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# Reproducibility and interoperator reliability of obtaining images and measurements of the cervix and uterus with brachytherapy treatment applicators *in situ* using transabdominal ultrasound

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**ABSTRACT**

**PURPOSE:** To validate interoperator reliability of brachytherapy radiation therapists (RTs) in obtaining an ultrasound image and measuring the cervix and uterine dimensions using transabdominal ultrasound.

**METHODS AND MATERIALS:** Patients who underwent MRI with applicators *in situ* after the first insertion were included in the study. Imaging was performed by three RTs (RT1, RT2, and RT3) with varying degrees of ultrasound experience. All RTs were required to obtain a longitudinal planning image depicting the applicator in the uterine canal and measure the cervix and uterus. The MRI scan, taken 1 hour after the ultrasound, was used as the reference standard against which all measurements were compared. Measurements were analyzed with intraclass correlation coefficient and Bland–Altman plots.

**RESULTS:** All RTs were able to obtain a suitable longitudinal image for each patient in the study. Mean differences (SD) between MRI and ultrasound measurements obtained by RTs ranged from 3.5 (3.6) to 4.4 (4.23) mm and 0 (3.0) to 0.9 (2.5) mm on the anterior and posterior surface of the cervix, respectively. Intraclass correlation coefficient for absolute agreement between MRI and RTs was >0.9 for all posterior measurement points in the cervix and ranged from 0.41 to 0.92 on the anterior surface. Measurements were not statistically different between RTs at any measurement point.

**CONCLUSIONS:** RTs with variable training attained high levels of interoperator reliability when using transabdominal ultrasound to obtain images and measurements of the uterus and cervix with brachytherapy applicators *in situ*. Access to training and use of a well-defined protocol assist in achieving these high levels of reliability. 

*Keywords:* Brachytherapy; Cervix cancer; Ultrasound; Reliability

## Introduction

The use of ultrasound to guide applicator insertion in the treatment of cervix cancer with brachytherapy is increasing around the world. Patterns of care studies indicate that ultrasound is available in more than 50% of radiotherapy departments in the United States, Canada and parts of Europe, and to a lesser extent Latin America (1–4). In a recent survey of Australia and New Zealand, ultrasound was identified as being used to guide applicator insertion in 74% of brachytherapy departments (5). Although ultrasound is heralded for its ready access and relative low cost,

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a number of factors that enhance its appeal also confound use. Ultrasound is perceived as being easy to use. It is possible to obtain an image immediately if a transducer is placed against the skin. However, understanding that image can be difficult and lack of understanding can quickly dissuade use. Because of easy availability and portability, ultrasound use in radiotherapy is often delegated to radiation oncologists (ROs) and radiation therapists (RTs) who have no formal education or training in its use (6). Ultrasound is an operator-dependent imaging modality so it is important to ensure adequate education, training, and scanning protocols are provided to optimize use and limit interoperator variability (7–9). In our department, ultrasound is used to guide insertion of brachytherapy applicators into the uterine canal, verify applicator placement, verify cervix and uterine dimensions, and plan treatment. RTs primarily perform the ultrasound imaging and, together with ROs, view and interpret the images for applicator insertion and planning decisions. To adequately perform and interpret ultrasound in brachytherapy, users are required to be familiar with anatomy, ultrasound theory and practice, and applicator construction, Fig. 1. These requirements are built into a detailed protocol that is followed at our institution, Table 1. As part of our quality assurance program, we validated the reproducibility and interoperator reliability of brachytherapy RTs in obtaining the ultrasound image and measuring the cervix and uterine dimensions using transabdominal ultrasound.

## Methods and materials

### *Study population*

The study consisted of patients who presented for curative intent brachytherapy for cervix cancer between May 2013 and October 2013 and who underwent MRI with applicators *in situ* after the first insertion. Data obtained from patients were part of a hospital-based quality assurance program and audit.

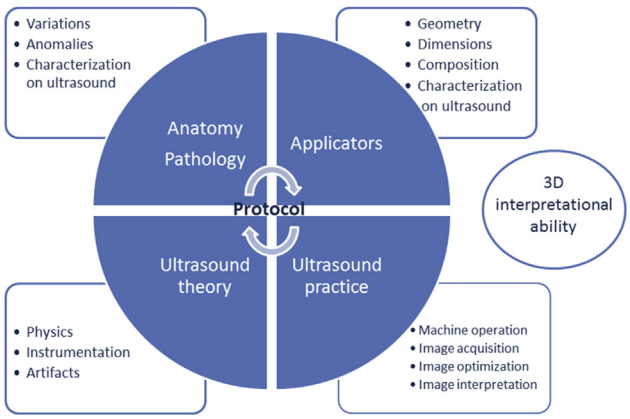


Fig. 1. Knowledge requirements for using transabdominal ultrasound in brachytherapy.

Table 1
Protocol for use of transabdominal ultrasound during gynecologic brachytherapy

| Protocol elements |
|---|
| Patient preparation: fasting, empty bowel, and bladder filling |
| Sufficient coupling medium (gel) used |
| Bladder covers fundus of uterus |
| Bladder does not compress anterior uterine wall |
| Volume scan undertaken in longitudinal and transverse directions to confirm location of cervix uterus and vagina |
| Assess cervix, uterus, parametria, and adnexa |
| Uterus, cervix, and vagina identified on longitudinal and transverse view |
| Uterine canal identified on longitudinal view |
| Applicator inserted under ultrasound guidance and watched on screen |
| Applicator identified on longitudinal and transverse views |
| Patient placed in treatment position |
| Applicator position optimized in uterus and cervix on longitudinal and transverse views |
| Ovoid separation confirmed on transverse view |
| Applicator imaged perpendicular to ultrasound beam |
| Whole applicator viewed in longitudinal view |
| Applicator length confirmed with digital calipers |
| Anterior and posterior cervix and uterine walls visible |
| Anterior and posterior wall of cervix and uterus measured in direction of ultrasound propagation |
| Image acquisition and measurements repeated to confirm orientation and dimensions |
| Image optimized throughout procedure with respect to frequency, depth, focus, gain, TGC, probe position, and probe pressure |
| Gel refreshed throughout procedure |
| Images periodically saved and appropriately annotated throughout procedure |
| All measurements saved on image, recorded on hard copy, and compared with any previous MRI and ultrasound measurements |
| All MRI and ultrasound measurements entered into gynae unit database for assessment, verification, and audit |
| Ongoing credentialing of RT sonographers and peer-to-peer review |

TGC = time gain compensation; RT = radiation therapist.

### *Interoperator reliability and reproducibility analysis*

Three RT sonographers were recruited to participate in the study. All three had to be present at the first brachytherapy insertion to obtain images and measurements on the same patients in the same clinical setting. RTs were designated as RT1, RT2, or RT3. RT1 had postgraduate qualifications in ultrasound and more than 10 years clinical experience in brachytherapy; RT2 received on the job training in ultrasound and had more than 7 years clinical experience in brachytherapy; RT3 attended a weekend workshop on ultrasound use in brachytherapy and had 10 months clinical experience in brachytherapy at the time of the study.

All scans were performed using the Flex Focus 400 ultrasound unit and a transabdominal curved array transducer 8820e, 2.5–6 MHz (BK Medical, Denmark). Only intracavitary applicators were used in this study, standard CT/MR tandem and ovoids and Vaginal CT/MR tandem and cylinder (Elekta, Nucletron, Veenendaal, The Netherlands).