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Gastroschisis: Growth Patterns and a Proposed Prenatal Surveillance Protocol

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Key Words
Gastroschisis · Intrauterine growth restriction · Prenatal diagnosis, gastroschisis · Amniotic fluid index

Abstract
Objective: To assess intrauterine growth for fetuses with gastroschisis using retrospective serial ultrasound assessment from fetuses diagnosed prenatally with gastroschisis. The growth assessment could be available as a prospective tool to direct an antepartum fetal surveillance protocol. ***Methods:*** This is a retrospective review of all cases of gastroschisis evaluated prenatally at a single institution between February 1996 and March 2002. Charts were reviewed for serial ultrasound assessment, gestational age at delivery, mode of delivery, and birth weight. Growth assessment was determined for abdominal circumference, biparietal diameter, head circumference, femur length, and estimated fetal weight (IRB No. 2002-1-2648). ***Results:*** Forty patients had delivered by March 2002. One hundred and two ultrasound reports were reviewed. Gastroschisis growth curves showed that the 50th percentile was shifted to the right when compared to normal growth curves for abdominal cicumference, biparietal diameter, head circumference, and femur length. The average birth weight was 2,359 g. Compared with a standard population, 44% (16/36) were below the 5th percentile, 61% (22/36) were below the 10th percentile, and 95% (34/36) were below the 50th percentile for gestational age. The average gestational age at delivery was 36.3 weeks. Mothers were nulliparous in 78%, with a mean age of 21.3 years. ***Conclusions:*** (1) Fetuses with gastroschisis show a symmetric intrauterine growth restriction pattern consistent with early development of growth delay; (2) the 50th percentile biometry measurements for the gastroschisis population are shifted to the right on normal fetal growth curves; (3) the birth weight is at or below the 10th percentile in 61% of the newborns with gastroschisis, and (4) an antepartum surveillance protocol is proposed based on growth patterns of fetuses with gastroschisis.

Introduction

Gastroschisis is a common prenatally diagnosed birth defect (0.5–4.5 cases/10,000 live births), with increasing incidence worldwide [1–10]. The specific etiology for this birth defect is unknown [7, 8]. Routine ultrasound has allowed this birth defect to be identified in utero with high specificity and sensitivity. The abdominal wall defect in the fetus permits the small and large bowels to herniate through the defect and be exposed to the amni-

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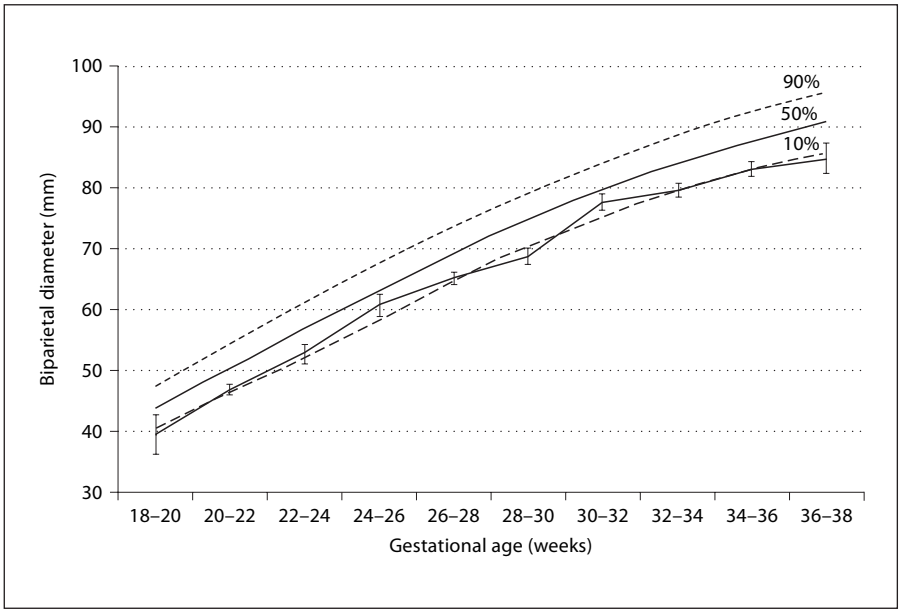

