ORIGINAL ARTICLE

Dosimetric study comparing intensity modulated and conformal pelvic radiotherapy boost plans in locally advanced cancer cervix

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Abstract

Purpose: This study was to compare 5 fields conformal technique to the intensity modulated radiotherapy (IMRT) 8 fields technique in boosting locally advanced cancer cervix cases after external beam radiotherapy with respect to target volume coverage and dose to normal tissues.

Materials and methods: We conducted a single institutional comparative dosemetric analysis of 10 patients with cancer cervix who was presented to radiotherapy department in National Cancer Institute, Cairo in period between June 2012 to September 2012 and received a conformal radiotherapy (CRT) boost in the place of planned brachytherapy after large field pelvic radiotherapy (PRT) with concurrent chemotherapy were retrospectively identified. All tumors were situated in the low central pelvis. Two plans were done for every patient; one using the 8 fields IMRT and the second one using 5 fields' 3DCRTthe two techniques were then compared using dose volume histogram (DVH) analysis for the planning target volume (PTV), bladder, rectum and both femoral heads.

Results: Comparing different DVHs, it was found that the PTV was adequately covered in both plans while it was demonstrates that the 8 fields IMRT technique carried less doses reaching organs at risk OARs (rectum, bladder, both femoral heads).

Conclusions: From the present study, it is concluded that IMRT technique spared more efficiently OARs than CRT technique but both techniques covered the PTV adequately so whenever possible IMRT technique should be used.

Key words

Dosimetric study in cancer cervix, Intensity modulated radiotherapy, Conformal radiotherapy

1 Introduction

The treatment for locally advanced cervical cancer (Stage IB2-IVA) is external beam radiotherapy to the pelvis, followed by intracavitary brachytherapy (ICT), which boosts the radiotherapy dose to the cervix, uterus, and parametrium.

The addition of chemotherapy to pelvic radiotherapy in patients with good performance status and adequate renal functions is considered the standard of care since 1999 [1, 2]. However, there are a variety of situations in which ICT cannot be carried out.

Patients who are unable to proceed with brachytherapy because of insufficient tumor regression during external beam radiotherapy, irregular pelvic anatomy or concurrent medical problems are at substantially higher risk of pelvic tumor recurrence [3, 4].

In this situation the delivery of further conformal external beam radiotherapy in the form of a cervical boost can increase the dose to the central pelvis. This conformal therapy is planned with the philosophy of reproducing, as much as possible, the treatment volume obtained with ICT while at the same time covering the visible gross tumor volume.

The aim of the present study is to make a dosimetric comparison between using 3D conformal radiotherapy (3D-CRT) and Intensity modulated radiotherapy (IMRT) when used as a boost for treating cases with cancer cervix regarding coverage of the target volume as well as dose reaching to the surrounding risk organs including bladder, rectum and head of femurs.

2 Patients and method

Ten patients with cancer cervix who were presented to radiotherapy department in period between Junes 2012to September 2012 and received a CRT boost in the place of planned brachytherapy after large field pelvic radiotherapy (PRT) with concurrent chemotherapy were retrospectively identified. All tumors were situated in the low central pelvis.

Prior to CRT boost treatment, all patients received external beam pelvic radiotherapy using either a 3 field technique or 4-field technique. The pelvic dose was 45-50 Gy in 1.8-2 Gy fractions over five weeks. Ten patients received concurrent intravenous chemotherapy with cisplatine 40 mg/m^2 weekly. The median gap between PRT and CRT was 11 days (range 1-37 days) with the median overall treatment days of 63.5 days (range 54-92 days) for all cases the maximum dose the bladder was 45 Gy whereas the maximum does the rectum was calculated to be 40 Gy. All patients were scanned using CT in a supine position with a “comfortably full” bladder. CT scan slices of 5 mm thickness were taken at 5 mm intervals from 10 mm inferior to the level of the ischial tuberosities to the bottom of the sacroiliac joint. The CT images were then automatically transferred to a planning workstation, where the CTV and relevant organs-at-risk (OARs) were outlined. The prescribed dose was 20 Gy/10 fractions.

The tumor volumes and adjacent normal organs-at-risk (OAR) including bladder, rectum and both femoral heads were defined for each patient, using information from a planning CT scan done after completing PRT specifically for these patients.

The gross tumor volume (GTV) is the residual tumor within the cervix with its invasion into the surrounding tissues. The GTV was expanded 3-dimensionally (3D) uniformly by 1 cm to define the clinical target volume (CTV), and then by a further 0.5 cm (3D) to define the planning target volume (PTV).

