American Journal of Obstetrics and Gynecology (2005) **193**, 1554–60

ELSEVIER

American Journal of
Obstetrics & Gynecology

www.ajog.org

Magnetic resonance imaging of the cervix during pregnancy: Effect of gestational age and prior vaginal birth

Michael House, MD,[a] Mark O'Callaghan, MD,[b] Stephane Bahrami, MD,[a] David Chelmow, MD,[a] Jonathan Kini, MD,[b] Danny Wu, MD,[a] Samuel Patz, PhD,[b] Rafeeque A. Bhadelia, MD[b]

Divisions of Maternal-Fetal Medicine[a] and Radiology,[b] Tufts-New England Medical Center, Boston, MA

Received for publication December 1, 2004; revised March 1, 2005; revised March 19, 2005

KEY WORDS
Pregnancy
Cervix
Anatomy
Magnetic resonance imaging

Objective: To investigate how gestational age and prior vaginal birth affect cervical anatomy on magnetic resonance imaging during pregnancy.
Study design: Magnetic resonance images of the cervix were obtained in consecutive patients referred for a suspected fetal abnormality. We used an image processing protocol to measure cervical dimensions, orientation, and signal intensity. We determined how outcome variables were affected by gestational age and prior vaginal birth.
Results: Adequate images were obtained in 53 of 57 patients at 17 to 36 weeks. As gestational age increased by 12 weeks, the mean cross-sectional area of the cervical canal and cervical stroma increased 31% (95% confidence interval 0% to 73%) and 31% (95% confidence interval 11% to 55%), respectively. The normalized signal intensity of the stroma increased from 0.83 (95% confidence interval 0.81 to 0.85) at 20 weeks to 0.91 (95% confidence interval 0.88 to 0.94) at 32 weeks. None of the outcome variables were affected by prior vaginal birth.
Conclusion: Magnetic resonance imaging revealed that cross-sectional area and signal intensity of the cervical stroma increase with increasing gestational age.

Obstetricians have a growing appreciation for the central role of the cervix in maintaining a healthy pregnancy.[1] The cervix is affected by many factors. Two recognized factors are the gestational age and obstetric history of the patient. During pregnancy, complex biochemical changes occur to the extracellular matrix of the cervical stroma with increasing gestational age.[2,3] On physical exam, the biochemical changes are recognized as a subjective increase in the softness of the cervix. Although a comprehensive understanding of the molecular events that occur in the cervical stroma is lacking, many suspect increased cervical softness is caused in part by increased cervical hydration.[4] Obstetricians also know that a prior vaginal birth is associated with a faster labor in subsequent pregnancies,[5] presumably by an effect on the collagen network of the cervical stroma.[6]

Supported by the Society of Maternal-Fetal Medicine/American Association of Obstetricians and Gynecologists Foundation.

Presented in part at the 25th Annual Meeting of the Society for Maternal-Fetal Medicine, Reno, Nevada, February 5-12, 2005.

Reprints not available from the authors.

0002-9378/$ - see front matter © 2005 Mosby, Inc. All rights reserved.
doi:10.1016/j.ajog.2005.03.042

Both ultrasonography and magnetic resonance (MR) imaging have been used to examine the changes in physical characteristics of the cervix during pregnancy. MR imaging of the cervix provides superior soft tissue resolution and contrast, compared with ultrasonography. Previous studies of MR imaging in pregnancy have demonstrated that increased stroma signal intensity is associated with prostaglandin use in the first trimester[7] and a short time interval to delivery in the third trimester.[8] However, prior studies are limited by a narrow range of gestational ages and lack of information with regard to obstetric history. A study of the anatomy of the cervix with MR imaging that includes obstetric history and a wider range of gestational ages is important for understanding better the complex physiological changes that occur to the cervix during pregnancy.

