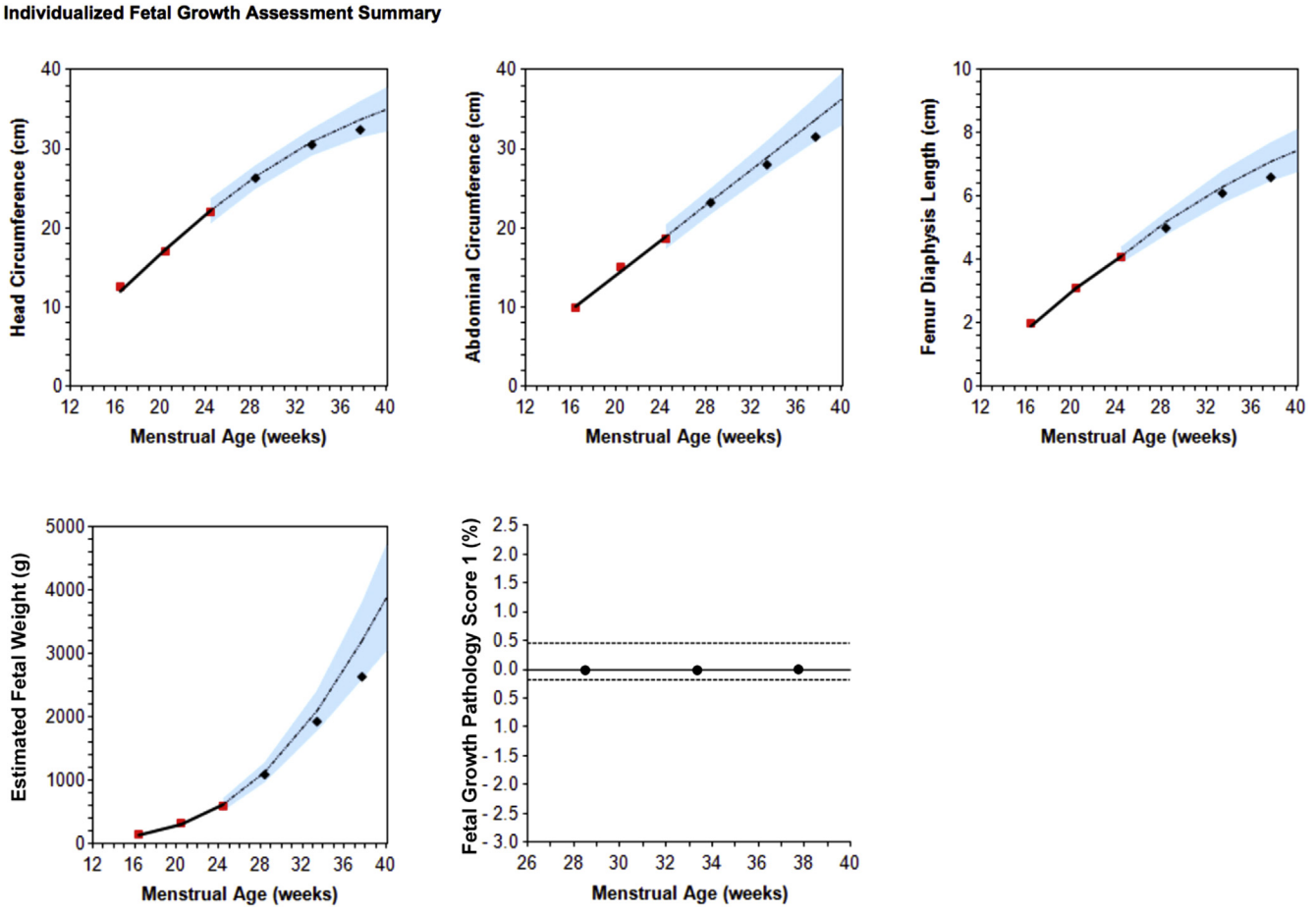
FIGURE 1
Normal prenatal growth in newborn considered small for gestational age



This small-for-gestational-age newborn had a birthweight of 2490 g at 39.1 weeks, which is at the fourth percentile according to the Intergrowth-21st standard. The growth summary for this individual included head circumference, abdominal circumference, femur diaphysis length, and estimated fetal weight. The estimated fetal weight is calculated using biparietal diameter, head circumference, abdominal circumference, and femur diaphysis length. FGPS1 values (head circumference, abdominal circumference, femur diaphysis length, and estimated weight) are plotted in the lower-right-hand panel. All of these values are equal to zero, indicating no growth pathology. The 2 *horizontal dashed lines* define reference range boundaries for the +FGPS1 (upper) and −FPGS1 (lower) values. All 3 growth potential realization index values were normal (neonatal assessment screen not shown): (weight: 83.0%; head circumference: [100.2%]; and crown heel length: 94.5%) with an average pathological growth potential realization index of 0.0%. Apgar scores were 9 of 9 at birth. The infant was discharged from the low-risk nursery at 4 days following delivery. This case illustrates that even small newborns can grow normally during the prenatal period, and this process can be verified using individualized growth assessment. The finding of normal interval growth in a small fetus, based on growth potential, may provide useful information for guiding decisions about the number and frequency of antenatal surveillance tests, delivery timing, and/or postnatal therapeutic interventions (eg, postnatal nutritional supplementation). However, optimal application of these individualized results will require additional clinical investigation.

FGPS1, fetal growth pathology score 1.

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A principal objective of this work has been to predict the SGA-AGA-LGA status of the neonate. Successful predictions would have allowed the utilization of associations between birthweight categories and perinatal complications and/or long-term neurobehavioral development. However, conventional approaches utilizing comparisons of an individual to his/her appropriate size group have not been able to reliably predict birthweight categorizations.[41,42] It is now time to think differently about how fetal and neonatal growth should be evaluated.

The importance of velocity in the assessment of fetal growth

Growth is defined as a change in body dimensions over time. The physical