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Shielding for Scattered Radiation to the Testis During Pelvic Radiotherapy: Is it worth?

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ABSTRACT

Objectives: To assess the value of external shielding of the testis during pelvic radiotherapy.

Material and Methods: Nineteen patients, receiving radiotherapy to the pelvis with the lower border of the field at the obturator foramen, were randomly selected. A 5 half value layer cerrobent shield was positioned at the inferior border of the field. The dose to the testis was measured with and without the shield. Observations were made regarding the reflex cremaster contraction and phantom measurements were done at different distances from the perineum.

Results: The mean radiation dose to the testis for patients receiving treatment with no shield was 7.4cGy (±1.3) and it was 5.7cGy (±2.5) for patients with external shield, this difference was statistically significant by the paired *t* test $p<0.0001$. This accounted for a 22% decrease in the dose received by the testis. The position of the testis with the contraction of the cremaster muscle and the dartos fascia after manipulation of the testis during diodes placement changed up to 3.5 cm (mean 1.5). Phantom measurements showed 37% increase in the dose with 2cm change in the position of the testis to the pelvic direction.

Conclusion: External shield at the inferior border of the pelvic field is a simple, easy reproducible, convenient shielding method. Clam-shell scrotal shield is not free of drawbacks, but still its benefits overweigh its harms and should be used with caution.

Key Words: *Testicular shielding – Pelvic radiotherapy – Scattered radiation.*

INTRODUCTION

Radiotherapy has been used for the treatment of many pelvic tumors in men like prostate, rectum and bladder cancer, also pelvic field added to certain cases of seminoma. The dose of scattered radiation to the testis carries a high risk of infertility induction in men and genetic risk especially for young patients **[1]**. The dose to the testis arises from both internal and external scatter. The role of scrotal shielding has been evaluated and it has shown a decrease in the scattered dose to the testis. The shielding was done either through gonadal shielding (clamshell lead shield), or an external shield at the inferior border of the field or both **[2-4]**. Although many trials have pointed more to the importance of the clamshell lead shield than the shield at the inferior border of the field, two points have been noticed during its clinical application in our center. The first is the inconvenience to the patient and the second is the considerable reflex contraction of cremaster muscle and dartos fascia so it decreases the distance between the testis and the inferior border of the treatment field. This distance has a very determinant effect on the dose received by the testis **[6]**.

The aim of this work is to assess the value of the external shield at the inferior border of the pelvic field in decreasing the dose of the external scatter to the testis. And to evaluate the effect of the change on distances between the testis and the inferior border of the pelvic field.

PATIENTS AND METHODS

Nineteen patients with bladder cancer were randomly assigned to participate in our study after achieving an informed consent. Patients were treated at the radiotherapy department, National Cancer Institute, Cairo University. To

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be eligible for this study, only male patients, aged between 18 and 70 years were included. Patients should have pelvic radiotherapy with linear accelerator machine 6 Mv and the inferior border of the field should be at the same chosen level (lower border of the obturator foramen). Patients treated by 3 fields (anterior and two laterals) and 4 fields (box technique) were included in our study, while patients receiving 2 parallel opposing or non co planer treatment were excluded. Exclusion criteria also included field size less than 10 X 10cm or more than 18 X 18 cm and patient with any prosthesis in the pelvic area. Patients were treated in supine position and apart from the laser immobilization system, no other immobilization devices were used. The dose per fraction to the planning target volume was 2Gy.

For each patient, the dose was measured with and without the addition of a shield at the inferior border of the treatment field.

Shield design:

The shield was made of cerrobend with its thickness equivalent to 5 half value layers and its width extended at least 3cm outside the outer edges of the field. The shield was positioned just outside the field at its inferior border. The shield was designed with a sloping edge which was placed at the side of the beam to accommodate for the beam divergence.

Method of measurement:

The measurement of the dose was done by diodes isorad-p detector 6-12 MV (3 Meter) negative output (Sun Nuclear Corporation, Germany). Two diodes were used, one at the anterior surface and the other at the posterior surface of the scrotum during the antroposterior and postroanterior fields. During the lateral fields, the diodes were placed at both lateral sides of the scrotum. The entrance and exit dose measurements were converted to midplan dose, which was used in combination with a depth dose correction to obtain the dose at the specified point (center).

Phantom:

To measure the effect of the shield on the dose to the target, a water phantom was used. The dose was measured at the center and the inferior border of the field after simulating the treatment situation. Several measurements were taken and the average was calculated.

Effect of the change in the distance:

The effect of the cremaster reflex contraction was observed and the change in the distance between the testis and the perineum was measured. To measure the effect of this change, we used Rando phantom and we measured the dose at one, two and three centimeters from the perineum after simulating the treatment conditions of the pelvic fields.

Statistical analysis:

The statistical Package for Social Sciences (SPSS) version 9 was used for data analysis. T test was used to compare quantitative variables. Pearson correlation coefficient was used to test correlation between different quantitative variables.

