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Technical Note

A novel urethral sparing technique for high-dose-rate prostate brachytherapy after transurethral resection of the prostate

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ABSTRACT

PURPOSE: The purpose of this study was to assess retrospectively the variability of the urethral dose optimized using a Foley catheter versus urethral contrast injected using a new modified triple-lumen catheter, in CT-based high-dose-rate (HDR) prostate brachytherapy of posttransurethral resection of prostate (TURP) patients.

METHODS AND MATERIALS: At our institution, there were six post-TURP patients with prostate carcinoma between July 2014 and April 2016 who underwent transperineal interstitial HDR brachytherapy (16 needles). A custom modified triple-lumen catheter was placed to inject contrast into the TURP defect. Three-dimensional optimal plans using inverse planning simulated annealing algorithm was generated according to radiation therapy oncology group dose requirements. Alternative plans were retroactively generated for comparison using standard technique based on a Foley catheter as a urethral constraint volume for each patient with the same weighting factors. We compared the dosimetry parameters in each planning using Wilcoxon's ranked sum nonparametric test.

RESULTS: The median followup of all patients was 17.5 months. No significant genitourinary or gastrointestinal toxicity was noted using this technique. In the dosimetric analysis, the prostate V_{100} values and TURP urethral V_{100} were significantly different between plans with and without the contrast (V_{100} [mean]: 92.4 [%] vs. 94.4 [%], $p = 0.046$; TURP UV_{100} [mean]: 1.4 cc vs. 2.2 cc, $p = 0.028$). There were no statistical differences in the mean values of planning target volume V_{150}%, V_{200}%, and D_{90}, and each bladder V_{75} and rectum V_{75}.

CONCLUSIONS: Post-TURP HDR brachytherapy with urethral contrast showed significantly more volume effect of the TURP defect than that with a Foley catheter alone. Better visualization of the TURP defect should lead to more accurate urethral sparing administration of HDR brachytherapy which is necessary to prevent urethral complication.

Keywords: Brachytherapy; HDR; Prostate; TURP; Urinary catheter

Introduction

High-dose-rate (HDR) brachytherapy is a treatment option as monotherapy for low to favorable intermediate-risk prostate cancer and as a dose-escalated boost for patients with unfavorable intermediate to high-risk prostate cancer (1). Excellent clinical outcomes have been documented with HDR brachytherapy. Five-year biochemical progression-free survival ranging from 85% to 100% for HDR brachytherapy monotherapy has been reported in multiple prospective single institutional studies. In addition, 5-year biochemical progression-free survival of 75% has been observed in clinical studies using HDR brachytherapy boost.

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Benign prostatic hyperplasia is the most common cause of lower urinary tract symptoms and affects up to 40−50% of men. Transurethral resection of the prostate (TURP) is used to treat symptomatic bladder outflow obstruction secondary to benign prostatic hyperplasia. Patients may be diagnosed with prostate cancer from TURP chips or several years after the procedure. Although HDR brachytherapy is an effective therapy for localized prostate cancer, the American Brachytherapy Society Consensus Guidelines has indicated that a prior TURP is a relative contraindication for HDR brachytherapy (2) due to increased risk of subsequent urinary tract symptoms, especially with incontinence. Previous studies have suggested a high rate of treatment-related morbidity in 17−83% of patients undergoing brachytherapy after a TURP. Demanes *et al.* (3) reported a 44.4%, 38.9%, 5.6% rate of Grade 2, 3, and 4 toxicities, respectively, in 36 patients who had undergone a prior TURP procedure before HDR brachytherapy and recommended that prior TURP is a contraindication for HDR brachytherapy.