Fig. 1. Biparietal diameter growth comparison of fetuses with gastroschisis to reference population [20].

otic fluid environment. Gastroschisis is a paraumbilical defect of the abdominal wall that is almost always right-sided and is usually <4 cm in diameter. The size of the abdominal wall defect and the exposure to the amniotic fluid have effects on the condition and function of the bowel after birth and carry significant morbidity and mortality risks to fetus and newborn. Gastroschisis can produce intrauterine and neonatal complications which include postnatal bowel dysfunction, bowel atresia, bowel necrosis, and subsequent short-bowel syndrome [7, 8].

The most common epidemiological association with gastroschisis is young maternal age, especially <20 years [1, 2, 4, 9–11]. Associated factors considered in this young maternal age population have been environmental teratogens such as cigarette smoke and drug abuse [12–14]. There is a significant association with poor maternal education, low socioeconomic status, more than one elective termination of pregnancy, and a short interval between menarche and first pregnancy [15, 16]. The infant survival may depend on ethnic/racial variation, with black infants being less likely to survive with gastroschisis (adjusted hazard ratio 2.23) as compared with white infants [17].

Intrauterine growth restriction (IUGR) is common in the gastroschisis population [18, 19]. Seventy percent of the infants with gastroschisis are below the 50th percentile for birth weight. This shift of the mean birth weight is highly significant. The prevalence of IUGR is increased in prenatally diagnosed infants with gastroschisis due to the small abdominal circumference measured in the standard ultrasound position.

The objective of this study was to compare a retrospective analysis of serial ultrasound assessments in fetuses diagnosed prenatally with gastroschisis to normal published growth curves [20] and to propose an additional prenatal surveillance testing protocol.

Materials and Methods

This is a retrospective review of all cases of gastroschisis evaluated prenatally in a single institution between February 1996 and March 2002 (IRB No. 2002-1-2648). Charts were reviewed for serial ultrasound assessment, including at least two examinations, gestational age at delivery, mode of delivery, and birth weight. A total of 40 fetuses were available for serial retrospective assessment with delivery prior to March 2002. Fetal growth biometry and surveillance were available for 29 fetuses. Fifty-five percent of the patients had three or more growth ultrasounds, and a total of 102 ultrasounds for fetal growth assessment were performed. Birth weight data were available for 36 fetuses. There was no prospective protocol for delivery management, and decisions were based on clinician choice.

Growth assessment was developed by computing the mean for each birth measure within gestational age strata. Standard error bars were computed separately for each gestational age stratum. The control group for growth comparison was from a large peer-reviewed published ultrasound database using fetal biometry in a well-defined North American population [20]. An amniotic fluid index value >24 cm was used to define polyhydramnios [21].

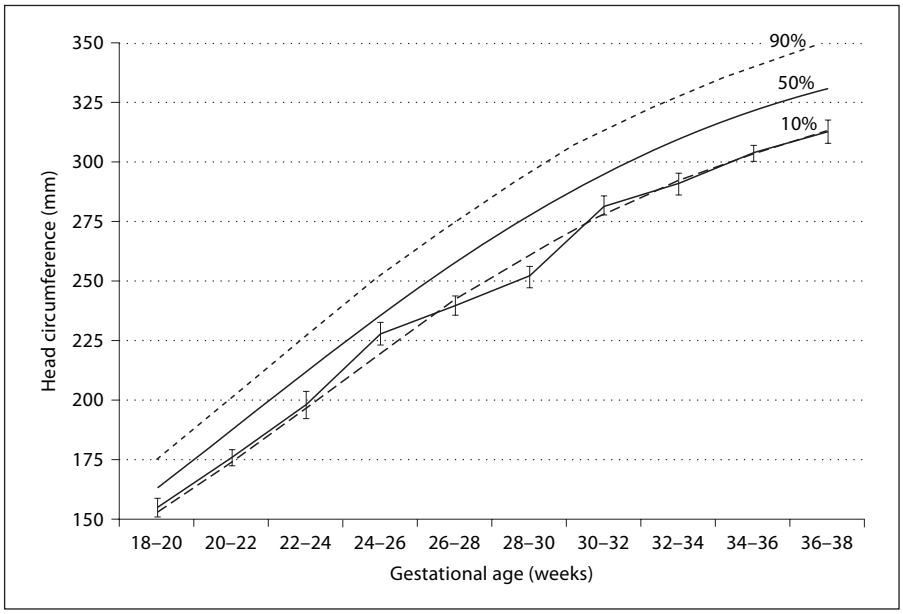

Fig. 2. Head circumference growth comparison of fetuses with gastroschisis to reference population [20].

