

The dosimetric impact of single, dual, and triple tandem applicators in the treatment of intact uterine cancer

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ABSTRACT

PURPOSE: To identify an optimal afterloading technique for high-dose-rate brachytherapy treatments in patients with medically inoperable uterine cancer.

METHODS AND MATERIALS: Eighteen treatment plans were generated using point and volume-based techniques for three patients using a single, dual, and triple tandem. Dosimetric parameters of the target and critical structures were evaluated.

RESULTS: Similar target coverage was achieved for each patient using volume-based planning; however, differences were evident when comparing point-based plans for the three applicators. In Patient 1, with a cylindrical uterus (8 cm by 4.5 cm), similar results were achieved with all three applicators (V_{95} [Single] = 90.6%, V_{95} [Dual] = 90.6%, and V_{95} [Triple] = 91.5%). In Patient 2, who had a more spherical uterus (5 cm by 5.4 cm), the dual tandem was inferior to the others (V_{95} = 65.9% vs. 83.7% with triple and 85.8% with single tandem). Analysis of isodose distributions showed that the dual tandem failed to achieve adequate coverage of the central portion of the fundus. In Patient 3, who had a uterus (6 cm by 5.5 cm) in close proximity to the bladder (0.5 cm) and bowel, both the triple and dual tandem point-based plans achieved better coverage than the single tandem, given dose constraints on the bladder and bowel, with uterus V_{95} of 83.4% (Triple), 84.9% (Dual), and 73.7% (Single), respectively.

CONCLUSIONS: For inoperable uterine cancer, optimal high-dose-rate applicator selection depends on the anatomy and location of the uterus and critical organs. The triple tandem applicator provides greater latitude in dose and anatomic uterus coverage as compared with either single or dual tandem applicators. © 2014 American Brachytherapy Society. Published by Elsevier Inc. All rights reserved.

Keywords: Uterine cancer; High-dose-rate; Brachytherapy; Tandem applicator

Introduction

Uterine cancer is the most common malignancy of the female genitourinary tract with an estimated 49,560 new cases and the second leading cause of genitourinary cancer death with 8190 estimated deaths in 2013 (1). The current standard treatment for patients with endometrial cancer is hysterectomy with bilateral salpingo-oophorectomy. However, many of these patients are elderly, obese, and/or have other comorbid conditions making them poor

surgical candidates (2). For these patients, radiation is the only treatment option, which often includes definitive brachytherapy. Unfortunately, there is a lack of consensus regarding which high-dose-rate (HDR) brachytherapy afterloading applicator should be used. Past studies of inoperable uterine cancer treated with HDR brachytherapy have used an assortment of applicators including Heyman capsules (3–6), single tandems (7–11), dual tandems (10–13), triple, or multiple tandem applicators (14, 15). Vendors offer several different applicators and designs, but the decision on which applicator to use is largely dictated by radiation oncologist preference (16).

The American Brachytherapy Society consensus guidelines provide limited information about applicator selection, although they suggest that a single applicator cannot treat all anatomic variants and disease presentations (16). Additionally, it has been suggested that a single tandem is only suitable for small uteri and that dual tandems create

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Table 1

A comparison of reference points and dose–volume parameters based on the point-based treatment plans

Reference points	Single tandem (Gy)			Double tandem (Gy)			Triple tandem (Gy)		
	Pt# 1	Pt# 2	Pt# 3	Pt# 1	Pt# 2	Pt# 3	Pt# 1	Pt# 2	Pt# 3
Point A left	5.9	5.8	5.7	6.1	6.0	6.0	6.0	6.0	6.0
Point A right	6.2	6.1	6.0	6.0	6.0	6.0	6.0	6.0	6.1
ICRU bladder point	6.3	1.1	5.8	6.3	0.8	6.4	6.3	1.3	6.3
ICRU rectum point	6.4	1.0	5.9	6.5	0.8	6.4	6.5	1.2	6.3
<i>V₉₅ CTV (uterus) (%)</i>	90.6	85.8	73.7	90.6	<i>65.9</i>	84.9	91.5	83.7	83.4
<i>D₉₀ CTV (uterus) (%)</i>	95.8	88.3	65.8	95.8	<i>69.1</i>	83.5	97.5	85.4	80.1
<i>D_{2cc} bladder</i>	5.0	2.5	5.9	4.4	1.8	5.1	4.5	3.0	5.4
<i>D_{2cc} rectum</i>	1.5	1.0	2.7	1.6	0.8	3.1	1.6	1.1	3.0
<i>D_{2cc} sigmoid</i>	5.3	5.6	6.0	4.9	3.7	6.1	5.0	4.9	6.3
<i>D_{2cc} left ureter</i>	1.5	0.0	0.0	1.4	0.0	0.0	1.4	0.0	0.0
<i>D_{2cc} right ureter</i>	2.0	0.6	0.0	1.8	0.4	0.0	1.8	0.6	0.0

ICRU = International Commission on Radiation Units and Measurements; CTV = clinical target volume.

