ELSEVIER

Brachytherapy 11 (2012) 176–180

BRACHYTHERAPY

Three-dimensional image-based high-dose-rate interstitial brachytherapy for vaginal cancer

Sushil Beriwal[1,*], Jean-Claude M. Rwigema[1], Emma Higgins[1], Hayeon Kim[1], Chris Houser[1], Paniti Sukumvanich[2], Alexander Olawaiye[2], Scott Richard[2], Joseph L. Kelley[2], Robert P. Edwards[2], Thomas C. Krivak[2]

[1]*Department of Radiation Oncology, University of Pittsburgh Cancer Institute, Pittsburgh, PA*
[2]*Department of Gynecologic Oncology, University of Pittsburgh Cancer Institute, Pittsburgh, PA*

ABSTRACT

PURPOSE: To evaluate dosimetric and clinical outcomes of three-dimensional (3D) image–based high-dose-rate (HDR) interstitial brachytherapy (HDRB) in patients with vaginal cancers.

METHODS AND MATERIALS: Thirty patients with vaginal cancers were treated with HDRB using Syed-Neblett template. CT scan was done after placement of needles for confirmation of placement and treatment planning. The target volume and organs at risk, including clinical target volume (CTV), rectum, bladder, and sigmoid colon, were contoured on CT scans. Twenty-eight (93.3%) patients received external beam radiation therapy at a median 45 (24.0–50.4) Gy in 12–28 fractions, followed by HDRB at 3.75–5.0 Gy per fraction in five fractions. Total doses for CTV and organs at risk from external beam radiation therapy and HDRB were summated and normalized to a biologically equivalent dose of 2 Gy per fraction.

RESULTS: Seventeen patients (56.7%) with primary vaginal cancer and 13 patients (43.3%) with recurrent vaginal cancers were treated with 3D HDRB. The mean CTV was 39.3 ± 25.7 cm^3, and the median tumor diameter was 3.3 (1.3–8.0) cm. The median biologically equivalent dose of 2 Gy per fraction for 2 cc of bladder, rectum, and sigmoid was 55.0, 56.3, 50.0 Gy, respectively. The median D_{90} for high-risk CTV was 74.3 (36.3–81.1) Gy. The mean volume receiving 100%, 150%, and 200% of prescribed dose was $90.7 \pm 10.0\%$, $41.3 \pm 14.6\%$, and $17.7 \pm 8.3\%$, respectively. With a median followup of 16.7 months, the respective 1-/2-year locoregional and overall survival rates were 84.4%/78.8% and 82.1%/70.2%, respectively. There were no Grade ≥3 gastrointestinal complications. Late complications of Grade 3 vaginal ulceration and Grade 4 vaginal necrosis were seen in two cases.

CONCLUSIONS: Initial results of 3D HDRB using our fractionation schedule in the treatment of vaginal cancers showed good local response with acceptable morbidities.

Keywords: Vaginal cancer; Interstitial brachytherapy; 3D HDR; High dose rate

Introduction

Primary or recurrent disease in the vagina from cervical, endometrial, or vaginal cancers is relatively uncommon (1–4). The initial tumor volume, location, regional lymph node spread, and previous treatment are important prognostic factors (5–7). Cancers involving the vagina are usually not amenable to curative organ-sparing surgery because of the proximity of the tumor to the rectum, bladder, urethra, and pelvic side wall. Radiation therapy is currently the most widely used and effective primary treatment for patients with invasive vaginal cancers, and it may include external beam radiation therapy (EBRT), brachytherapy, or both.

The brachytherapy technique may be either intracavitary or interstitial depending on extent, thickness, location, and the morphology of the disease (8–11). Lesions that are ≤0.5-cm thick on presentation may be treated with

Received 23 February 2011; received in revised form 16 May 2011; accepted 18 May 2011.

Conflicts of interest notification: The authors state that they have no conflicts of interest.

* Corresponding author. Department of Radiation Oncology, Magee-Womens Hospital, 300 Halket Street, Pittsburgh, PA 15213. Tel.: +412-641-4600; fax: +412-641-1971.

E-mail address: beriwals@upmc.edu (S. Beriwal).

1538-4721/$ - see front matter
doi:10.1016/j.brachy.2011.05.005

intracavitary brachytherapy, whereas the remainder of cases are typically treated with interstitial brachytherapy. High-dose-rate (HDR) interstitial brachytherapy (HDRB) has potential advantages over low-dose-rate brachytherapy (LDRB) by limiting exposure to caregivers and visitors as well as the ability to optimize the dose distribution (12, 13).

Because of the rarity of this disease, there are currently limited data on HDRB and no consensus on optimal fractionation schedule. There have been no prospective randomized trials evaluating this subject. Single-institutional studies have shown the long-term efficacy of radiation therapy for both primary and recurrent vaginal cancers (14–16). We have previously reported early results in patients with vaginal cancers treated with HDRB, which demonstrated the feasibility and safety of this technique (17, 18). We herein report clinical outcomes of HDRB for vaginal cancer using our fractionation schedule optimized with three-dimensional (3D) image–based treatment planning. Furthermore, we evaluated dosimetric results of HDRB in this setting.