RESULTS

The absolute dose received by the testicles of the 19 randomly selected patients undergoing radiotherapy for bladder cancer was measured by on-line diode dosimetry.

Patients' treatment characteristics:

The characteristics of the patients' treatment fields are summarized in Table (1). Ten patients received 4 field (box) technique and nine patients received 3 field technique (anterior and 2 lateral beams).

Effect of the shield on the dose to the testis:

Delivering 200cGy to the pelvis resulted in a mean radiation dose to the testis of 7.2± 3.1cGy (3.7%) for patients receiving treatment with no shield and a mean dose of 5.5±2.5cGy (2.85% reduction) for patients with external shield, this difference was statistically significant by the paired *t* test $p<0.0001$.

The dose to the testis without shield ranged from 4 to 18cGy and in cases with external shield it ranged from 3 to 14cGy. Sixteen patients showed decrease in the measured dose to the testis by adding the external shield, one patient showed the same and 2 patients showed increase in the measured dose.

The mean difference in the dose was 1.7cGy (22%) and the maximum difference was 5.5cGy

(50%) decrease in the dose. Table (2) presents the measured dose in the 19 patients.

The percentage of decrease in the dose did not show significant correlation with the initial dose received by the testis, although the absolute amount of the decrease in the dose showed significant correlation with the initial dose.

Regarding the effect of the field size, the volume irradiated and the number of the fields used, there was no significant correlation with any of them and with the percentage of the decrease in the dose. The only significant correlation was found with the SSD of the anterior field Pearson Correlation 0.483 (p=0.036).

Effect of the shield on the dose to the target:

To evaluate the effects of this shield on the dose received by the target, water phantom measurements were done with and without the shield. These measurements showed a significant decrease in the dose at the center of the field with the addition of the shield (p=0.003). The mean difference when delivering 200cGy was 1.55±0.69cGy decrease (0.7%) (range from 2.56 to 0.6cGy). Regarding the dose at the edge, there was no significant difference (p=.541). The mean difference was 1.45±5.4cGy increase in the dose and it ranged from -7.7 to 5.2cGy change in the dose.

Effect of the cremaster reflex on the distance from the testis to the perineum:

Observations were made during diodes placement regarding the effect of the scrotum manipulation on the position of the testis. In most of the patients, there was a measurable change in the position to the pelvic direction after the reflex contraction of the cremaster muscle reaching up to 3.5cm (mean 1.5cm). None showed a change to the opposite direction while 4 showed no measurable change.

Effect of change in the distance on the dose received by the testis:

After simulating the treatment position using Rando phantom the dose was measured at 1, 2 and 3cm away from the perineum. A 14% increase in the measured dose from scatter was observed when the diodes position was advanced one cm to the perineum (from 3cm away from the perineum to 2 cm). A further 20% increase was observed when it was advanced for another one cm (from 2cm away from the perineum to 1cm). This accounts for a 37% increase in the dose at 1cm compared to 3cm.

Table (1): Patients fields' characteristics of the 19 studied patients.

Number	Fields number	Width of lateral field (cm)	Width of ant field (cm)	Length of the field (cm)	SSD Anterior (cm)	Lateral separation (cm)	Volume (ml)
1	4	11.5	14	13	87	37	2093
2	4	12	15	13.5	92	32.5	2430
3	3	11.5	15	13	95	32	2243
4	4	12.5	16	13.5	91	35	2700
5	4	12.5	14.5	14	93	31	2538
6	4	11.5	12.5	12	90	30	1725
7	3	10	13	13.5	91	28	1755
8	3	11.5	16.5	13	93	31	2467
9	4	12.5	14	12	91	32	2100
10	4	11.5	15.5	13	90	34	2317
11	3	10.5	14	14	94	29	2058
12	4	13	15.5	14	91	33	2821
13	3	12	16	15	92	32	2880
14	4	14	17	13	91	35	3094
15	3	12	15	12.5	91.5	32	2250
16	3	11.5	14.5	11	94	30	1834
17	4	12	14.5	16	92	31	2784
18	3	11.5	15	13	91	32	2243
19	3	12	15	13	91	32	2340
Mean±SD		11.8±0.8	14.8±1.1	13.2±1	91.6±1.7	32±2.1	2351±386

Table (2): The measured dose (cGy) with and without shielding.

