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Measuring cervical strain with tissue Doppler imaging depending on the shape and placement of the region of interest and its correlation with cervical consistency index

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ABSTRACT

Objectives: We want to evaluate tissue Doppler imaging (TDI) for measuring cervical strain. We compare three different methods for measuring strain depending on the region of interest (ROI) placement and evaluate patient discomfort. We correlate the strain measured through TDI with cervical consistency index (CCI), cervical length and width of both cervical lips.
Study design: This is a prospective study in 30 singleton primigravida pregnancies without obstetrical risks between 40 + 0 and 41 + 3 weeks of gestation. The CCI was calculated according to Parra-Saavedra et al. We tested three methods of measuring cervical elasticity depending on shape and location of ROIs.
Results: The CCI ranged between 36.4% and 71.9% with an average of 50.78%. The CCI shows negative correlation with strain and no correlation with cervical length or with the width of either cervical lip. The strain measurements regardless of tested method were reproducible and independent on cervical length. The average strain was higher in outer cervical regions. The ROIs placed on the anterior lip had higher reproducibility than those placed on the posterior lip. The average score for patient discomfort during examination was 3.7/10.
Conclusion: The strain depends on the size and location of ROIs. The circular ROIs with diameter equal to the width of the cervical lip are recommended. There is a correlation between CCI and TDI. The cervix shows heterogeneous consistency with increased stiffness from the outer to the inner sections. The TDI seems to be an easy to learn, quickly to perform, acceptable and reproducible method for measuring cervical elasticity. There is room for optimization and refinement of measuring methods before being tested for clinical significance.

Introduction

Determining whether a tissue is hard or elastic could provide invaluable information for diagnosis [1]. Bishop's score represents an example for utilizing the physical characteristics of the cervix for clinical use [2]. Digital examination is limited by its subjective nature as well as patient discomfort [3,4].

Transvaginal sonography (TVS) has established itself for predicting premature delivery [5]. It has been extensively studied for predicting the success of induction of labor [6]. Simple B-mode TVS lacks the information on cervical consistency obtained through digital examination [7]. A cervical consistency index (CCI) was conceived for the purpose of using data gained from B-mode ultrasound for estimating cervical elasticity [8].

The introduction of elastography made it possible to measure tissue compliance, strain and elasticity objectively [9]. There are currently two main methods for sonographic measurement of tissue elasticity. The first of these utilizes shear wave speed (SWS). The consistency can be assessed depending on the speed of traveling waves [10], but this method carries the disadvantages of thermal tissue damage and questionable reproducibility in complex tissues.

The second method is real-time elastography which has been used for measuring the elasticity of the liver, thyroid, prostate, breast, pancreas and many other organs [11].

Tissue Doppler imaging (TDI) tracks displacement within a region of interest (ROI) after applying pressure, thus measures strain. It has been tested as a method for quantitation of cervical tissue strain [12,13].

The strain is the change in size or shape produced by applying stress. It represents a ratio of the change to the original

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measurement and is measured as a percentage. The high tissue strain corresponds to low tissue stiffness (i.e., more elastic) and vice versa [14].

Another noble method for quantitatively describing the cervical consistency is the aspiration technique. It is a non-invasive procedure for measuring the required pressure for displacing cervical tissue to a predefined deformation. It showed progressive softening of the ectocervix during pregnancy [15].

Few studies utilize elastography in the evaluation of cervical consistency and discuss its clinical value [16].

There are two main issues when using TDI for measuring cervical elasticity. A method for standardizing the applied pressure remains unclear, and published literature does not adequately address cervical heterogeneity in TDI studies [17].

We wanted to evaluate TDI for measuring cervical strain and compared three different methods for measuring strain depending on the ROI placement. We correlated the strain measured through TDI with CCI, cervical length and width of both cervical lips and evaluated patient acceptance.

Materials and methods

This is a prospective study. We recruited 30 women attending our maternal care unit between 40 + 0 and 41 + 3 weeks of gestation. All pregnancies were singleton primigravida without obstetrical risks. The patients were randomly recruited after verbal consent was given. TVS was carried out using a Toshiba Aplio XG with a PVT-661VT vaginal transducer (Toshiba Medical Systems, Europe). A single observer acquired three sets of TDI raw data from each patient. Each set contained two cycles of compression and decompression perpendicular to the longitudinal axis of the uterine cervix.

Pressure was gently applied to the middle of the anterior cervical lip until maximal compression was reached. We defined maximum compression as the amount of pressure applied to the anterior lip before producing any longitudinal or lateral tissue dislocation at the posterior lip. This was our method for standardizing the applied pressure. The raw data was saved and analyzed offline in order to minimize subjective bias generated during recording data. Analysis was carried out on a Toshiba TDI-Q module.

