ELSEVIER

Brachytherapy ■ (2013) ■

BRACHYTHERAPY

Dosimetric and clinical outcome in image-based high-dose-rate interstitial brachytherapy for anal cancer

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ABSTRACT

PURPOSE: To evaluate dosimetric and clinical outcome in patients of anal cancer treated with image-based interstitial high-dose-rate brachytherapy following chemoradiation.

METHODS AND MATERIALS: Sixteen patients with anal cancer were treated with chemoradiation followed by brachytherapy boost with image-based high-dose-rate interstitial brachytherapy from January 2007 to June 2011. Two brachytherapy dose schedules were used: 21 Gy in seven fractions and 18 Gy in six fractions depending on response to chemoradiation. CT scan was done after placement of needles for confirmation of placement and treatment planning. Target volume was contoured on CT scans. Volumetric quality indices and dose parameters were calculated.

RESULTS: The mean clinical target volume was 17.7 ± 4.98 cm^3, and the median overall tumor size was 4.2 cm (3.4−5 cm). The mean values of coverage index, dose homogeneity index, overdose volume index, dose non-uniformity ratio, and conformal index were 0.94, 0.83, 0.21, 0.37, and 0.88, respectively. With a median followup of 41 months (range, 20−67.2 months), preservation of the anal sphincter was achieved in 14 patients. The 1- and 2-year local control rates were 93.8% and 87.5%, respectively. Treatment was well tolerated and none of the patients developed Grade 3 or higher late toxicity.

CONCLUSIONS: The combination of external beam radiotherapy with interstitial brachytherapy increases the dose to the tumor volume and limits the volume of irradiated normal tissue, thereby decreasing late toxicity. The use of image-based treatment planning provides better dose conformality with reduced toxicity and helps to prevent a geographic miss.

Keywords: Anal cancer; High dose rate; Image based; Interstitial brachytherapy; Quality indices

Introduction

The management of anal cancer has undergone an interesting and tremendous transformation over the last three decades. Definitive chemoradiation is now the standard first-line treatment for anal carcinoma. Brachytherapy has been shown to be a component of treatment in these patients. The combination of external beam radiotherapy (EBRT) with interstitial brachytherapy increases the dose to the tumor volume and simultaneously limits the volume of irradiated normal tissue, thereby decreasing late toxicity.

There is very limited data on brachytherapy for anal cancer. Although high-dose-rate (HDR) brachytherapy is widely available, the published data on this technique for anal cancer treatment are limited. New tools for plan evaluation such as three-dimensional (3D) visualization and volumetric parameters calculated from the dose-volume histograms (DVHs) are now available in the modern treatment planning systems. DVHs can provide data about volumes or volume elements receiving a particular dose, along with quantitative parameters that can be derived so as to characterize the dose uniformity and conformality. Several volumetric irradiation indices quantifying the homogeneity of dose distribution have been formulated and applied to assessment of interstitial implants (1, 2).

Received 15 February 2013; received in revised form 28 May 2013; accepted 23 September 2013.

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1538-4721/$ - see front matter
http://dx.doi.org/10.1016/j.brachy.2013.09.006

The present article details a single institution's experience of 16 patients of anal cancer treated with concomitant chemoradiation followed by image-based HDR interstitial brachytherapy. This study was done to evaluate clinical outcome and toxicity and also to perform dosimetric analysis using various volumetric quality indices. To the best of our knowledge, this is the only study of its kind in anal cancer treatment.

Methods and materials

This is a retrospective study of 16 patients of anal cancer treated with concomitant chemoradiation followed by image-based interstitial HDR brachytherapy at our institute from January 2007 to June 2011. Diagnosis was established by biopsy. All patients underwent clinical examination and a CT scan for disease extent and assessment of lymph node involvement. Tumors were classified according to the 2002 staging system of the American Joint Committee on Cancer (3).

Treatment

External beam irradiation

All patients were treated with concomitant chemoradiation. CT-based treatment planning was performed for all patients. All patients underwent a planning CT scan in the treatment position on Light Speed VFX-16 CT simulator (GE Medical Systems, Waukesha, WI). EBRT was given as 3D conformal radiotherapy using anteroposterior-posteroanterior or multifield techniques. Initial radiation fields were to include the pelvis, anus, perineum, and inguinal nodes, with the superior field border at L5−S1 and the inferior border to include the anus with a minimum margin of 3 cm around the anus and tumor. Dose ranged from 40 to 45 Gy in 20−25 fractions in 4−5 weeks (equivalent dose in 2 Gy [EQD2] ranged from 40 to 44 Gy in 20−25#).

