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THE ROLE OF MODERN DIAGNOSTICS IN STUDYING THE PLACENTA OF FETUS

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Abstract

Diagnostic ultrasound has been used in practical medicine for more than half a century, although in the available literature less attention is often paid to the study of the placenta than to the study of the fetus or uterus. Throughout pregnancy, the placenta performs many important functions, such as fetal oxygenation, fetal nutrition, endocrinological functions, protein synthesis, etc. Ultrasound examination reveals the location, anatomical structure and other visual dimensions of the placenta.

Key words: ultrasound, placenta, diagnostics

INTRODUCTION

Ultrasound is the most commonly used medical imaging modality for diagnosis and screening in clinical practice [1]. It has many advantages over other methods, such as X-ray, magnetic resonance imaging (MRI) and computed tomography (CT), since it does not use ionizing radiation, is highly portable and relatively inexpensive [2]. However, ultrasound also has its disadvantages. It often has relatively poor image quality, is prone to artifacts, is highly dependent on operator (clinician) experience, and has variability between devices from different manufacturers [3]. However, its safety profile, noninvasiveness, and convenience make it the primary imaging modality for fetal assessment during pregnancy [4]. This includes dating early pregnancy, screening for fetal structural abnormalities, and assessing fetal weight and growth rate [5]. Although two-dimensional (2D) ultrasound is most commonly used to evaluate pregnancy due to its wide availability and high

resolution, most machines also have three-dimensional (3D) sensors and software that have been successfully used to detect fetal structural abnormalities [6].

Currently, many factors influence fetal development, which have been proven in various experiments, so ultrasound screening is becoming very important.

Measurements of placental diameter and thickness using two-dimensional ultrasound have been used as an indicator of high-risk pregnancy and have been correlated with birth weight [8]. Several studies have examined these ultrasound parameters in fetuses that are small for gestational age and have shown that placental diameter and thickness are smaller in these fetuses [7,8]. Additionally, Schwartz and colleagues sought to combine early direct ultrasound assessment of the placenta with other markers of placental development, such as mean uterine artery Doppler pulsatility index, to identify pregnancies delivering low birth weight infants [7]. Placental volume, placental quotient (PQ = placental volume/gestational age), and mean placental diameter were significantly smaller in fetuses in the low-weight group compared with the normal-weight group. This indicates that lower placental weight is associated with low fetal weight [9]. On the other hand, the placental morphology index was significantly higher in the normal group, demonstrating a stronger association between slower fetal growth and a relatively wide and flat placenta [7]. Studies have shown that abnormal placental shape (placental thickness > 4 cm or > 50% of placental length) is a predictor of fetal growth restriction. In addition, Proctor et al showed that fetal growth restriction syndrome was associated with small placental size (placental linear length <10 cm) in a group of women with low PAPP-A (pregnancy-associated protein A) levels in the first trimester (<0 .30 times the median).

To evaluate placental morphometry during pregnancy using ultrasound, the sonographic reliability of placental measurements must be adequate. In this regard, several limitations need to be addressed. First, there are no in vivo reference ultrasound maps of normal placental size. Although Higgins et al described that estimated placental biometry and volume during pregnancy correlate with their measurements at postnatal assessment, they are not equal [10]. Measurements of placental length and width, as well as three-dimensional placental volume measurements performed within 7 days before delivery were smaller compared to ex vivo measurements [10]. Placental depth and two-dimensional placental volume measurements were found to be greater compared with their ex vivo correlates. These differences are likely due to collapse of the intervillous space due to loss of maternal blood flow after birth and less distension of the placenta due to loss of intrauterine pressure due to amniotic fluid and baby volumes after birth. Azpurua et al described that placental weight can be accurately predicted using 2D ultrasound with volumetric calculation. Interobserver variability plays a much larger role in in vivo ultrasound measurements than in real life ex vivo measurements [10]. Higgins et al examined intraobserver variability between measurements of placental length, width, depth, and volume made using 2D ultrasound. The variability of measurements was suboptimal, the intraclass correlation coefficient did not exceed 0.75 [10]. More recently, a new semi-automated technique for estimating placental volume based on three-dimensional ultrasound scanning has been developed [12]. In this study, the placental volume of 2393 pregnancies was assessed by three operators on the one hand and this semi-automated instrument on the other hand. The clinical utility of placental volume was tested by examining the prediction of small gestational size at term. The results showed good agreement between operators and the instrument and almost identical clinical results for predicting pathologies [12]. [11] proposed a weakly supervised convolutional neural network for

anatomy recognition in 2D ultrasound images of the placenta. This was the first successful attempt to detect multiple structures in ultrasound images of the placenta. A convolutional neural network was designed to learn discriminative features from class activation maps (one for each class), which are generated by applying a pool of global averages to the final hidden layer. To evaluate the proposed method, an image set consisting of 10,808 image fragments from 60 placental ultrasound volumes was used. The experimental results showed that the proposed method provides high recognition accuracy and makes it possible to localize complex anatomical structures around the placenta. [12] used a convolutional neural network called DeepMedic to automate placenta segmentation in 3D ultrasound. This was the first attempt to segment 3D ultrasound of the placenta using a convolutional neural network. Their database contained 300 3D ultrasound images of the first trimester. The placenta was segmented semi-automatically using the Random Walker method [13] to obtain a reliable dataset. [12] then presented a new 3D FCNN called OxNNet. This was based on a 2D U-net architecture to fully automate placental segmentation in 3D ultrasound volumes. A large dataset consisting of 2393 first trimester 3D ultrasound volumes was used for training and testing purposes. The base dataset was generated using a semi-automated random walk method [13] (initially seeded by three experienced operators). Using OxNNet FCNN it was possible to obtain placenta segmentation with the highest accuracy. They also demonstrated that increasing the size of the training set improves the performance of FCNN. Additionally, placental volumes segmented using OxNNet were correlated with birth weight to predict height in small-for-gestational age infants, demonstrating nearly identical clinical findings to those obtained using validated semi-automated tools.

Based on the above, we can conclude that the study of the placenta using ultrasound has gone through several stages of improvement. At the moment, it is the gold standard for diagnosing various pathologies of the placenta and fetus in different trimesters of pregnancy.

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