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Dosimetric evaluation of image based brachytherapy using tandem ovoid and tandem ring applicators

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ABSTRACT

Aim: The aim of the study is to evaluate the differences in dosimetry between tandem-ovoid and tandem-ring gynaecologic brachytherapy applicators in image based brachytherapy.
Background: Traditionally, tandem ovoid applicators were used to deliver dose to tumor in intracavitary brachytherapy. Tandem-ring, tandem-cylinder and hybrid intracavitary, interstitial applicators are also used nowadays in cervical cancer brachytherapy.
Methods and materials: 100 CT datasets of cervical cancer patients (stage IB2 – IIIB) receiving HDR application (50 tandem-ovoid and 50 tandem-ring) were studied. Brachytherapy was delivered using a CT-MRI compatible tandem-ovoid (50 patients) and a tandem-ring applicator (50 patients). DVHs were calculated and D2cc was recorded for the bladder and rectum and compared with the corresponding ICRU point doses. The point B dose, the treated volume, high dose volume and the treatment time were recorded and compared for the two applicators.
Results: The mean D2cc of the bladder with TR applicator was 6.746 Gy. TO applicator delivered a mean D2cc of 7.160 Gy to the bladder. The mean ICRU bladder points were 5.60 and 5.63 Gy for TR and TO applicator, respectively. The mean D2cc of the rectum was 4.04 Gy and 4.79 Gy for TR and TO applicators, respectively. The corresponding ICRU point doses were 5.10 Gy and 5.66 Gy, respectively.
Conclusions: The results indicate that the OAR doses assessed by DVH criteria were higher than ICRU point doses for the bladder with both tandem-ovoid and tandem-ring applicators whereas DVH based dose was lower than ICRU dose for the rectum. The point B dose, the treated volume and high dose volume was found to be slightly higher with the tandem-ovoid applicator. The mean D2cc dose for the bladder and rectum was lower with tandem-ring applicators. The clinical implication of the above dosimetric differences needs to be evaluated further.

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1. Background

Brachytherapy is an integral part of radiation treatment of cervical cancers. Traditionally tandem ovoid applicators have been used to deliver dose to the tumour. The applicators commonly used nowadays in delivering HDR intracavitary brachytherapy are tandem ovoid (TO) and tandem ring applicators (TR).[1] With the advent of image based brachytherapy, CT/MRI compatible intracavitary applicators are used in many centres. Combined intracavitary/interstitial implantation can be done with hybrid applicators.

When the vaginal vault does not accept ovoid or ring geometry, tandem cylinder applicators can be used. In addition to this, several customised applicators are also available to suit individual patient needs. In this study, we evaluated the differences in dosimetry between the most commonly used HDR gynaecological brachytherapy applicators, namely tandem ovoid and tandem ring applicators.

Tandem ring applicators can be used in patients with narrow vagina and in patients with obliterated vaginal fornices.[2,3] Better reproducibility is achieved with tandem ring applicators because of fixed geometry. Comparison of the dosimetric profile of the two applicators has been done earlier in several studies using orthogonal X rays.[4] Here, we used CT images to study the dosimetric parameters of the two applicators.

2. Aim

The aim of the study is to evaluate the differences in dosimetry between tandem ovoid and tandem ring gynaecologic brachytherapy applicators in CT based intracavitary brachytherapy of carcinoma cervix.

3. Methods and materials

Between January 2015 and September 2015, we evaluated 100 consecutive CT datasets of cervical cancer patients with FIGO stage IB2 to IIIB treated with HDR brachytherapy, out of which 50 datasets were tandem ovoid applicators and 50 were tandem ring applicators. TO applicators were CT MR compatible ones whereas TR applicators were metallic. All patients were treated with external beam radiotherapy to the whole pelvis to a dose of 50 Gy in 25 fractions. HDR brachytherapy was delivered with Ir^{192} sources to a dose of 8 Gy to point A given one week apart.

The intracavitary application was performed under anaesthesia in the operating room. Bladder was catheterised and the Foley's bulb was filled with 7 ml dilute contrast solution. After sounding the uterus and serial dilatation of the cervix, the tandem of TO applicator was inserted followed by the ovoids. Dilatation was not required for the TR applicators because of thin stem of TR tandem.

After securing the applicators in place, careful vaginal packing was done to displace the bladder and rectum. In addition to posterior vaginal packing, a rectal retractor was used in all TR applications. For TR applications, 4 cm and 6 cm tandem lengths were commonly used. The most common size of the ovoid for TO applications was 2.5 cm. The most common tandem angle used for TO applicator was 30 degrees. 45 degree tandem angle was most commonly used for TR applicator.

CT simulation was taken for all patients using a CT simulator (Siemens, Somatom). 3 mm slices were taken and treatment planning was done using Oncentra planning system. Bladder, rectum and sigmoid colon were contoured and a 3D treatment plan was generated. Catheter reconstructions of the applicators were done. A standard loading pattern was followed for both tandem ovoid and tandem ring applicators. A step size of 2.5 mm was used for all applications.

Depending on the length of the tandem, the dwell positions namely 1,3,5,7,10,13,16,20, were activated for the tandem. For the TO applicator, 3,4,5,6 dwell positions were activated for the ovoids. The lateral dwell positions were activated for the ring applicator, namely 7,8,9,0, on the right side of the ring and 4,5,6,7 positions on the left side of the ring. A dose of 8 Gy was prescribed to point A for both TO and TR applications. Manual optimisation was done in select cases of TO and TR applications to meet GEC ESTRO constraints for organs at risk.

DVHs were generated and D2cc was recorded for the bladder, rectum and sigmoid. ICRU point doses were recorded for the bladder and rectum. Point B doses, 100% volume and 200% volume were recorded for both the applicators. Examples of coronal and sagittal and axial views of isodose distributions for the TO and TR applicators are shown in Figs. 1 and 2, respectively.

4. Statistical analysis

Statistical analysis was done using SPSS statistical package (version 20, IBM). Descriptive statistics, like mean and standard deviation, were calculated. Statistical analysis was done using unpaired student t test to assess the relationship between dosimetric values of TO and TR applicators. Significance was assessed at $p < 0.05$.

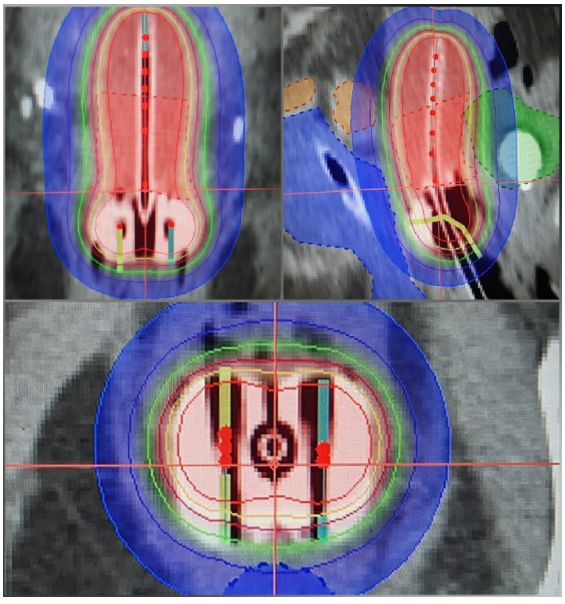

Fig. 1 – Coronal, sagittal and axial views of isodose distributions of tandem ovoid applicators.