Our study had two objectives. Our group is interested in biomechanical modeling of cervical mechanical function during pregnancy. An important factor that affects biomechanical function is cervical anatomy (ie, the dimensions of the cervix and the angle of the cervix with respect to gravity). These data are not available with ultrasound because sonographic measurements depend on transducer position and the ultrasound transducer can distort cervical anatomy.[9] Hence, the first objective was to use MR imaging to make anatomic measurements that can be used in biomechanical modeling. The second objective was to use MR imaging to describe changes to the cervix associated with increasing gestational age and prior vaginal birth. We hypothesize that gestational age and prior vaginal birth may cause changes in the cross-sectional area of the cervical canal, cross-sectional area of the cervical stroma, signal intensity of the cervical stroma, and angles between the lower uterine segment and the axis of the cervix.

Material and methods

Patient selection

The study was performed at a single tertiary care facility from March 2002 to July 2004. The study protocol was approved by the institutional review board prior to initiating the study, and informed consent was obtained prior to the MR scan. A cross-sectional study design was used. All data were collected at the time of the visit to MR imaging.

Patients were referred to antenatal MR imaging for 1 of 2 reasons: suspected fetal anomaly or suspected placental abnormality. Cervical MR imaging was performed after the clinically indicated MR imaging. An obstetrician obtained the obstetric history by performing a brief patient interview of the day of the MR imaging. The patient interview was supplemented by review of medical records when these were available. Patients were divided into 2 groups: (1) prior vaginal birth (defined as a birth that occurred after 20 weeks) and (2) no prior vaginal birth. The second group included both nulliparous patients and patients with prior cesarean sections. We attempted to further subcategorize patients with a prior cesarean section into those who underwent a trial of labor and those who did not. However, our ability to determine this information was limited by poor patient recollection and unavailability of medical records. Gestational age was determined by standard obstetric criteria confirmed by a first- or second-trimester ultrasound. Exclusion criteria included suspected cervical incompetence, multiple gestation, placenta previa, and suspected preterm labor. One scan per patient was performed.

Cervical anatomy pulse sequence

All scans were performed on a Siemens Symphony 1.5 Tesla system (Malvern, PA) with a phased array surface coil. We desired a pulse sequence that satisfied the following aims: (1) sufficient contrast to resolve cervical zonal anatomy and endopelvic fascia, (2) volumetric acquisition for off-line reformatting and manipulation, and (3) a fast imaging technique to minimize motion artifact. A fast-spin echo (FSE) proton density-weighted pulse sequence was chosen (repetition time [TR] 9900 milliseconds, echo time [TE] 10 milliseconds). There were 2 averages, a turbo factor of 17, a flip angle of 150 degrees, and 50% oversampling in the phase-encoding direction. A 256×256 matrix was interpolated to a 512×512 matrix. The field of view was 250 mm. Fifty slices were obtained with a slice thickness of 1.6 mm and a slab thickness of 8.0 cm. To obtain proton density weighting, the lines near $k = 0$ were acquired at the first turbo TE time. Note however that there is some T2 weighting because other lines of k-space have TE times up to 177 milliseconds. The total acquisition time was 7 minutes 46 seconds. Images were obtained in the coronal plane. The most anterior slice was positioned at the symphysis pubis.

Image processing

Volume data sets were transferred to a desktop workstation running Analyze 4.0 (AnalyzeDirect, Lenexa, KS). The inhomogeneity correction filter in the spatial filter module of Analyze was used to correct for intensity variations across the volume because of nonuniformities in the radio frequency field.[10] Data sets with isotropic resolution were desired. The in-plane resolution (0.488 mm = 250 mm/512) was chosen. Because the slice thickness was 1.6 mm, a linear interpolation was performed to achieve 0.488 mm resolution in the slice direction, which created a data set with cubic voxels. Last, the intensity was rescaled to set a uniform maximum intensity for all the data sets.

To perform measurements on the cervix in a symmetric fashion, a second volume data set was created.