	Dose with	Dose without	Difference	Difference %
1	5.17	4.7	-0.47	-10
2	7	7	0	0
3	5.5	7.4	1.9	25.68
4	4	6	2	33.33
5	4.6	6.65	2.05	30.83
6	3.7	5.4	1.7	31.48
7	9	8	-1	-12.5
8	6	7.66	1.66	21.67
9	4.3	5.6	1.3	23.21
10	6	7	1	14.29
11	5.5	11	5.5	50
12	3.5	5	1.5	30
13	6	9	3	33.33
14	7	9	2	22.22
15	3	5	2	40
16	14	18	4	22.22
17	3	4	1	25
18	3	4	1	25
19	5	6	1	16.67
Mean±SD	5.5±2.5	7.2±3.1	1.7±1.4	22±15

DISCUSSION

The scattered radiation to the testis has many harmful effects. These effects include oligospermia, temporary azospermia [7], permanent azospermia, changes in the hormonal (LH-FSH) levels [8], testicular atrophy [9] and genetic risk of hereditary disease or developmental impairment for the offspring of irradiated patients [10].

The scattered dose to the testis comes from both internal and external scatter. Amies et al. [11] calculated the dose contribution from the internal (from the primary beam) and external scatter (from scattered radiation) for pelvic radiotherapy and it was shown that internal scatter was responsible for 0.97% of the dose received by the testis while external scatter was responsible for 1.07%. The measurement of the primary beam contribution was done by the use of an external shield to prevent external scatter and it decreased the dose received by the testis from 1.90% to 0.97%. These results are consistent with our in vivo results which showed a significant decrease (from 3.7% to 2.85%) in the dose with the external shielding which prevent external scatter.

A simple method of testicular protection is the use of a sufficient gonadal shield, most commonly made of lead. In 1982, Kubo & Shipley described a reduction of testicular dose to negligible levels when a 10cm thick lead scrotal block above the scrotum immediately outside the field was added to a standard clam-shell shielding [4]. In a comparative study of patients irradiated to the paraaortic lymph nodes alone or additional homolateral iliac lymph nodes, Bieri et al. [5] evaluated the use of different types of gonadal shielding. The testicular dose was reduced from 1.86cGy/fraction to 0.65 cGy and from 3.89cGy/fraction to 1.48cGy for the two groups. The addition of a lower field border block did not significantly reduce the scattered dose. They concluded that the application of a testicular shielding was the only way to reduce the overall scattered gonadal dose to <20cGy. In a similar study, the use of a clam-shell shielding was recommended, as it reduced the mean testicular dose from 4.8 to 1.8cGy [12]. The same conclusion and recommendation were given in an evaluation of 207 men in the Southwest Oncology Group study of orchidectomy and irradiation of patients with seminoma (SWOG-8711) [13]. None of these trials pointed to the effect of the clam-shell shielding on cremaster contraction and the effect of change in the distance on the dose received by the testis and none of them compared the dose received with the shield to the dose to the testis in the resting position before contraction of the cremaster muscle.

In the present study, we could show that the position of the testis was affected by the contraction of cremasteric muscle and dartos fascia (simulating the case during application of the clam shell) that may increase the dose to the testis during this contraction. Hermann et al. [14] showed significant increase in the dose received by the testis by decreasing the distance between the inferior edge margin and the testis. The inferior border for any pelvic field is judged by the clinical situation of the patient and in our study we have chosen bladder cases with the lower border at the obturator foremen. As it is impossible to measure the dose without touching the sensitive area and inducing cremaster reflex contraction, we made observational measurements on the change of the position of testis before and after diodes placement and we measured the dose at different levels in a phantom. This difference, which reached up to 37% increase in the dose for 2cm distance change, is still below the gain from the clam-shell shielding which reached more than 50% in the above mentioned trials.

Hermann et al. [14] used an ionization chamber in their measurements; Amies et al. [11] used thermo luminescent chips. In our study, we used diodes as the accuracy of the measurements of the delivered dose is dependent on the overall uncertainty associated with the calibration of the detector and geometric setup. In the verification methods, ion chambers are important detectors to use in these processes as their calibration and use are well established. The main problem in the ion chamber comparable to the diode is the size and directional dependence [15,16]. In addition, although they can be calibrated, their response changes with the magnitude of the cumulative dose [17]. The degree of uncertainties of the TLD is more than diode as the TLD is characterized by lower reproducibility inherent to the TLD process itself and to the acquisition and annihilation procedures [18].

Although the data of the different shielding methods to the testicular dose are plenty, the data regarding the effect of these shields on the dose to the target are scarce. In our study, we measured the dose both at the center and the lower edge of the field. It is clear that this external shield has minimal effect (less than 1%) on the dose to the center of the target and this effect is measurable and can be compensated easily while its effect on decreasing the dose to the testis is countable. On the other hand, at the edge of the field we were not able to prove a significant effect of the shield on the dose as there is a sharp dose gradient in the penumbra area. Different radiation detector types showed wide variation in the accuracy of dose measurement in this area. These major deviations can be explained based on the characteristics of the sensitive materials and the construction of the detector [17].

Conclusions:

External shield at the inferior border of the pelvic field is a simple, easy, reproducible and convenient method for decreasing the dose of scattered radiation to the testis. Clam-shell scrotal shield is not free of drawbacks but still its benefits overweigh its harms and should be used with caution.

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