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Rectal and bladder dose reduction with the addition of intravaginal balloons to vaginal packing in intracavitary brachytherapy for cervical cancer

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ABSTRACT

PURPOSE: The use of intravaginal Foley balloons in addition to conventional packing during high-dose–rate (HDR) tandem and ovoids intracavitary brachytherapy (ICBT) is a means to improve displacement of organs at risk, thus reducing dose-dependent complications. The goal of this project was to determine the reduction in dose achieved to the bladder and rectum with intravaginal Foley balloons with CT-based planning and to share our packing technique.

METHODS AND MATERIALS: One hundred and six HDR-ICBT procedures performed for 38 patients were analyzed for this report. An uninflated Foley balloon was inserted into the vagina above and below the tandem flange separately and secured in place with vaginal packing. CT images were then obtained with both inflated and deflated Foley balloons. Plan optimization occurred and dose volume histogram data were generated for the bladder and rectum. Maximum dose to 0.1, 1.0, and 2.0 cm^3 volumes for the rectum and bladder were analyzed and compared between inflated and deflated balloons using parametric statistical analysis.

RESULTS: Inflation of intravaginal balloons allowed significant reduction of dose to the bladder and rectum. Amount of reduction was dependent on the anatomy of the patient and the placement of the balloons. Displacement of the organs at risk by the balloons allowed an average of 7.2% reduction in dose to the bladder ($D_{0.1}$ cm^3) and 9.3% to the rectum ($D_{0.1}$ cm^3) with a maximum reduction of 41% and 43%, respectively.

CONCLUSIONS: For patients undergoing HDR-ICBT, a significant dose reduction to the bladder and rectum could be achieved with further displacement of these structures using intravaginal Foley balloons in addition to conventional vaginal packing.

Keywords: Foley balloon catheter; Rectal dose; Bladder dose; Intracavitary balloon; Vaginal packing technique; Intracavitary brachytherapy; High-dose-rate; Cervical cancer

Introduction

Approximately 12,900 new cases of cervical cancer will be diagnosed in the United States in 2015 (1). These numbers have significantly decreased over the last century after the advent of Pap smear testing; however, cases continue to persist especially in high-risk populations. At the University of Texas Health Science Center in San Antonio, we treat a high-risk population of Hispanic women who do not routinely receive Pap smear testing. As a result of a lack of education regarding frequent Pap smear testing and patient funds, this has led to a large number of locally advanced cervical cancer cases. Cervical cancer is treated with both external beam and intracavitary brachytherapy (ICBT). The use of brachytherapy plays an important role in the definitive management and at this time cannot be replaced by current external beam techniques. Brachytherapy is effective because it allows for high doses of radiation at the gross disease with rapid dose fall off beyond the radiation. As the clinical toxicity profiles of high-dose–rate (HDR) ICBT are comparable with low-dose–rate ICBT

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(2, 3), HDR−ICBT continues to gain more acceptance because of less motion of the HDR apparatus, less patient discomfort, and greater patient compliance (4). Nevertheless, the risk of late effect toxicity with any ICBT correlates directly with rectal and bladder doses, and minute variations in position may initiate significant changes in dose to these organs (5, 6). Furthermore, in some patients who are at higher risk of complications, minimizing dose to the rectum and bladder is crucial (7, 8).

Previously, we have experimented with intravaginal Foley balloons in HDR−ICBT using plain film imaging for plan optimization (9). A significant reduction in the dose to the rectum and bladder was achieved without significant reduction of dose to the tumor coverage. These data were determined based on radiographic film planning that was digitized. Isodose calculations were attained using Nucletron Plato Brachytherapy v14.1 treatment planning software (Nucletron, Veenendaal, The Netherlands). Bladder and rectal point doses were assessed using the International Commission of Radiation Units and Measurements #38 report (10). Our goal for the present study was to achieve similar or improved results with CT-based planning and optimization as the current standard form of imaging used in ICBT. This study also looks at specific volumes of each organ receiving high doses based on current GEC-ESTRO (The Groupe Européen de Curiethérapie and European Society for Therapeutic Radiology and Oncology) guidelines (11). We also like to share our technique of vaginal packing with illustrations in this study because detailed references on vaginal packing techniques are lacking in the literature.