The outer aspect of the rectum was contoured from the level of the sciatic notch superiorly to the inferior aspect of the obturator foramen. The entire outer surface of the bladder was contoured. Both femoral heads were contoured.

Two plans were done for every patient, one using the 8 fields IMRT and the second one using 5 fields 3DCRT. The dose-volume constraints for the portions of the rectum, bladder and both femoral heads outside of the PTV were set so that 30% of the OAR-received less than 66% of the prescribed dose, and 70% of the OAR-received less than 33% of the dose [5].

Statistical analysis was done by Wilcoxon test.

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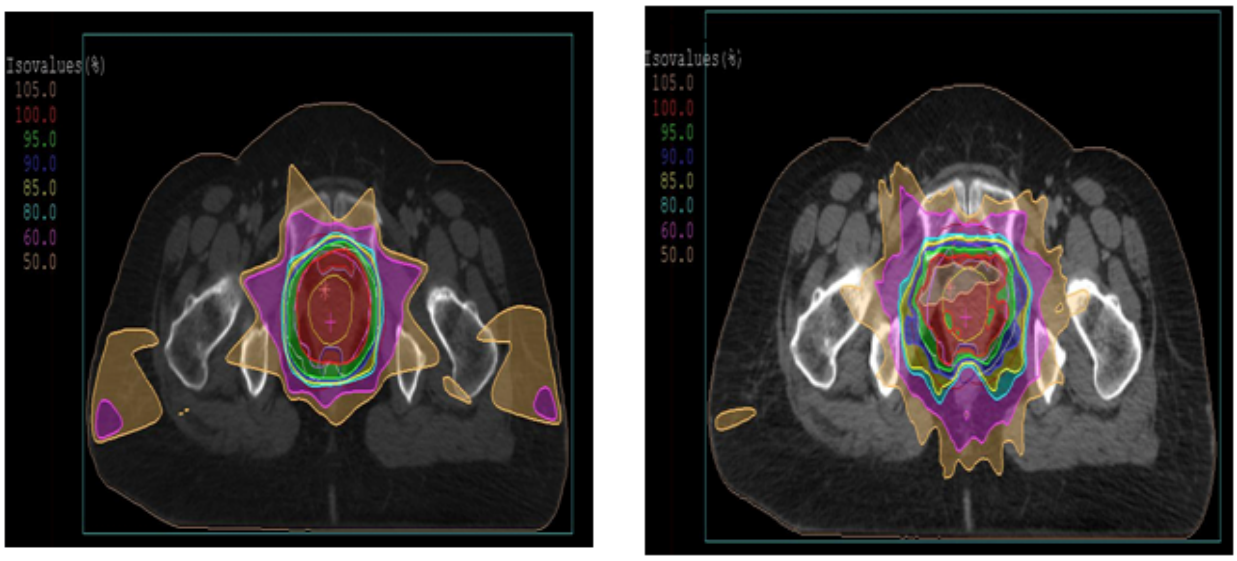

Figure 1. Dose distribution for 3DCRT and IMRT

3 Results

For each of the ten patients 2 DVHS were constructed for PTV, bladder, rectum and both femurs, one for the conformal technique and one for the IMRT technique, they were the exported to the CMS treatment computer system and averaged using Microsoft Excel to "a mean" DVH for each organ or volume. The percentage volume receiving different doses was calculated and then averaged over the 10 patients to obtain a mean value. These values were then plotted to produce a mean DVH.

For Radiation dose to the bladder, both techniques did not achieve the required target, but the radiation dose to the bladder is much lower in the IMRT technique Figure 2, it was found that 30% of the bladder volume received 100 % of the prescribed dose for the 3DCRT and 70% of the prescribed dose in the IMRT technique respectively, also 70% of the bladder volume received 70% of the prescribed dose in the 3DCRT while it receives only 50% of the prescribed dose in the IMRT technique with non-significant *p* value= 0.09.

