

A comparative dosimetric study of 3D conformal radical radiotherapy for bladder cancer patients versus conventional 2D radical radiotherapy in NCI-Cairo

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Abstract

Purpose: This study was to compare this multiple-field conformal technique to the 2D conventional technique with respect to target volume coverage and dose to normal tissues.

Materials and methods: We conducted a single institutional prospective comparative dosimetric analysis of 15 patients who received radical radiation therapy for bladder cancer presented to radiotherapy department in National Cancer Institute, Cairo in period between November 2011 to July 2011 using 3D conformal radiotherapy technique for each patient, a second 2D conventional radiotherapy treatment plan was done, the two techniques were then compared using dose volume histogram (DVH) analysis.

Results: Comparing different DVHs, it was found that the planning target volume (PTV) was adequately covered in both (3D & 2D) plans while it was demonstrated that this multiple field conformal technique produces superior distribution compared to 2D technique, with considerable sparing of rectum and to lesser extent for the head of both femora.

Conclusions: From the present study, it is recommended to use 3D planning for cases of cancer bladder especially in elderly patients as it produces good coverage of the target volume as well as good sparing of the surrounding critical organs.

Introduction

Bladder cancer represents a significant worldwide health problem with an estimated 356,370 new cases and 146,000 deaths reported globally for the year 2002 (1). Although the majority of bladder cancers, present with disease confined to the superficial layers of the bladder wall, approximately 20-40% of the patients will present with or subsequently develop invasive cancer. Transitional cell carcinomas (TCC; also known as urothelial carcinoma) represented more than 90% of cystectomy specimens worldwide (2). In areas where schistosomiasis is endemic, urothelial cancer represents approximately 50% of bladder cancers, while the other subtypes represents the remaining percentage (3).

Since the late 1980s, many centers investigated the bladder preservation strategy as an alternative to radical cystectomy. The rationale of this strategy depends on 3 goals: first, eradication of the local disease, second, elimination of potential micrometastasis and third, maintenance of the best possible quality

of life (QoL) through organ preservation (4). Several treatment protocols were carried out by different investigators. However, they all characterized 3 main and essential procedures with varying timing and varying minute details. The first main procedure is maximal TURBT. This is to be followed by neoadjuvant chemotherapy or radiochemotherapy (second procedure) and then after cystoscopic assessment, followed by either radical radiotherapy or consolidation radiochemotherapy for the complete responders (third procedure). The 5-year OS rates ranged between 39% and 58% and the 5-year survival with native bladder preservation ranged from 36% to 43% (5-9)

Patients and Methods

The aim of the present study is to compare between the 2D and 3D conformal planning for bladder cancer cases treated by trimodality approach regarding the dose distribution to the target as well as the organs at risk.

We conducted a single institutional prospective comparative dosimetric analysis of 15 male patients with muscle-invasive (Stage T2-T4a) transitional cell carcinoma of the bladder that presented to radiotherapy department in National Cancer Institute, Cairo in period between November 2011 to July 2012. Maximum Transurethral resection (TUR) was done for all patients then followed by concurrent chemoradiotherapy. Patients were simulated in the supine position and should have an empty bladder.

In 2D planning, the treatment field typically extends craniocaudally from the L5-S1 disc space to the lower pole of the obturator foramen and laterally to 1-2 cm beyond the margin of the bony pelvis at its widest part. For the lateral field anteriorly, the field extends 1.5-2 cm beyond the bladder and posteriorly to the level of the third sacral vertebra.

The CTV for irradiating the whole bladder should encompass the entire outer circumference of the bladder, any extra vesical disease spread and any microscopic disease spread.

In 3D planning, an initial planning pelvic CT scan was performed with the patient in a supine position strictly within 10 mm of bladder empty. The planning gross target volume (GTV) is determined by including the bladder with any extravascular extension. It is widely accepted that the CTV is created with 2- to 2.5-cm margins. However, these margins are still debatable and not universally accepted. The CTV included the bladder, prostate and prostatic urethra in males or the upper vagina in females. The pelvic nodal CTVs extend around external

and internal iliac vessels. The external iliac CTV extends anteriorly along the iliopsoas muscle to include the lateral external iliac nodes. The internal iliac CTV extends laterally to pelvic side wall. The contours around the external and internal iliac vessels were joined

to create a single volume on each side of the pelvis, ensuring that it included the obturator nodes. The pre-sacral CTV extends over the anterior sacral prominence guided with Tayler et al atlas (10). The planning target volume (PTV) margins are 5-10 mm according to the institutional policy of creating CTV-PTV margins. The dose delivered was 50 Gy to the bladder and lymph nodes followed by boost to the bladder only 16 Gy giving total dose 66 Gy.

Results

For each of the 15 patients 2 DVHs were constructed for the PTV, rectum, head of both femurs, one for the conformal technique and the other for the 2D technique, they were then exported for the precise treatment planning 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 15 patients to obtain a mean value. These values were then plotted to produce a mean DVH for each OARs and PTV.

Radiation dose to the rectum is much lower in the 3D conformal radiotherapy planning compared to the 2D plan as showed in Fig. 1, it was found that the V50 in the 3D plan is 39% while in the 2D plan is 90%, the V60 for 3D plan is 35% while it is 87% in 2D plan, the V70 is 32% for the 3D plan while it is 82% in the 2D plan.

