Determination of Placental Weight Using Two-dimensional Sonography and Volumetric Mathematic Modeling

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ABSTRACT

An abnormally decreased placental weight has been linked to increased perinatal complications, including intrauterine fetal demise (IUFD) and fetal growth restriction (IUGR). Despite its promise, determining placental weight prenatally using three-dimensional systems is time-consuming and requires expensive technology and expertise. We propose a novel method using two-dimensional sonography that provides an immediate estimation of placental volume. Placental volume was calculated in 29 third-trimester pregnancies using linear measurements of placental width, height, and thickness to calculate the convex-concave shell volume within 24 hours of birth. Data were analyzed to calculate Spearman’s rho ($r_s$) and significance. There was a significant correlation between estimated placental volume (EPV) and actual placental weight ($r_s = 0.80, p < 0.001$). Subgroup analysis of preterm gestations ($n = 14$) revealed an even more significant correlation of EPV to actual placental weight ($r_s = 0.89, p < 0.001$). Placental weight can be accurately predicted by two-dimensional ultrasound with volumetric calculations. This method is simple, rapid, and accurate, making it practical for routine prenatal care, as well as for high-risk cases with decreased fetal movement and IUGR. Routine EPV surveillance may decrease the rates of perinatal complications and unexpected IUFD.

KEYWORDS: Placenta, volume, ultrasound, IUFD, IUGR

A healthy baby at term is the product of three important factors: a healthy mother, normal genes, and good placental implantation and growth. Currently the focus of prenatal surveillance is the fetus. Much effort has been directed toward the detection and assessment of intrauterine growth restriction (IUGR). The many cases of IUGR have traditionally been subdivided into fetal, placental, and maternal. It is clear that a normally functioning placenta is critical for normal fetal growth and development. Adequate fetal growth depends on the efficient delivery of nutrients from the mother to the fetus and therefore requires normal uterine perfusion, normal transplacental exchange of nutrients and waste, and normal umbilical blood flow. Placental

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and height (H) were measured on a flat surface, which were then used to calculate actual placental volume using the formula for an elliptical cylinder, where \( V = \pi ABH \). Data were collected on an Excel spreadsheet (Microsoft, Redmond, WA) and analyzed using SPSS for Windows, version 15.0 (Chicago, IL). A scatter graph was obtained, and Spearman’s rho (\( r_s \)) was used to compare the EPV to the actual placental weight (APW) and volume (APV). The coefficients of variation were calculated by performing five repeated measurements on three patients, using the formula: standard deviation/mean \( \times 100 \). The mean error was calculated by taking the mean value of all the positive and negative errors without regard to sign.

**RESULTS**

Among the 38 patients who consented, nine placentas could not be evaluated properly either due to a body mass index \( > 35 \) (\( n = 3 \)) or a very large placenta that did not fit in the ultrasound screen (\( n = 6 \)). The acquisition of the placenta volume was successfully achieved in the remaining patients (\( n = 29 \)) in ~1 to 2 minutes for each patient. The maternal age of the study population ranged between 20 and 42 years, gestational age ranged between 29 and 40.7 weeks, and the amniotic fluid index ranged from 8 to 26 cm (Table 1). The intraobserver reproducibility was excellent for placenta volume calculations (intraclass correlation coefficient: 0.99).

There was a significant positive correlation between EPV and APW (\( r_s = 0.80, p < 0.001 \)) at all gestational ages examined (Fig. 2A). In the preterm pregnancies, the correlation between EPV and APW was even stronger (\( r_s = 0.89, p < 0.001 \); Fig. 2B). There was also a significant positive correlation between EPV and APV (\( r_s = 0.76, p < 0.001 \)). Subanalysis of the full-term placentas revealed a lower correlation between EPV and APV (\( r_s = 0.68, p < 0.001 \)). The mean error was 16% among all the patients, 19% for the term cases, and 13% for the preterm cases. When placental location was analyzed regarding the difficulty of visualization, no differences were found between fundal, anterior, or posterior placentas. The placentas examined in this study were minimally elliptical, with a mean minor to major axis ratio of 0.96 ± 0.08.

**Figure 2** Correlation of estimated placental volume to actual placental weight. (A) Graph of all 29 patients examined revealing a Spearman’s rho (\( r_s \)) of 0.80. Note that as placental weight increases, the data scatter increases. (B) Graph of only patients at less than 37 weeks’ gestation. Note that Spearman’s rho (\( r_s \)) is now 0.89 due to the fact that it was significantly easier to visualize these placentas in one ultrasound field.

**DISCUSSION**

As is well known, the human placenta is essential for the exchange of substances between the mother and the fetus.\(^{23}\) It facilitates the transfer of oxygen and nutrients from the maternal circulation into the umbilical vein and transports all the metabolic waste and \( CO_2 \) from the fetal umbilical arteries into the maternal venous circulation. Its normal development during gestation ensures the necessary support for the formation of a healthy fetus.\(^{10}\) Prior to the general use of ultrasound in prenatal surveillance, placental hormonal levels were used to assess placental function.\(^{24}\) In the early days of