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Permanent prostate brachytherapy pubic arch evaluation with diagnostic MRI

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ABSTRACT

PURPOSE: Pubic arch interference (PAI), when it occurs, is often a limiting factor for patients pursuing brachytherapy treatment of prostate cancer. Pre-brachytherapy pubic arch evaluation is often performed by CT or transrectal ultrasound (TRUS), but MRI has increasingly replaced these modalities for prostate cancer evaluation. The purpose of this study was to determine if staging MRI could be used to evaluate PAI and compare it with these other imaging methods.

METHODS AND MATERIALS: Forty-one consecutive patients undergoing brachytherapy evaluation had pelvic MRI-, CT-, and TRUS-based brachytherapy simulation. Pubic arch overlap on T2-weighted MRI and CT was determined by contouring the prostate gland on its largest axial slice and superimposing this contour onto the pubic arch bones. The largest degree of overlap of the prostate gland on MRI and CT was used to predict the existence of PAI as determined by TRUS-based simulation. The correlation between prostate contour overlap was also compared between MRI and CT.

RESULTS: Nineteen patients (48%) exhibited PAI on TRUS brachytherapy simulation evaluation. The average ($\pm$standard error) amount of prostate contour overlap on the pubic arch on CT was 2.9 ± 0.6 mm and on MRI was 2.0 ± 0.6 mm (linear correlation, R, of 0.783, $p < 0.001$). CT and MRI were equally predictive of PAI on TRUS evaluation (area under the curve = 0.75).

CONCLUSION: Pre-brachytherapy pubic arch assessment with diagnostic MRI provides similar predictability of PAI compared with CT, potentially obviating the need for additional pre-brachytherapy CT in the setting of staging MRI.

Keywords: Pubic arch; Brachytherapy; Prostate; MRI

Introduction

Permanent prostate brachytherapy is one treatment option available to men diagnosed with prostate cancer which is able to provide excellent therapeutic outcomes with relatively minimal morbidity (1−3). Unfortunately some men are precluded from this treatment modality secondary to anatomic or patient specific factors such as prostate size or the presence of pubic arch interference (PAI) (4, 5). The assessment for PAI has been traditionally performed before brachytherapy implantation using CT and/or transrectal ultrasound (TRUS) (6, 7). For CT, a common method of PAI determination consists of outlining the prostate on the largest axial slice and superimposing this over the pelvic bones (6). Overlap of the prostate with the pubic rami of ≤1 cm has been proposed as a threshold value suitable for brachytherapy consideration (8). These methods are generally able to provide an approximate assessment of PAI before brachytherapy implantation but can be subject to operator variability and often require additional testing/procedures in addition to the routine staging and workup for prostate cancer in the modern era.

In recent years, MRI of the pelvis has often replaced CT as the modality of choice for imaging of the prostate and

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seminal vesicles because of its improved soft tissue delineation and improvements in MRI capabilities over the past decade. MRI is able to provide good sensitivity and specificity for detection of extracapsular extension or seminal vesicle involvement especially with using multiparametric MRI (9, 10), which can lead to altered treatment recommendations especially with regard to brachytherapy candidacy. The use of MRI in the pre-prostatectomy setting has been an area of active on-going research and implementation (11), but its routine clinical adoption in permanent prostate brachytherapy outside staging purposes remains limited (12). The purpose of this study was, therefore, to investigate whether diagnostic MRI performed for the staging of prostate cancer is able to predict PAI in patients being considered for permanent prostate brachytherapy and compare these MRI results to traditional CT- and TRUS-based methods.

