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Research article

In vivo assessment of placental elasticity in intrauterine growth restriction by shear-wave elastography

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ABSTRACT

Purpose: In this study, we evaluated the placental elasticity in vivo by shear-wave elastography in pregnant women under follow-up for intrauterine growth restriction (IUGR) and compared the elasticity values to normal pregnancies.

Material and methods: This prospective study included 42 pregnant women with a possible diagnosis of intrauterine growth restriction based on obstetrical grayscale and Doppler ultrasonography and 42 women with a normal pregnancy during the 2nd and 3rd trimester. During follow-up examinations, seven fetuses showed an increased growth and were delivered with a birth-weight above the 10 percentile. However, for statistical purposes we included these seven patients in the IUGR group due to prospective nature of the study. All patients initially underwent obstetrical grayscale and Doppler ultrasonography with measurement of resistivity and pulsatility indices from uterine arteries. Subsequently, elasticity values of the peripheral and central part of the placentas from fetal and maternal surfaces were measured by shear-wave elastography. Following delivery, Apgar scores at 1 st and 5th minute, birth weight were collected. For statistical analysis, Mann-Whitney *U* test was used. ROC curves were plotted and cut-off values for elasticity values were analyzed.

Results: Median elasticity values of the central part of the placentas from maternal (28 kPa vs 6 kPa) and fetal sides (21.5 kPa vs 5 kPa) were significantly higher in IUGR pregnancies compared to the control group ($p < 0.001$). Similarly, median elasticity values of peripheral part of placentas from maternal (22 kPa vs 5.35 kPa) and fetal sides (22.5 kPa vs 5.3 kPa) were significantly higher in IUGR pregnancies compared to the control group ($p < 0.001$).

Conclusion: Placental stiffness values are significantly higher in patients with IUGR. Shear-wave elastography can be used as a non-invasive, complementary method to gray-scale and Doppler ultrasound for diagnosing IUGR.

1. Introduction

Intrauterine growth restriction (IUGR) is the inability of the fetus to maintain expected growth with an estimated fetal weight less than 10th percentile for gestational age [1]. IUGR has an incidence rate of 3–15% and is associated with increased intrauterine demise, neonatal morbidity and mortality [2]. The etiology of IUGR can be related to maternal, fetal and placental causes [1]. Placental insufficiency with poor placental perfusion is one of the most common pathologies associated with IUGR [3].

Since placentation is a determinant factor in IUGR, improved assessment of placenta could enable earlier recognition and improve management options [4]. For diagnostic purposes, estimated fetal weight based on biometric measures, amniotic fluid assessment and Doppler study of uterine arteries are commonly used [1,5]. However, the clinical utility of these assessments is still inadequate to detect placental dysfunction before delivery [6]. A new complementary method to evaluate the placenta is elastography, which is a non-invasive imaging technique to assess soft tissue stiffness [7]. Shear-wave elastography is based on the principle of induction of mechanical vibrations which cause transverse shear waves that propagate laterally within the tissue [8]. The speed of propagation is calculated which