Multiple studies have correlated increasing urethral dose with urinary toxicity after brachytherapy (4, 5). Therefore, accurate delineation of the urethra is important to avoid excessive urethral dose in HDR treatment planning. Our clinic follows the radiation therapy oncology group (RTOG) 0321 protocol for contouring of the urethral volume which recommends that the urethra be contoured based on the outer surface of the urinary catheter (6). Because post-TURP defect come in all different shapes and sizes, as is evident on cystoscopy (Fig. 1) and the urinary catheter does not conform to the shape of post-TURP urethral anatomy, an urinary catheter is not adequate surrogate to define the post-TURP urethral anatomy. The inability to accurately visualize and delineate the TURP defect and urethra may lead to underestimation of the urethral dose during image-guided HDR treatment planning.

Our group has developed a method to visualize the post-TURP defect and urethral anatomy on the HDR treatment planning CT. With this method, a CT-imaging contrast agent is injected into the urethra directly using a modified triple-lumen catheter. The contrast agent fills the TURP defect to allow for visualization of the TURP defect and urethral anatomy. This, in turn, allows for dose optimization to the prostate while minimizing dose to the urethra. In the current study, the dosimetry based on using the urinary catheter alone "conventional" to delineate the urethra will be compared to that of the "contrast-enhanced" approach with the modified triple-lumen catheter. The hypothesis of the study is improved visualization of the TURP defect and urethra using the contrast-enhanced approach that will improve treatment planning dosimetry when compared to the conventional approach.

Methods and materials

Catheter modification for injection of urethral contrast

Prior to the HDR procedure, the triple-lumen catheter is selected based on the size of the patient's urethra. The triple-lumen catheter is modified as follows: (*1*) identify the third lumen of the catheter; (*2*) introduce a stiff obturator into the third lumen through the eyelet to visualize the entire length of the third lumen to 1−1.5 cm proximal to the balloon; (*3*) cut a 0.5-cm opening on the outer wall of the third lumen using a scalpel or scissors; (*4*) tie off the distal end of the third lumen with a 0-silk suture; (*5*) confirm that the balloon is still intact by inflating and checking for leakage. Figure 2 shows the final modified catheter. The catheter is then placed during the implant procedure. Then, immediately before acquisition of the treatment planning CT scan, 5 cc of contrast is injected in the third lumen into the urethra. This contrast will fill the urethra and the TURP defect through the opening in the third lumen of the catheter created from Step 3.

CT-based planning for prostate HDR brachytherapy after TURP

Six patients with prostate carcinoma and previous TURP between July 2014 and April 2016 underwent transperineal

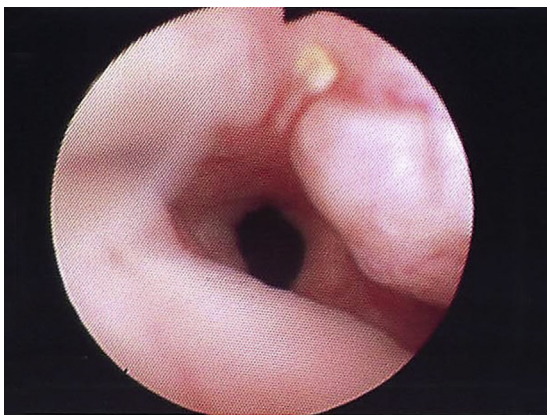

Fig. 1. Cystoscopy image urethra of a representative patient with TURP. It shows the complex shape created by the TURP defects. TURP = transurethral resection of prostate.

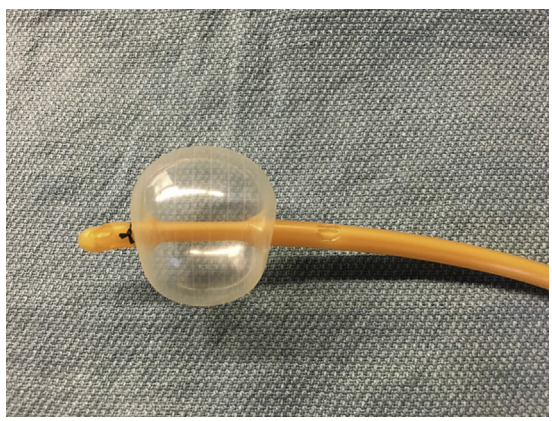

Fig. 2. An image of the modified catheter with inflated balloon.