Methods and materials

Between February 2000 and August 2010, 30 patients (median age, 66 [44–89] years) with vaginal cancer or recurrent gynecologic cancer to the vagina were treated with HDRB using Syed-Neblett template. Location of disease was upper ($n = 11$), middle ($n = 3$), lower ($n = 13$), and entire length ($n = 3$). Twenty-eight (93.3%) patients received EBRT at a median 45 (24.0–50.4) Gy in 12–28 fractions before interstitial brachytherapy. Sixteen patients (53.3%) (primary [$n = 11$] and recurrent [$n = 5$]) had concurrent chemotherapy with weekly cisplatinum at 40 mg/m^2. Two patients did not receive any EBRT because of previous radiation, whereas 3 patients received lower dose of EBRT because of previous radiotherapy. Brachytherapy procedure was done after completion of EBRT under general anesthesia with epidural catheter placed for analgesia. Gold seeds were inserted to demarcate residual disease extent. Syed-Neblett template was used in the placement. For apical lesions, laparoscopic guidance was used for the placement. Initially in the study, stainless steel needles (17 Ga) were used, but since 2008 we have been using titanium–zirconium (15 Ga) needles. CT scan was done after placement of needles for confirmation of placement and treatment planning. Diluted contrast of 40–60 cc was inserted into rectosigmoid and bladder for help in contouring of these organs. The needle positions were adjusted on the scanner under epidural analgesia. The needles into the bladder, urethra, and rectosigmoid were either removed or not loaded with radiation source at those positions. Nucletron PLATO Brachytherapy planning system (versions 14.2–3; Nucletron B.V., Veenendaal, The Netherlands) was used for generating 3D HDR treatment planning. The target volume and organs at risk (OARs), including clinical target volume (CTV), rectum, bladder, and sigmoid colon, were contoured on the CT scan images

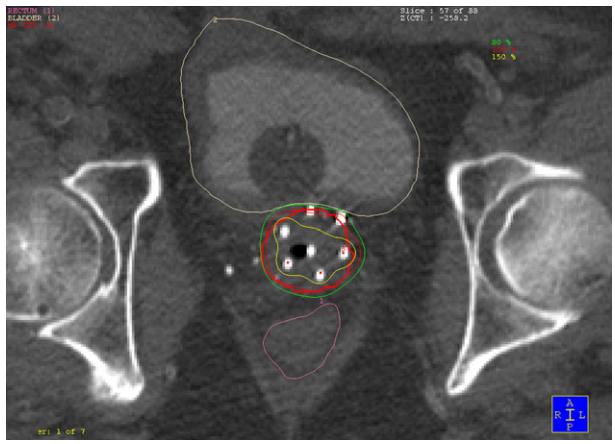

Fig. 1. The clinical target volume (red) involving vaginal apex covered with 100% isodose line (green).

(see Fig. 1). The target volume was defined by the combination of information, including pretreatment MRI scan, positron emission tomography (PET) scan, and clinical findings. Overall, the prescribed dose was 3.75–5.0 Gy per fraction for a total of five fractions twice daily. Initially, patients were treated with 3.75 Gy per fraction using CT-based treatment planning only but only point-based optimization with assessment of coverage of CTV by isodose lines and trying to limit rectal and bladder point dose to less than 80% of prescribed dose. Since 2005, we started using volume-based optimization and increased dose per fraction to 4–5 Gy per fraction based on volume of disease. The goal was to deliver biologically equivalent dose of 2 Gy per fraction (EQD_2) of 70–80 Gy to CTV and limiting dose to 2 cc of rectum and sigmoid to ≤70 Gy and bladder to ≤85 Gy. Manual and graphical optimization was used for optimization. For these patients previously established, dosimetric indices were used to assess the quality of interstitial implant using HDRB. These were conformality index (COIN), homogeneity index (HI), and overdose volume index (OI) (19).

Total doses for CTV and OARs, including rectum, bladder, and sigmoid colon, from EBRT and brachytherapy were summated and normalized to an EQD_2 (20). An α:β ratio of 3 was used for normal tissues ($Gy_{\alpha/\beta 3}$) and 10 for tumor ($Gy_{\alpha/\beta 10}$). At 3 months post-therapy, early response was assessed with clinical examination and/or PET/CT imaging. Kaplan–Meier survival analyses were used to estimate locoregional (LC), and overall survival (OS) rates. All statistical analyses were performed using SPSS version 17.0 (SPSS Inc., Chicago, IL).

Results

Seventeen patients (56.7%) with primary vaginal cancer (Stages I [$n = 2$], II [$n = 9$], III [$n = 5$], and IVA [$n = 1$]) and 13 patients (43.3%) with recurrent gynecologic malignancies to the vagina (cervical = 4; endometrial = 7;