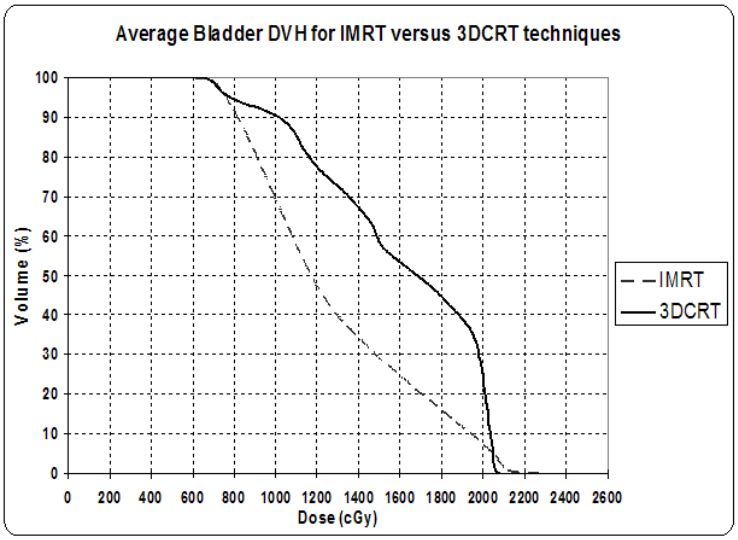

Figure 2. DVH comparing 3DCRT and IMRT for bladder

Regarding dose to the rectum, the doe received by IMRT technique is much lower than that received by 3DCRT as shown in Figure 3, where in the IMRT, 30% of the rectal volume received about 70% of the prescribed dose which is very close to the required target whereas in the 3DCRT 30% of the rectal volume received about 95% of the prescribed dose, but for the 70% rectal volume both techniques showed high dose to the rectum with a significant *p* value=0.03.

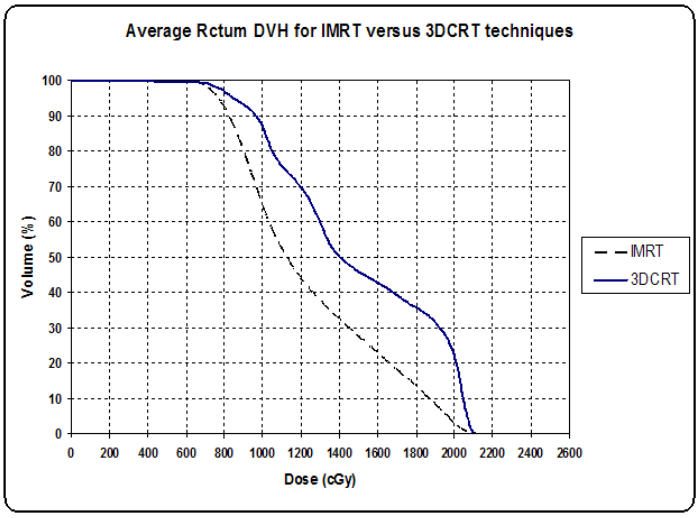

Figure 3. DVH comparing 3DCRT and IMRT for Rectum

For radiation dose to the right femur, no difference was found between IMRT and 3DCRT for the 30% volume, as this volume received about 50% of the prescribed dose, but for the 70% volume, it was very close to the required target as the dose received by IMRT was 35% of the prescribed dose where as for the 3DCRT it was about 45% of the dose as shown in Figure 4 with *p* value= 0.07.

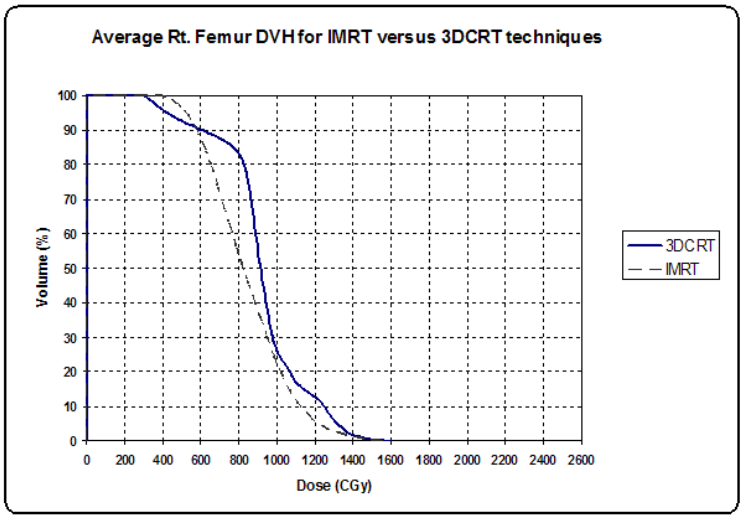

Figure 4. DVH comparing 3DCRT and IMRT for head of right femur

For the left femur, the radiation dose received by 30% of the volume was 55% of the dose in the IMRT technique and was 65% of the prescribed dose in the 3DCRT, whereas for the 70% volume of left femoral head, the dose in the IMRT was 40% of the prescribe dose while it was 45% for the 3DCRT as shown in Figure 5 with *p* value =0.08