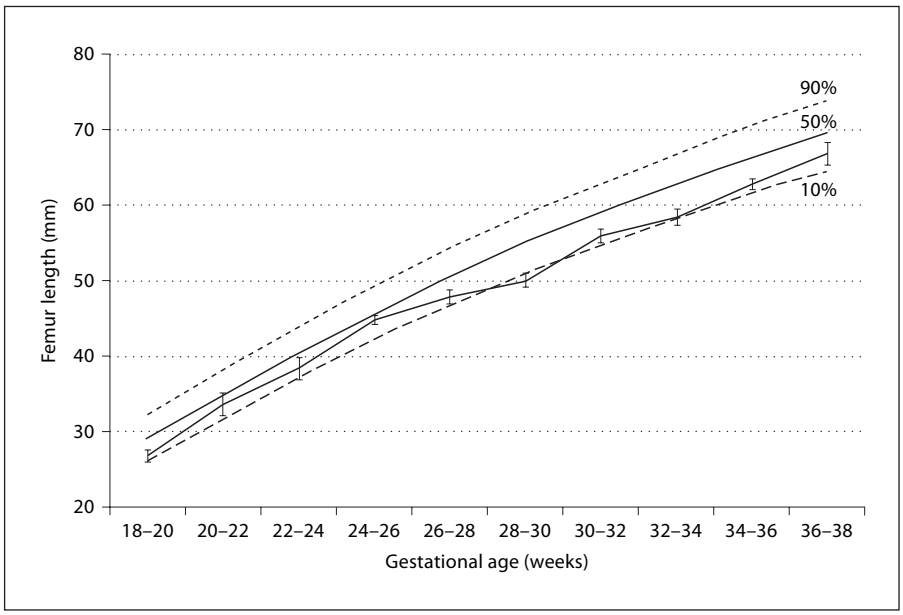

Fig. 3. Femur length growth comparison of fetuses with gastroschisis to reference population [20].

Results

Growth assessment for fetal biometry in fetuses with gastroschisis was constructed for biparietal diameter, head circumference, abdominal circumference, femur length, and estimated fetal weight, and these were compared to normal growth biometry charts from a published population [20] (fig. 1–5). Growth assessment for fetuses with prenatally diagnosed gastroschisis showed that the 50th percentile was shifted to the right as compared with normal growth curves for abdominal circumference, biparietal diameter, head circumference, and femur length. The average birth weight for affected fetuses was 2,359 g, with 44% (16/36) below the 5th percentile, 61% (22/36) below the 10th percentile, and 94% (34/36) below the 50th percentile for standard gestational age birth weight [18, 22]. The amniotic fluid index showed normal values (5–24 cm) in 90%, severe oligohydramnios ($\leq$5 cm) in 5%, and polyhydramnios ($>$24 cm) in 5% [21]. Ultrasound assessment of bowels was variable, as no spe-