Concomitant chemotherapy

All patients received concomitant chemoradiation; 5-fluorouracil plus cisplatin ($n = 6$), mitomycin C plus 5FU ($n = 10$). Chemotherapy in the cisplatin-based group included cisplatin, 75 mg/m^2 intravenously on Days 1 and 29, and fluorouracil, 1000 mg/m^2/d by continuous infusion on Days 1−4, 29−32. Chemotherapy in the mitomycin-based group included mitomycin, 12 mg/m^2 intravenous bolus on Day 1, and fluorouracil, 1000 mg/m^2/d by continuous infusion on Days 1−4 and 29−32.

Brachytherapy

Brachytherapy procedure was done after completion of EBRT under general anesthesia. Patients were considered eligible for interstitial brachytherapy if they had good general status and good response to radiation (defined as tumor regression more than 50%, tumor involving <2/3 of the anal canal circumference [as ≥2/3 is a contraindication for brachytherapy because of the risk of long-term anal stenosis and decrease in internal anal sphincter function], thickness of lesion not to exceed 1 cm). The procedure was carried out in the lithotomy position. Interstitial brachytherapy was performed using Syed Neblett Classic Multiple use Rectal Template (Best Medical International, Springfield, VA). First, meticulous examination was carried out under general anesthesia to determine the extent of residual tumor. The longitudinal length of tumor along the anorectum, circumferential involvement of lumen, and thickness of tumor were assessed. The circumferential involvement was marked on perianal skin. Needle implantation was performed under general anesthesia using the Syed Neblett rectal template (Best Medical International), which was fixed to the perineum and an intra-anal obturator was inserted to separate the other side of the anal canal, to spare it from irradiation. The needles were placed at least 2 cm beyond the longitudinal length of tumor and 1 cm along the anal verge or lowermost extent of tumor. CT scan was done after placement of needles for confirmation of placement and treatment planning. The target volume was contoured on CT scan images. The target volume was defined by the combination of information, including CT scan and clinical findings. Computerized planning for interstitial HDR brachytherapy was done on Oncentra MasterPlan treatment planning system (Nucletron, an Elekta company [Elekta AB, Stockholm, Sweden]) (Fig. 1). Volume-based optimization was done. The catheter separation was 1 cm and the source step size ranged from 2.5 to 5 mm. The dose per fraction was 300 cGy delivered twice daily with an interfraction interval of 6−8 hours. Two brachytherapy dose schedules were used: 21 Gy in seven fractions ($n = 7$) and 18 Gy in six fractions ($n = 9$) depending on response to EBRT. The biologically effective dose (BED) and the equivalent dose in 2 Gy [EQD2] to the tumor using the

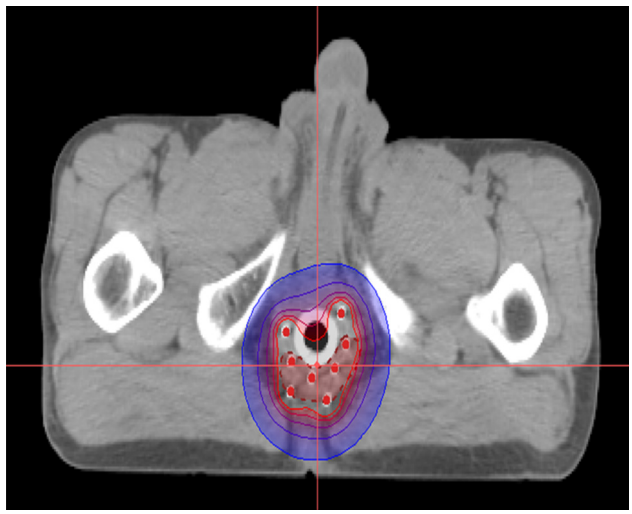

Fig. 1. The clinical target volume (dotted red) covered with 100% isodose line. (For interpretation of the references to color in figure legend, the reader is referred to the web version of this article.)