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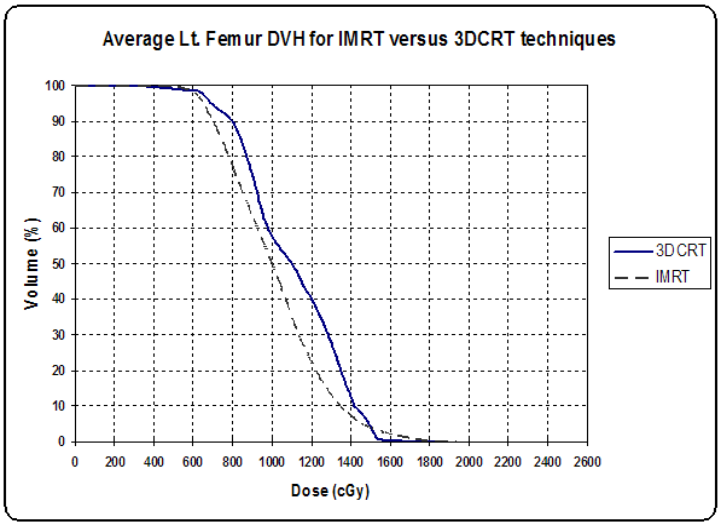

Figure 5. DVH comparing 3DCRT and IMRT for head of left femur

Regarding the coverage of the PTV as shown in Figure 6 no difference was found between the 3D and IMRT techniques, as it was found that the V95 was nearly the same that it was 96% for 3D plane and 98% for IMRT plane with *p* value =0.09

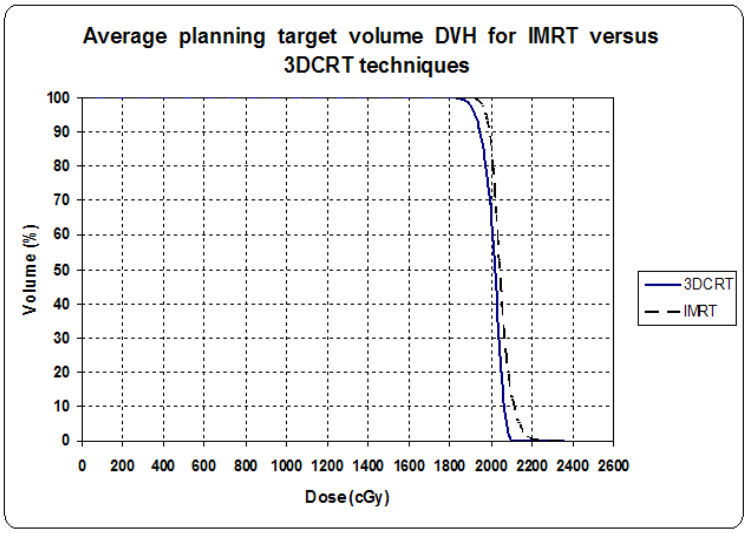

Figure 6. DVH comparing 3DCRT and IMRT for covering PTV

4 Discussion

Ideally, patients with cervix cancer who are candidates for curative treatment with radiotherapy should receive a combination of external beam treatment and brachytherapy [6, 7].

In this study, we identified a cohort of 10 patients with cervical tumors who did not receive brachytherapy as the machine was out of function, and received a CRT boost. Tumor control and toxicity for these patients were correlated with dose-volume parameters, and the cases were re-planned to assess the potential benefit of IMRT.

4.1 Regarding PTV coverage

Philip Chan et al 2006 [5] showed that the use of IMRT significantly improved the conformality relative to CRT treatment both the 95% isodose line encompassed 95% or more of the PTV in both of the IMRT and CRT plans which is similar to our results which showed that the V99 was nearly the same for 3D plane and for IMRT plane. In our study normal tissue

avoidance was assessed using cumulative DVH for both bladder and rectum. In all patients the IMRT reduced the volume of bladder and rectum receiving the dose of radiation better than that of 3DCRT.

4.2 Regarding bladder dose

In our study it was found that the IMRT technique reduces the volume of the bladder receiving the dose by about 30% than that of the 3DCRT which is in concordance to what was reported by Philip Chan et al 2006 [5] who reported reduction in the bladder volume by 19% on using the 8 fields IMRT.

4.3 Regarding the rectal dose

In our study it was found that 30% of the volume of the rectum received about 70% of the prescribed dose by the IMRT field while in CRT 30% of the rectal volume received 95%of the dose, this is in concordance to what was reported by Philip Chan et al 2006 [5] where there was rectal volume reduction by about 22% on using the 8 fields IMRT.

5 Conclusions

From the present study, it is concluded that IMRT technique spared more efficiently OARs (rectum, bladder and, both femoral heads) than CRT technique but both techniques covered the PTV adequately with nearly no difference in this coverage so whenever possible IMRT technique should be used in boosting cases with locally advanced cancer cervix if brachytherapy is not available.

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