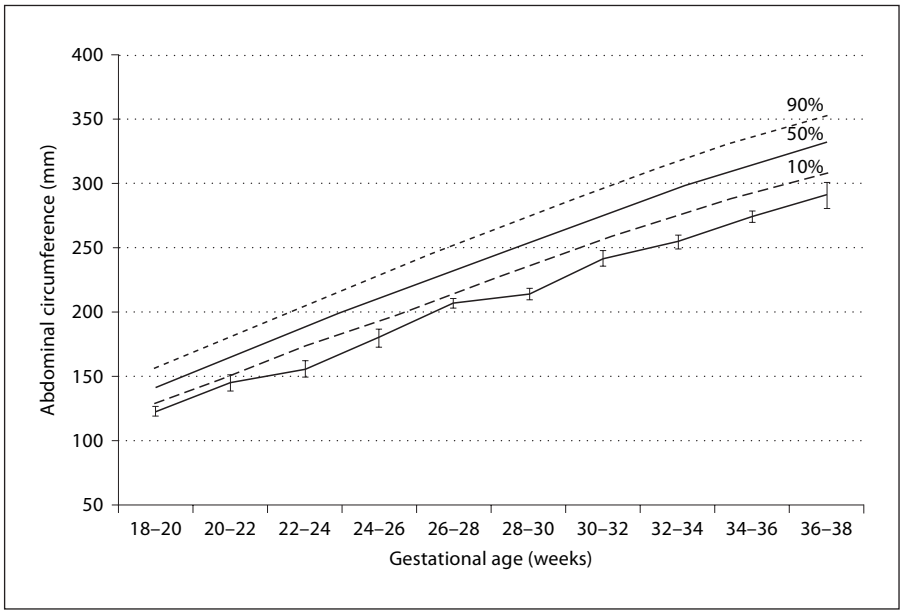

Fig. 4. Abdominal circumference growth comparison of fetuses with gastroschisis to reference population [20].

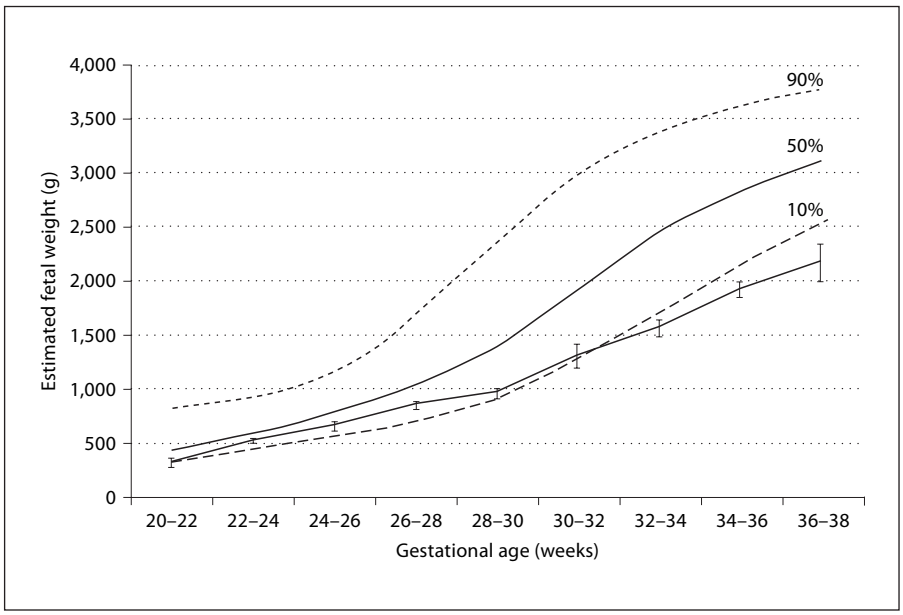

Fig. 5. Estimated fetal weight comparison of fetuses with gastroschisis to reference population [20].

cific criteria were reported in this retrospective clinical evaluation. A normal bowel appearance was present in 15%, an external thickened bowel wall in 15%, and dilated bowel loops in 70%. Herniated stomach and dilated stomach were seen in 2 fetuses. Doppler assessment of the umbilical artery was not evaluated consistently in this cohort.

The mothers were nulliparous in 78%, with a mean age of 21.3 years. No specific drug or medication history was documented. The average gestational age at delivery was 36.3 weeks. Fetal gender was male 60% and female 40%. A total of 76% of the infants (22/29) were born by cesarean delivery. A change of the protocol regarding the mode of delivery occurred in 2001, with 85% (17/20) of the infants born before 2001 being delivered by cesarean section and 55% (5/9) born after 2001 being delivered by cesarean section. The most common indication for cesarean delivery after protocol change was nonreassuring fetal heart rate tracing. The surgical repair technique was available for 27 neonates, with in 5 (4/5 birth weight

<10th percentile) using gradual reduction by sequential tightening of the Silastic silo, and 22 (11/22 birth weight <10th percentile) had primary repair.