Methods and Materials

Following institutional review board approval, 38 consecutive patients were included prospectively during August 2011 to July 2012. Patient consent was obtained for treatment with HDR tandem and ovoids (T&O) brachytherapy after completion of external beam radiation. Each patient was individually assessed and planned following current American Brachytherapy Society HDR recommendations (12, 13). Each brachytherapy procedure occurred under an established conscious sedation protocol using clean procedures. An appropriately sized Fletcher style HDR T&O apparatus (Nucletron, Columbia, MD) was inserted in a conventional manner.

Packing technique

In our technique, we typically used two packs of ½ inch (5 yards) packing gauze (McKesson) per procedure in most cases. They were dampened with betadine, 2% viscous lidocaine, and contrast solution unless contra-indicated because of allergy or sensitivity. A Foley catheter balloon, with the excess tip removed and stitched closed (Fig 1a), was then inserted with rigid guiding wire posterior to the tandem between the ovoids, as near the flange as patient's geometry permitted, to the vaginal apex, anterior to the rectum (Fig. 1b). After placing the uninflated Foley balloon, we began packing at the apex between the Foley balloon and the tandem/flange to displace the rectum posteriorly within the high-dose area and to secure the catheter in place (Fig. 1c). We continued to pack behind and lateral to the ovoids under the tandem without obstructing the view of the flange and ovoids (Fig. 1d). This usually required one pack of gauze. We then used a similar technique to place the second uninflated Foley balloon posterior to the bladder between the ovoids anteriorly atop the flange (Fig. 1e). With the second pack of gauze tied to the first, packing was placed posterior to this balloon and anterior to the tandem next to the flange to displace the bladder anteriorly within the high-dose area (Fig. 1f). We continued to pack atop the ovoids anteriorly and along the T&O apparatus to the introitus without lifting the T&O apparatus followed by the removal of the lighted retractor (Fig. 1g−i). The Foley balloons were properly labeled, and the T&O apparatus was secured with surgical foam tapes with slight cephalic traction to minimize movement (Fig. 1j). The patient was then transported from the procedure table to the CT simulator.

Simulation and planning procedure

At the CT simulator, each intravaginal balloon was inflated with 5−10 cm^3 of saline with diluted contrast based on patient tolerance. We stopped inflation when the patient felt increased pressure or any pain, usually after about 7 cm^3 (most common volume used). Orthogonal scouts were obtained (Fig. 1k−l). The orthogonal projections were used to take into account positional assessment of the Foley balloons. If excessive superior spatial positioning was present, the intravaginal Foley balloons were deflated, retracted, and reinflated to achieve desired critical organ displacement. Once positional accuracy was determined, CT images were obtained with the balloons inflated. Another set of CT images was obtained with the saline removed. The information was then sent over to the Oncentra treatment planning system (Nucletron/Elekta, Veenendaal, The Netherlands). Volumes were contoured included the target volume and the organs at risk (OAR): bladder and rectum. Dose optimization then occurred on each plan with treatment prescribed to Point A defined as a point 2 cm superior to the cervical os along the tandem and 2 cm perpendicular to the tandem. Once optimization had been achieved and approved by the attending physician, rectal and bladder doses were obtained for both the inflated and deflated plans, based on current GEC-ESTRO guidelines. The rectum and bladder doses to 0.1, 1, and 2 cm^3 volumes for each OAR were obtained. A total of 106 plans from 38 patients were used in this study for sufficient power to detect a difference. All bladder and rectal points, both with and without intravaginal Foley balloon inflation,