Methods and materials

Forty-one consecutive patients' charts being considered for brachytherapy at our institution received staging MRI, pre-brachytherapy CT, and TRUS-based simulation. Clinical information, such as demographics, prostate cancer stage, prostate gland size on TRUS, and imaging data, were collected. All patients underwent pelvic MRI with a T2-weighted sequence with endorectal coil (inflated to 30−60 cubic centimeters) as part of their cancer staging. Patients are considered eligible at our institution for permanent prostate brachytherapy monotherapy if they have low-to-intermediate prostate cancer with prostate specific antigen <10 and can be considered for permanent prostate brachytherapy boost along with external beam radiation for high-risk prostate cancer. Before brachytherapy implantation, all potential candidate patients also underwent a CT scan in the supine position and TRUS evaluation in the dorsal lithotomy position for assessment of PAI.

TRUS evaluation for PAI consisted of performing a simulated brachytherapy implant, which is part of routine clinical practice at our institution. Specifically, patients were placed in the dorsal lithotomy position with ultrasound probe inserted into the rectum. The base of the prostate was identified on TRUS by the treating Radiation Oncologist, and the ultrasound (US) probe was moved inferiorly in 5-mm slices until the largest axial image of the prostate was obtained. Brachytherapy needle grid positions were aligned with rectal ultrasound probe and the center of the prostate gland. A stylet was then passed through all brachytherapy needle grid positions around the perimeter of the prostate as determined on ultrasound. The stylet was used to identify positions on the patient's perineum consistent with each grid position. The physician assessed for the presence of PAI at each of these positions using palpation, evaluating bone vs. soft tissue. PAI was ultimately determined by the presence of bone at any of these grid positions that could preclude brachytherapy needle access.

CT and MRI evaluation for PAI consisted of contouring the prostate at its largest extent on axial CT/MRI scan slices and superimposing this contour to the level of the patients' pubic bones. Evaluation of US prostate contour overlap was performed in a similar manner to CT and MRI on the 71% of patients in this cohort with archived US imaging; however, US assessment was performed with the patient in the dorsal lithotomy position as described during the TRUS simulation procedure. The largest amount of overlap of the prostate contour and the pubic arch was taken at a right angle to the pubic rami (Fig. 1). All contouring and PAI assessment of US, CT, and MRI were performed in MIM (MIM Software Inc, Cleveland, OH). The amount of pubic arch overlap was compared between the imaging modalities, and they were compared with the definition of PAI through the simulated brachytherapy implant using TRUS. A student's t test was used to determine if the amount of prostate contour overlap was different between CT and MRI, and logistic regression was used to test if US, CT, or MRI prostate contour pubic arch overlap was a significant predictor of PAI via TRUS-based simulation. Linear correlations between CT and MRI prostate contour pubic arch overlap were also performed. SPSS, version 23 (IBM, Armonk, NY), was used for all statistical analyses with two-sided p-values <0.05 considered statistically significant.

Results

The average age for patients at the time of brachytherapy evaluation was 66 years old. All patients but one were classified as having intermediate-risk prostate cancer. The patient with high-risk prostate cancer was evaluated for brachytherapy implant in addition to external beam radiation. The average prostate size (±standard error) on pre-brachytherapy ultrasound was 32.6 ± 2.33 mL. Full details of patient characteristics are summarized in Table 1.

Nineteen patients (46%) exhibited evidence of some PAI on TRUS-based brachytherapy simulation procedure. The amounts of overlap of the prostate contour from the largest axial prostate slice for CT, MRI, and US are depicted for all patients in Fig. 2. The average (±standard error) amount of prostate contour overlap on CT was 2.9 ± 0.6 mm and on MRI was 2.0 ± 0.6 mm. These values were not statistically different between the two modalities ($p = 0.29$); 30 patients (75%) had larger values of prostate contour pubic arch overlap on CT compared with MRI. In contrast, the average (±standard error) of prostate contour overlap with the pubic arch on US was −0.6 ± 0.5 mm, which was significantly different than both CT and MRI ($p < 0.06$).

CT and MRI were equally predictive of PAI on receiver operating characteristic curve analysis with areas under the curve (AUCs) of 0.746 and 0.749, respectively, and both were slightly more predictive than US-based prostate contour projection onto the pubic arch (AUC of 0.713). Using a cutoff of 0 mm of prostate contour overlap with the US