Discussion

IUGR affects 3–10% of all pregnancies, depending on the study definition [23]. As a general classification, IUGR increases the perinatal mortality by four to eight times in the growth-restricted group and contributes to significant perinatal morbidity in up to 50% of the survivors [23]. Fetal growth can be affected by chronic uterine placental insufficiency, exposure to drugs or environmental agents, congenital infections, or intrinsic genetic limitations of growth potential. Additional congenital anomalies will impact intrauterine status, as a recent study [24] identified a 4% incidence of congenital heart disease with gastroschisis and an association with African-American infants and bowel atresia. Maternal genetic predispositions for thromboembolism as an etiology for gastroschisis (factor V Leiden, prothrombin, methylenetetrahydrofolate reductase mutations) were not increased in another gastroschisis population [25].

Ultrasound has identified different patterns of abnormal fetal growth and classifies IUGR as either asymmetric or symmetric. Asymmetric IUGR is generally considered a nutritional compromise with normal head growth and decreased abdominal growth. Symmetric IUGR presents with decreased growth for both head and abdomen (using a clinical definition of <10th percentile) and generally suggests a more significant fetal pathology, including chromosomal, placental, and genetic abnormalities.

The serial assessment of growth curves for fetuses with gastroschisis may allow the differentiation between growth changes due to gastroschisis as compared with additional risk factors which may be additive to the gastroschisis growth restricted background risk. The identification of additional growth abnormalities may allow a more directed fetal assessment (amniotic fluid index, biophysical profile, fetal arterial and venous Doppler evaluation) with possible decreases in perinatal morbidity and mortality [26–29]. Isolated gastroschisis has an increased stillbirth rate (×14; 85/1,000) and an increased neonatal death rate (×4; 17.5/1,000) as compared with controls [30]. A retrospective assessment of surveillance techniques was not possible from this present gastroschisis population by chart review.

Controlled studies have indicated that chick embryos with gastroschisis were smaller in size and had reduced intravascular levels of sodium, chloride, amino acids, and glucose when compared to controls [31]. A more recent human study [32] showed a significant decrease in fetal cord blood serum protein, but a rise in amniotic fluid protein in fetuses with gastroschisis as compared with normal controls or fetuses with omphalocele. These studies support the hypothesis that in utero protein and fluid loss from the bowel to the amniotic fluid may account for the raised incidence of growth restriction, oligohydramnios, and intrauterine death that occur in these at-risk pregnancies. A rat model has shown that gastroschisis had a direct correlation with IUGR, but that the time of exposure to the amniotic fluid had no influence on body weight, but did interfere with intestinal length [33].

Prospective use of growth assessment for the gastroschisis population must be undertaken to see whether it can be helpful for fetal assessment beyond the usual fetal assessment testing and protocols [34, 35]. It may be possible that in fetuses with a more significant IUGR the management using invasive assessment of amniotic fluid protein levels may allow a more directed choice for timing of labor induction or for the type of delivery. This approach may minimize fetal intrapartum stress and morbidity.

An antenatal surveillance protocol [36–40] has been developed at this center with multidisciplinary expert opinion and includes: (1) isolated gastroschisis has ultrasound growth assessment starting at 28 weeks and repeated every 4 weeks and biophysical assessment starting at 32 weeks with biophysical profile or nonstress testing with amniotic fluid index at twice per week frequency, and (2) complicated gastroschisis (IUGR, oligohydramnios) has ultrasound growth assessment starting at 28 weeks with frequency based on clinical opinion and/or biophysical assessment starting at 28 weeks with biophysical profile or nonstress testing/amniotic fluid index at a twice per week frequency and umbilical artery Doppler flow once per week.

In summary, prospective use of gastroschisis growth assessment may allow an additional form of prenatal assessment to improve the identification of those fetuses at an increased risk of intrauterine morbidity and mortality. A prospective clinical surveillance protocol needs to be tested in this 'at-risk' gastroschisis population.

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