Please note that the values in italics show decreased CTV coverage with the use of a single tandem for Patient 3 and double tandem for Patient 2.

an inhomogeneous dose distribution (15). The American Brachytherapy Society also provides HDR dosimetric recommendations but only based on a uterine width of 4 cm (16). Past series have shown that uterine widths exceeding 4 cm result in lower dosing to the prescription point (7). Other studies have shown large variability of uterine size (17, 18), further complicating brachytherapy treatment for this disease site. The present study is the first, which attempts to address which applicator should be used by providing a dosimetric evaluation of single, dual (Y-shaped), and triple tandem applicators in patients with varying anatomy.

Methods and materials

General clinical considerations

In most cases, a medically inoperable patient who has not been surgically staged, undergoes clinical workup including CT abdomen/pelvis and MRI pelvis to better determine the extent of disease. Assuming no distant metastases, these patients are then treated to pelvic lymph nodes and uterus with external beam radiation therapy (EBRT) to a dose of 45–50 Gy. After completion of the external radiation, the patients are taken to the operating room and under general anesthesia, with the assistance of our gynecologic oncologist, the cervix is dilated and the uterus is sounded to determine its length. Using this information, the three tandems are inserted and packing is placed in the vaginal vault to displace the bowel and bladder as well as to keep the applicator in place. Following CT-based planning, the patient's received 4–5 Gy/fraction in 3–4 bi-daily treatment fractions that were scheduled at least 6 hours apart.

Dosimetric case series

Three patients with early-stage medically inoperable endometrial cancer with varying body habitus (body mass index) and uterine size were treated for curative intent using EBRT in addition to Ir-192 HDR brachytherapy at

our institution. All patients underwent a single insertion of a triple tandem applicator (3 channel endometrial applicator, Mick Radio-Nuclear Instruments, Inc., Mount Vernon, NY) under general anesthetic in an operative setting. The applicator was immobilized with gauze, which also helped to displace the organs at risk (bladder and rectum).

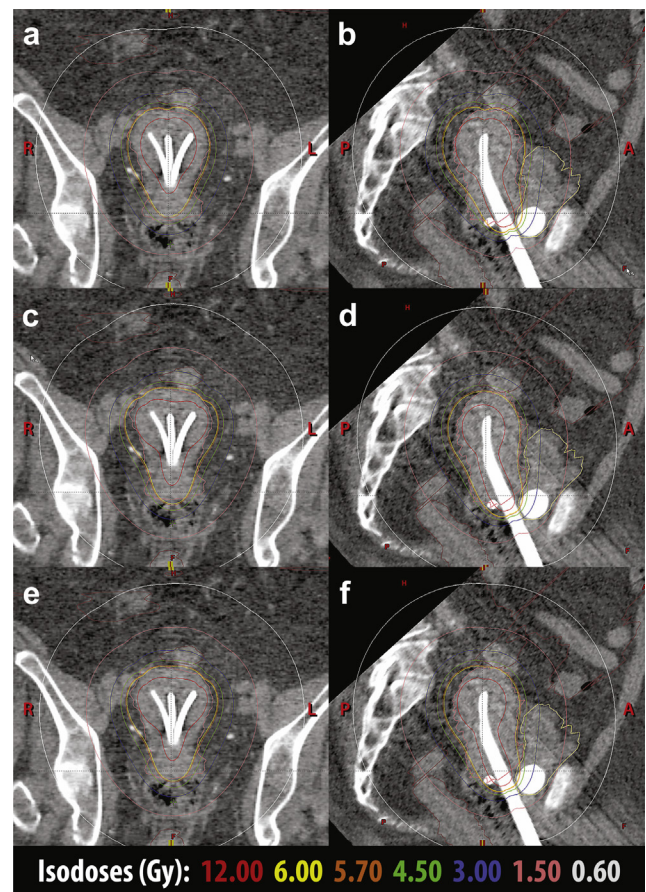


Fig. 1. (a), (c), and (e) Paracoronar and (b), (d), and (f) parasagittal CT images, respectively, through the central tandem for Patient 1 using point-based planning based on a single (a, b), dual (c, d), and triple (e, f) tandem application.

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