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Dosimetric analysis of rectal filling on rectal doses during vaginal cuff brachytherapy

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ABSTRACT

PURPOSE: Several studies have analyzed the effect of bladder filling during vaginal cuff brachytherapy (VCB), but the effect of rectum filling has not been studied. We sought to evaluate the effects of rectal volume on rectal doses during postoperative VCB.

METHODS AND MATERIALS: Brachytherapy planning CT scans (334 sets) obtained from 92 consecutive patients treated with VCB were resegmented (bladder and rectum) and replanned retrospectively using the same parameters to homogenize data and improve analysis. Rectal volume and a set of values derived from dose–volume histograms (DVHs) were extracted (maximal dose [D_{max}], $D_{0.1cc}$, D_{1cc}, and D_{2cc}). Univariate and multivariate analyses were carried out to evaluate the association between rectal volume and DVH metrics after adjusting for other clinical factors.

RESULTS: A positive significant correlation was observed between rectal volume correlated and D_{max}, $D_{0.1cc}$, D_{1cc}, and D_{2cc}. Multiple linear regression models found that rectal volume, cylinder angle position, and cylinder diameter variables correlated significantly with the different DVH parameters analyzed. These variables explained the 14.5% and 18% of variance on regression models.

CONCLUSIONS: Larger rectal volumes are associated with higher rectal dose parameters during VCB fractions. Prospective studies are needed to investigate whether these data are linked to differences in rectal toxicity.

Keywords: Endometrial neoplasms; Brachytherapy; Rectum; Dilatation; Dose–volume histogram

Introduction

Vaginal cuff brachytherapy (VCB) is a leading adjuvant treatment modality in the management of gynecologic neoplasms (1). The dosimetric effect of bladder filling on organs at risk (OARs) has been extensively studied (2–4), but there are no similar published studies that have addressed the effect of rectum filling. Ideally, a customized plan is recommended for each fraction (5), but when a fixed geometry is assumed at every insertion, it is acceptable to use only one plan for overall treatment, which is the most common VCB procedure. Corso *et al.* (6) retrospectively analyzed the dosimetric differences between a reimaging and a customized plan at every fraction and the single plan approach for the overall treatment, as well as the economic consequences associated with each approach. Although no statistical dosimetric differences were reported, the reimaging scheme was associated with an excess of $663.06 compared with the single plan approach. Nevertheless, day-to-day variations can limit that assumption. Some of these issues are the dosimetric effects of cylinder tilt (7) or the effect of individualized fraction optimization (8). Differences in bladder filling have been reported to affect

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differences in bladder doses, so it is of interest to analyze whether differences in rectal volume modify rectal doses. An extensive knowledge of every variable that can modify pelvic anatomy and implant relationship, standardizing clinical variables during different applications for the same patient, might improve clinical results over a single plan for overall treatment.

In long-lasting and low-dose-rate treatments, rectal evacuation before brachytherapy is advised. Nevertheless, for high-dose-rate (HDR) gynecologic brachytherapy, there are no clear directions. European Society for Radiotherapy & Oncology–Groupe Européen de Curiethérapie guidelines advise rectal evacuation but without stating why (9), and the American Brachytherapy Society (ABS) guidelines do not make any recommendation at all (5). Rectal volume can be considered a surrogate of the rectal cleaning efficacy; therefore, we sought to investigate the dosimetric effects of rectal volume on rectal doses during VCB in a population treated without rectal enemas before the VCB procedures.

Methods and materials

A retrospective analysis of 92 consecutive patients who underwent fractionated postoperative HDR–VCB. All patients had undergone hysterectomy followed by HDR–VCB alone (37% of patients) or whole pelvic radiation therapy in conjunction with an HDR–VCB boost (63% of patients). Patients' characteristics are shown in Table 1.

Gynecologic patients (85 endometrial cancer patients and 7 cervical cancer patients) were referred for postoperative radiotherapy after an individual multidisciplinary assessment. Patients with endometrial cancer, having intermediate risk of recurrence, received exclusive HDR–VCB, whereas high-risk patients received external irradiation plus an HDR–VCB boost. Cervical cancer patients at high risk were referred for external radiotherapy and HDR–VCB after surgery.

The surgical management of endometrial cancer patients consisted of abdominal hysterectomy (56.5% patients), laparoscopy (31.5%), vaginal hysterectomy (5.4%), and 1 patient had salvage surgery after an endometrial cancer relapse at the vaginal vault. A radical hysterectomy was carried out in 5 cervical cancer patients, and the remaining patient was treated via laparoscopy procedure. All cervical cancer patients and 92.8% of endometrial cancer patients underwent a pelvic lymphadenectomy ± para-aortic lymphadenectomy.

Every patient underwent three to six VCB fractions carried out with the largest diameter cylinder (Nucletron Vaginal Applicator Set #085350, Elekta AB, Stockholm, Sweden) that could fit comfortably inside the vagina, which was then used in subsequent applications, to spare adjacent tissue by exploiting the inverse-square law and to avoid air gaps between the vault cylinder and vaginal mucosa. CT images at every brachytherapy fraction were used to assess the vault cylinder contact with the vaginal cuff mucosa. The cylinders were always positioned so as to remain parallel to the craniocaudal axis of the patient with a fabric strip tied to the waist. The only instruction given to the patients before the procedure was to try to evacuate before coming to the hospital for VBT.

After treatment, the patients were evaluated every 3–4 months for the first 2 years and every 6 months thereafter.

Table 1
Patients' characteristics and treatment details

Characteristics	Endometrium		Cervix	
n	85		7	
Histology, %				
Adenocarcinoma	82.4		0	
Serous	10.6		0	
Squamous	0		85.7	
Other	7.1		14.3	
Stage (FIGO 2009), %				
	Ia	34.5	I	71.4
	Ib	41.7	II	14.3
	II	8.3	III	14.3
	III	15.5		
Grade, %				
1	55.4		16.7	
2	21.7		33.3	
3	22.9		50	
Myometrial invasion, %				
≤50	41.8			
>50	58.2			
Hysterectomy, %				
Abdominal	60.1		71.4	
Laparoscopic	33.8		28.6	
Vaginal	6.3		0	
Irradiation				
EBRT + VCB	60		100	
VCB alone	40		0	
Cylinder diameter (cm)				
2.5	1.09% patients/0.89% fractions			
3	33.7% patients/30.56% fractions			
3.5	65.22% patients/68.55% fractions			
Mean cylinder angle (°)	−2.09			
Mean rectal volume (cm^3)	52.32			
Mean bladder volume (cm^3)	82.64			

FIGO = International Federation of Gynecology and Obstetrics; EBRT = external beam radiotherapy; VCB = vaginal cuff brachytherapy.

CT simulation

Until 2012, it was clinical practice in our department to carry out a CT for each fraction. All patients underwent pelvic CT scans at every brachytherapy fraction, with 2-mm thick slices and no gap between them, in the supine position with a Foley bladder catheter that instilled dilute contrast medium (5 mL of Omnipaque 350 [GE Healthcare Bio-Sciences, S.A.U. La Florida (Madrid), Spain] into 45 mL of saline solution). Rectal contrast medium was instilled at the oncologist's discretion to improve