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Optimization of Fractionated HDR Vaginal Cuff Brachytherapy of Endometrial Cancer by using Multiple Channels Cylinders

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INTRODUCTION

High-intermediate risk Endometrial cancer (EC), often diagnosed in its early stages with the main symptom of postmenopausal vaginal bleeding, mainly relapses at the vaginal cuff after a curative surgery. Results of PORTEC-2 randomized trial (Nout, 2010) have proven that postoperative vaginal cuff brachytherapy (VCB) can reduce the recurrence similar to the external beam radiotherapy (EBRT) but with less grades 1 and 2 GI toxicities. Thus, we choose VCB alone or in combination with EBRT by using multi-channel cylinders (MCC) according to American Brachytherapy Society (ABS) consensus guidelines for adjuvant VCB after hysterectomy (Small Jr, 2012).

However, there are different opinions in the selection of the prescription doses and MCC vs. single channel cylinders (SCC). Also there is lack of comprehensive analysis of the 3D image-guided VCB particularly in consideration of the inter-fractional changes of the high risk CTV (HRCTV) and organs at risk.

AIM

1. To systematically analyze the dose distributions with use of MCC or SCC applicators by consideration of the tumor coverage with the prescription dose (PD) and hotspot doses of D1cc, D2cc, and D10cc of the bladder, recto-sigmoid and vaginal membrane

2. To make recommendation for optimal selections of applicators and prescription by comparing doses to the tumors and organs at risk

METHOD

1. *After each fractional insertion of a MCC with diameter of 2.5, 3.0, or 3.5 cm, a central plus 6 to 8 peripheral channels, 3D CT scans were taken for physicians to delineate HRCTV, recto-sigmoid and bladder. Applicator/packing materials and contrast in OARs were excluded to create HRCTV-app and organ wall by the planning physicists. Hotspot dose of the vaginal mucous membranes is D1cc of HRCTV-app.*
2. *VCB Plans of MCC for 38 EC patients (31 with 6-Gy per fraction for total 122 fractions, 4 with 7-Gy per fraction for 18 fractions, and 3 using cylinder + tandem (C+T) for 6Gy/fx for total 11 fractions) were manually optimized by activating only the central channel for SCC plans (using Oncentra RTPs) for having the similar constrains as that of original MCC plans.*
3. *Compared EQD2s of all ROIs using a LQ model as routine plan evaluation and then reevaluated by a unified model (Li, 2020) for determination of optimal VCB.*

RESULTS

Fig. 1 on the right illustrates the two VCB plans of a patient using 3.0 cm MCC (left panel) or SCC (right panel) with the same HRCTV, HRCTV-App and OARs. The prescription dose is 6-Gy per fraction as yellow thick curves that follows some asymmetric shape of the target (in red) in the MCC plan but not the SCC plan. DVHs of HRCTV does not show the significance of coverage changes from 95% to 99% but there is a significant improvement of the coverage from 86% to 98% of HRCTV-app as the true biological target. The major concern of D10cc to Bladder in MCC plan was maintained in the SCC plan but D2cc and D10cc to the recto-sigmoid were increased by 4% and 7%, respectively. D1cc of HRCTV-app was 167% in MCC plan vs. 133% in the SCC plan.

Table 1 lists the target volumes and some implant information for patients in groups of different applicators. The ratio of HRCTV to the cylinder volume inside the treatment segment and the average depth of HRCTV-app were all calculated based on the general geometric models.

Considering effects of treatment length and cylinder size for traditional 0.5 cm depth prescription using SCC (Li, 2007), we have compared the group mean doses of D90% of HRCTV and HRCTV-App, D2cc and D10cc to the bladder and recto-sigmoid, D10cc of Bladder Wall and D1cc of vaginal membrane in the table 2. All data in red have not met the criteria in our HDR VBT. Although D90% of HRCTV are mostly acceptable, D90% of HRCTV-app in SCC plans are not. D2cc of recto-sigmoid in SCC plan is usually higher than that of MCC plan. D1cc of the vaginal membrane in MCC plans is 20% to 30% higher than that of corresponding SCC plans. The D1cc in the last group occurred at the uterus treated with tandem and it has not in concern for standard Tandem-Ovoid brachytherapy.