The cervical length was measured once in each set of data in accordance with the known standard recommendations [18]. The width of both anterior and posterior cervical lips was measured at the end of the decompression phase perpendicular to the midpoint of the cervical length.

The CCI was calculated once for each patient according to the method described by Parra-Saavedra et al. CCI represents the ratio of cervical width after compression to the width before compression. The cervical width is always measured perpendicular to the longitudinal cervical axis [8].

The TDI-Q settings used for analysis included auto tracking, natural strain, 5 mm derivative pitch and no angle correction. We divided the cervix into six regions. These were the inner anterior (A), middle anterior (B), outer anterior (C), inner posterior (D), middle posterior (E) and outer posterior (F) regions.

The strain values were measured once in each of the three sets of data for each patient during the decompression phase. We tested three methods of measuring cervical elasticity.

Method one used circular ROIs to measure strain at each of the previously defined cervical regions. These ROIs had a diameter equal to the width of the cervical lip. The ROIs were placed during the frame of complete decompression and were referred to as A1, B1, C1, D1, E1 and F1, accordingly (Fig. 1A). The diameter of the ROIs varied between 9.7 mm and 25 mm.

The second method was similar to the first one, but used free ROI drawing instead of circular ROIs for a more precise tracking of the edges of the six cervical regions. Each cervical lip was divided into three equal regions, and the ROIs were drawn by tracing along the edges of those regions during the frame of complete decompression and referred to as A2, B2, C2, D2, E2 and F2 (Fig. 1B).

The third method used free ROI drawing to measure the elasticity along the entirety of both the anterior and posterior cervical lips (AL and PL, respectively) during the frame of complete decompression (Fig. 1C).

Each participant received a scoring form to evaluate acceptance and discomfort during examination. Each form was scored between 0 (no discomfort) and 10 (maximum discomfort) like the classical quantitation of pain.

Statistical analysis was undertaken with the help of BiAS. (Version 10.01, Goethe University, Frankfurt am Main, Germany). The critical P-value of 0.05 was considered as a cutoff point for significance. The intraobserver reproducibility for the tested elastography methods was assessed using intraclass correlation coefficient (ICC). The three sets of data for each patient were evaluated by the same observer separately, with the observer blinded to them belonging to the same patient. The ICC was also used for assessing the reproducibility of our cervical length measurement.

Our measurements (cervical length, cervical lip width, CCI and strain for the different cervical regions with different methods) were analyzed with the ICC, Student's t-test, Pearson's linear regression and correlation tests.

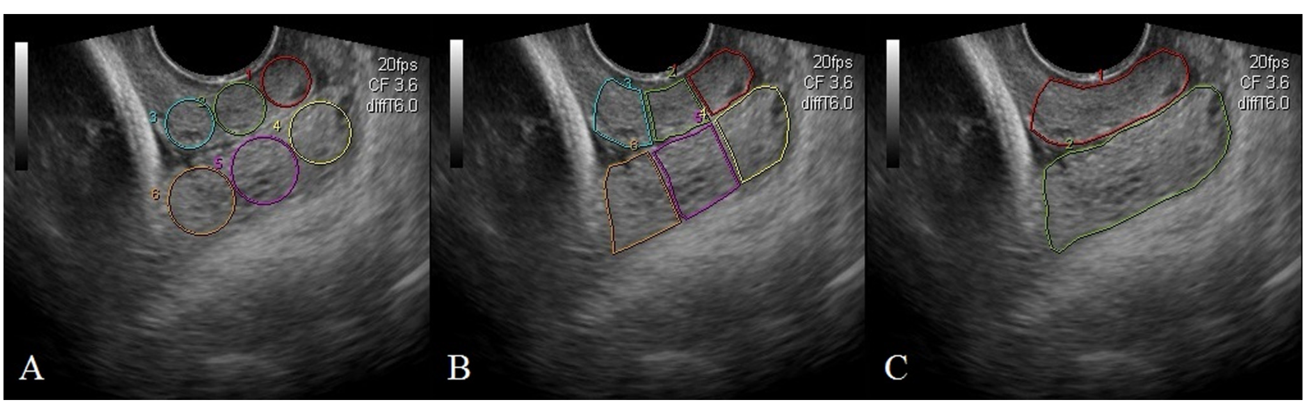

Fig. 1. Placement of the region of interest (ROI) in the tested elastography methods. (A) Method one uses round ROIs, 1 = C1, 2 = B1, 3 = A1, 4 = F1, 5 = E1, 6 = D1. (B) Method two uses free hand ROI drawing in six regions, 1 = C2, 2 = B2, 3 = A2, 4 = F2, 5 = E2, 6 = D2. (C) Method three uses free hand ROI drawing along the entirety of anterior and posterior cervical lips, 1 = AL, 2 = PL.

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