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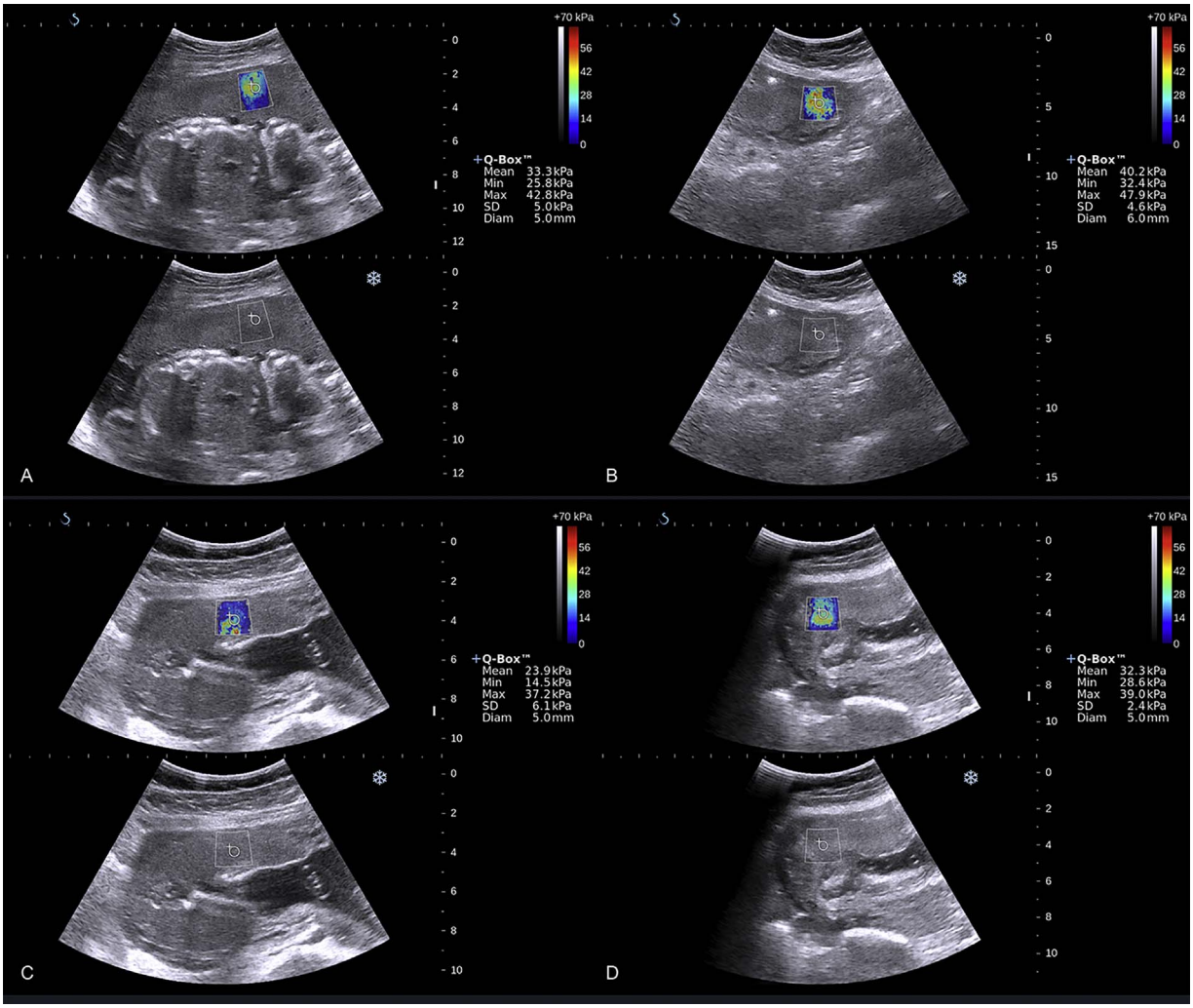

Fig. 1. Example of shear-wave elastography measurement from the placenta of different IUGR pregnancies obtained from A) central part of placenta maternal surface, B) peripheral part of placenta maternal surface, C) central part of placenta fetal surface, D) peripheral part of placenta fetal surface. During region-of-interest placement, stiffest areas as revealed by color-coding were chosen.

provides a quantitative data, with high reproducibility [8]. Shear-wave elastography is a non-invasive method for assessing tissue elasticity where increased stiffness is reflected by faster shear wave speeds [6]. Elastography is used in clinical practice for assessing liver fibrosis, lymph nodes, breast and thyroid gland lesions [9]. There are a limited number of in-vivo elastography studies evaluating the placenta in preeclampsia, gestational diabetes mellitus and fetal anomalies which found an increased elasticity values in placentas afflicted by these conditions [10]. Elastography studies using strain elastography and acoustic radiation force impulse methods have been performed ex-vivo to assess the placenta in IUGR [6,11]. In these ex-vivo studies, increased placental stiffness values were noted in IUGR pregnancies compared to normal pregnancies [6,11]. To better delineate the role of elastography in IUGR in clinical settings, an in-vivo assessment of placental elasticity values in IUGR pregnancies is necessary. For this reason, we evaluated the placental elasticity in-vivo by shear-wave elastography in pregnant women under follow-up for IUGR and compared to gestational-age matched control normal pregnancies.

2. Material and methods

2.1. Patient selection

In this study, 84 pregnant women in their 2nd and 3rd trimesters were prospectively enrolled between October 2015 and August 2016. Approval by institutional review board and informed consent from each patient were obtained. 42 cases with a possible diagnosis of IUGR based on initial ultrasound examinations with an estimated fetal weight (EFW) less than 10th percentile were included. EFW calculations were performed by measuring biparietal diameter, femur length and abdominal circumference [5]. The gestational age was calculated according to the first day of the last menstrual period and crown-rump length measurement. Out of the 42 cases with possible IUGR, seven fetuses showed an increased growth During follow-up examinations,and were delivered with a birth-weight above the 10 percentile. However, for statistical purposes we included these seven patients in the IUGR group due to prospective nature of the study. 42 gestational-week matched pregnancies with no maternal or fetal complications constituted the control group.

Multiple gestations, insufficient placental adherence or penetration and pregnancies with fetal chromosomal or major structural anomalies were excluded from the study. It has been shown that patients with smoking history, high blood pressure or preeclampsia have increased placental stiffness values and to limit the confounding effect of these factors, we excluded these groups of pregnancies after their evaluation at the Department of Gynecology and Obstetrics [10,12]. Due to the limitations in obtaining elastography measurements, posteriorly located placentas were also excluded.