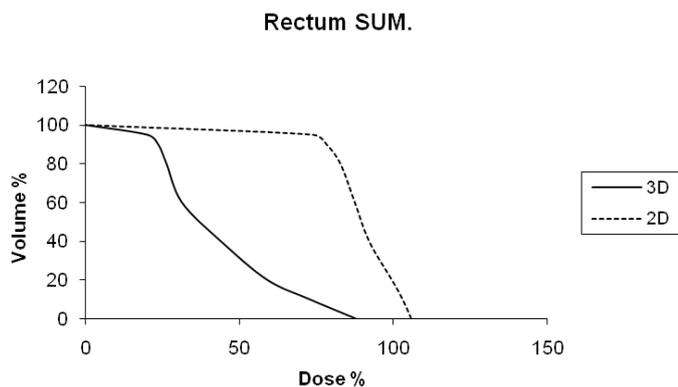


Fig 1: Mean DVH for rectum using 2D technique and 3D technique.

Figure 2 showed that the average maximum dose received for the head of right femur is in favor for the 3D conformal planning which is 52 Gy compared to 72 Gy for the 2D planning. The mean average dose for the 3D planning was 43 Gy versus 39 Gy for the 2D plan, while for the head of left femur Fig. 3 the mean average dose is in favor for 3D conformal planning 57 Gy compared to 69 Gy for the 2D technique, it was found that the V50 in both the 2D and 3D plans are nearly the same and they are about 44 Gy for both.

RT. Femur SUM

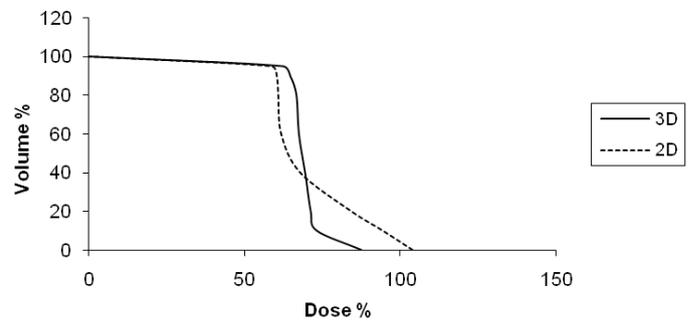


Fig 2: Mean DVH for right femur using 2D technique and 3D technique.

LT. Femur SUM

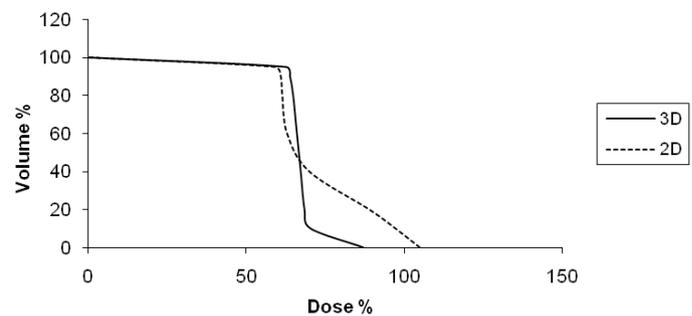


Fig 3: Mean DVH for left femur using 2D technique and 3D technique.

Regarding the coverage of the PTV as shown in fig. 4 no difference was found between the 3D and 2D techniques where the average dose for the 50 % PTV was about 69 Gy, also it was found that the V99 was nearly the same that it was 102 % for 3D plane and 104 % for 2D plane.

PTV SUM.

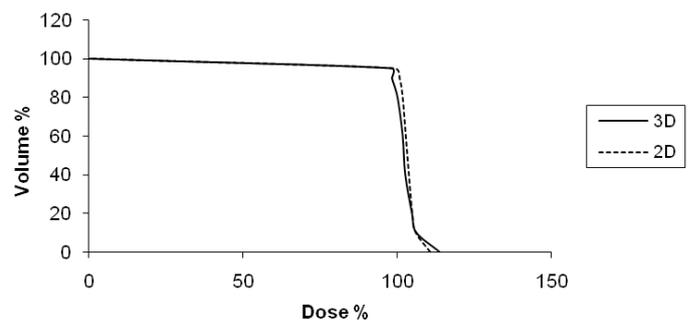


Fig 4: Mean DVH for PTV using 2D technique and 3D technique.

Discussion

This preliminary study showed that 3DCRT for bladder cancer produces lower dose to OAR including the rectum and head of femur. This supports the use of this modality in elderly patients.

Radiation dose to the rectum is much lower in the 3D conformal radiotherapy planning compared to the 2D plan, the V70 is 32% for the 3D plan, while it was 28% for the study reported by **Wojciech et al. 2009 (II)**, this difference may be attributed to the difference in the degree of bladder filling in the patients in both studies.

In the present study, it was found that the V50 for the rectum is 39% in the 3D plan while in the 2D plan is 90%, this is similar also to what was reported by **Chen-Hsi Hsieh et al (I2)** where the V55 in the rectum was 4.7% for the IMRT compared to 46.1% for the 2D planning.

The average maximum dose received by the head of right femur is in favor for the 3D conformal planning which is 52 Gy compared to 72 Gy for the 2D planning while for the head of left femur it was 57 Gy compared for 3D conformal planning to 69 Gy for the 2D technique, this is similar to what was reported by **Chen-Hsi Hsieh et al (I2)** who compared 2D planning versus IMRT for planning of cancer bladder where the dose received by the IMRT technique for the head of right femur was 35% versus 73.7% for the 2D planning and the dose received by the head of left femur was 26.5% for IMRT planning versus 71.1% for the 2D planning much less than that by 2D planning.

Regarding the coverage of the PTV, no difference was found between the 3D and 2D techniques, this is different from what was reported by **Chen-Hsi Hsieh et al (I2)**, where better coverage was found for the IMRT technique than for the 2D planning, this difference is attributed to the use of inverse planning of the IMRT that allows better intensification of the dose to the target.

Conclusions and Recommendations

From the present study, it is recommended to use 3D planning for radical radiotherapy for cases of cancer bladder especially in elderly patients as it produces good coverage of the target volume as well as good sparing of the surrounding critical organs when compared to conventional 2D plan.

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