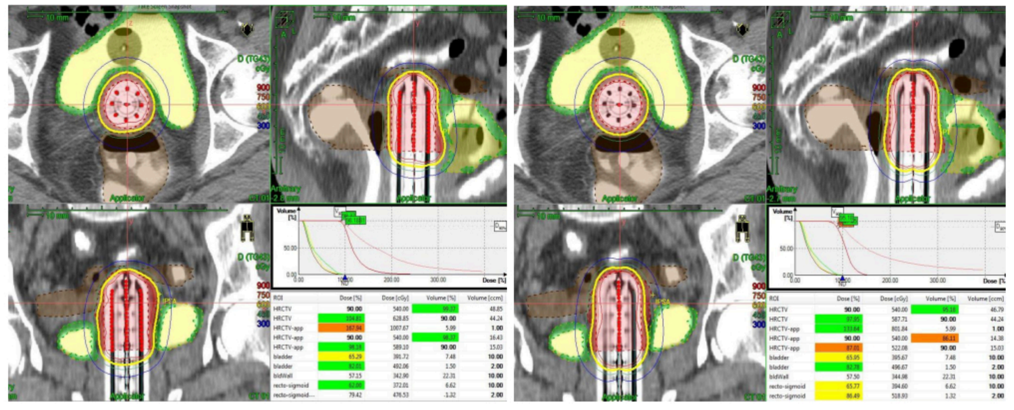

Fig. 1. Comparison of isodose distributions and DVHs between VCB plans using a 3 cm diameter MCC (left panel) or SCC (right panel). Since D10cc of the Bladder is the major concern of planning, similar D10cc in SCC plan is obtained at the SCC plan but only 77% HRCTV-app coverage in comparing with 94% HRCTV-app coverage in the MCC plan. D2cc of recto-sigmoid and bladder as well as the total treatment time were increased. Only advantage of the SCC is the hotspot dose D1cc of vaginal membrane.

Table 1. Characteristics of patients Underwent cylinder-based HDR VCB in the study

Groups	# of Insertions	# of Patient	Length (mm)	HRCTV (cc)	CTV/app. ratio	HRCTV-app (cc)	Treatment depth (mm)
2.5cm Cylinder	15	4	40-80	46.0+/-14.3	1.4+/-0.2	21.2+/-7.5	7.0+/-1.9
3.0cm Cylinder	65	16	40-80	51.9+/-11.1	1.2+/-0.2	21.7+/-5.4	5.6+/-1.9
3.5cm Cylinder	42	11	30-50	61.6+/-11.4	1.1+/-0.2	25.5+/-8.9	5.7+/- 2.3
700cGy	18	4	50	69.1+/-11.9	1.2+/-0.3	29.9+/-9.9	6.8+/- 2.6
2.5/3.0cm C+T	11	3	90-120	51.9+/-20.8	Varaible	29.3+/-13.1	Variable

Table 2. Comparison of Planned Doses using MCC and SCC for the groups of patients listed in Table 1

VCB plan	Mean D90% of HRCTV	Mean D90% of HRCTV-app	Mean D10cc of the Bladder	Mean D2cc of the Bladder	Mean D10cc of Recto-Sigmoid	Mean D2cc of Recto-Sigmoid	Mean D10cc of Bladder Wall	Mean D1cc of the Vagina
2.5cm MCC	614.7	572.1	314.5	435.6	354.1	464.1	232.6	1038.5
2.5cm SCC	590.3	548.8	307.3	429.8	383.2	509.6	234.3	867.1
3.0cm MCC	622.7	576.2	345.7	459.1	350.6	456.9	277.9	990.2
3.0cm SCC	581.3	520.5	359.8	472.3	374.1	499.2	294.9	838.3
3.5cm MCC	628.5	575.2	353.6	456.6	326.4	438.4	281.5	902.4
3.5cm SCC	564.0	496.9	361.9	465.1	337.7	466.9	297.8	724.2
MCC 700cGy	742.3	683.2	426.8	536.8	368.8	504.2	375.9	1270.8
SCC 700cGy	706.7	640.3	437.3	551.1	409.8	576.0	386.1	1087.0
MCC+T	595.5	558.3	364.5	459.5	331.8	445.7	293.7	1314.3
SCC+T	492.3	451.4	335.0	422.6	318.9	429.9	310.0	1193.3

CONCLUSIONS

1. *Our group data approved that by taking account of the D90% of HRCTV-app, MCC are superior to the SCC when dose to vaginal membrane is tolerable.*
2. *Use of HRCTV-app is strongly recommended since we have found significant difference before and after using this true biological target volume.*
3. *We have routinely calculated EQD2 for D90% of HRCTV and HRCTV-app and for hotspot doses of OARs by using the same α/β ratio = 3 Gy for normal tissue and 10 Gy for tumor. Such a calculation for doses of 6 to 12 Gy requires further investigation (Li, 2020).*

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CONTACT INFORMATION

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