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Absorbed Dose Measurement in Gonads Menduring Abdominal and Pelvicradiotherapy

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***Abstract*—**Two different testicular tissues have to be distinguished in regard to radiation damage: first the seminiferous tubules, corresponding to the sites of spermatogenesis, which are extremely radiosensitive. Second the testosterone secreting Leydig cells, which are considered to be less radiosensitive. This study aims to estimate testicular dose and the associated risks for infertility and hereditary effects from Abdominal and pelvic irradiation. Radiotherapy was simulated on a humanoid phantom using a 15 MV photon beam. Testicular dose was measured for various field sizes and tissue thicknesses along beam axis using an ionization chamber and TLD. For transmission Factor Also common method of measuring the absorbed dose distribution and electron contamination in the build-up region of high-energy beams for radiation therapy is by means of parallel-plate Ionisation chambers. Gonadal dose was reduced by placing lead cups around the testes supplemented by a field edge block. For a tumor dose of 100 cGy, testicular dose was 2.96-8.12 cGy depending upon the field size and the distance from the inferior field edge. The treatment at parameters, the presence of gonad shield and the somatometric characteristics determine whether testicular dose can exceed 1 Gy which allows a complete recovery of spermatogenesis.

***Keywords*—**Absorbed Dose, Abdominal and pelvic, gonads men, Radiotherapy.

I. Introduction

SECONDARY radiation exposure of patients undergoing radiation therapy with high energy photon is of great concern due to possible tissue damage and risk of induction of secondary cancers.

During pelvic irradiation several organs at risk (OARs) are significantly exposed to radiation like the testicles, the bladder, the small intestine or the femoral heads. The amount of scattered irradiation to the testicles and its impact on gonadal integrity has been studied in detail before [1]. Two different testicular tissues have to be distinguished in regard to radiation damage: first the seminiferous tubules, corresponding to the sites of spermatogenesis, which are extremely radiosensitive. Second the testosterone secreting Leydig cells, which are considered to be less radiosensitive.

A single dose as low as 0.78 Gy leads to reversible azoospermia in nearly all patients [2]. Recovery time is dependent on the received dose: after 2 Gy regeneration takes about 30 months, while after 4 Gy it will take over 5 years and often results in irreversible azoospermia [3]. Fractionated radiation (which is the common form of therapeutic exposure to radiation) is more toxic to the germ track than single dose exposure [4]: there is a high risk of irreversible azoospermia with fractionated testicular doses >1.5 Gy [5]. Leydig cell damage resulting in a decrease of testosterone levels in approximately 20% of the patients appears after 12 Gy fractionated irradiation. After 33 Gy testosterone levels are suppressed in 50% of the patients [6]. However, Dueland et al. showed a 36% reduction of testosterone levels compared to the levels at the beginning of therapy in 25 patients after radiotherapy of rectal cancer (mean testis dose 8.4 Gy) [7].

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II. The Effect of Radiation on Fertility

The effect of radiation on fertility is not apparent immediately, because the postspermatogonial cells are relatively resistant compared with the sensitive stem cells. After exposure to a moderate dose of radiation, the individual remains fertile as long as mature sperm cells are available, but decreased fertility or even temporary sterility follows if these are used up. The period of sterility lasts until the spermatogonia are able to repopulate by division [8]-[10].

Radiation doses as low as 0.15 Gy (15 rad) result in oligospermia (diminished sperm count) after a latent period of about 6 weeks. Doses above 0.5 Gy (50 rad) result in azoospermia (absence of living spermatozoa) and therefore temporary sterility. The duration of azoospermia is dose dependent; recovery can begin within 1 year after doses of less than 1 Gy (100 rad) but requires 2 to 3½ years after a dose of 2 Gy (200 rad). The original single-dose data came from the irradiation of prisoners, which showed that a dose in excess of 6 Gy (600 rad) is needed to result in permanent sterility. In contrast to most organ systems, where fractionation of dose results in sparing, fractionated courses cause more gonadal damage than a single dose. Studies of patients receiving radiation therapy indicate that permanent sterility can result from 2.5 to 3 Gy (250-300 rad) in a fractionated regime over 2 to 4 weeks. The induction of sterility by radiation in human males does not produce significant changes in hormone balance, libido, or physical capability [11]-[14].

III. Material and Method

A Primus linac (Siemens, Germany) High Energy X-ray machine and Shinva linear accelerator (China) of the Mahdieh Radiotherapy and Oncology, Hamadan, Iran were used in this work. The primus linac provides two low and high energy photon beams (6 and 15 MV) and a range of electron beams

(5-12 MeV).

A. Dosimetry System

Absorbed dose measurements were made with thermoluminescence (TL) dosimetry. We used Lithium florid (LiF) Thermoluminescent Dosimeters (TLD-100) chips (3.7mm*3.7mrn*0.9mm, manufactured by Harshaw, Solon, USA) Pre-irradiation annealing was carried out in 400 C for 1 h, followed by cooling to room temperature. Each dosimeter was rinsed before being read out with a solution of methanol containing 12 mmolHCl/l. The dosimeters were read out in 300 C for 10 s. Each dosimeter was individually calibrated. The calibration was carried out in a PMMA phantom with 5 mm build up in a 60Co beam. The stability of the dosimeters was within ^3%. The variation in the mass energy transfer coefficient in the energy interval for 6 MV, ^{60}Co and 192Ir is less than 3%. This value was calculated from a standard textbook of TL dosimetry [15].

B. External Beam Radiotherapy Planning

Treatment planning is a multi-step process. The complexity of this process depends upon the treatment intent, the site of the tumor, the equipment/facilities available and the desired accuracy of treatment (including reproducibility and verification). The aim of radiotherapy in the radical setting is to deliver the maximum possible dose of radiation to the tumor to achieve local tumor control, whilst trying to spare surrounding normal tissue.

IV. Result

During radiotherapy treatment, critical organs are shielded using lead and cerrobend blocks.

A. Transmition Factor X-Ray

For transmission Factor Also common method of measuring the absorbed dose distribution and electron contamination in the build-up region of high-energy beams for radiation therapy is by means of parallel-plate Ionisation chambers.

The transmission factor is the ratio of the doses (at the depth and distance from the source corresponding to the reference condition) with and without the cerrobend in position.

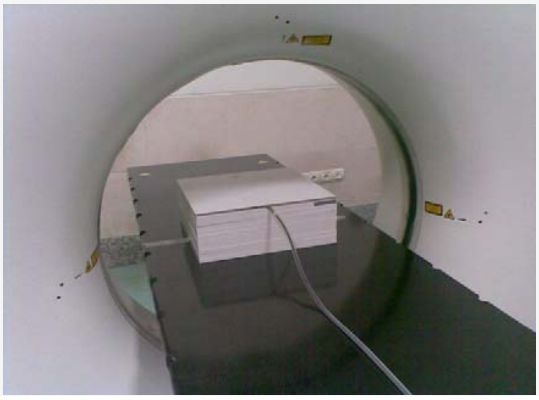

Fig. 1 phantom placed in CT scan device

Fig. 2 placement of Tissue equivalent phantom on a flat linear accelerator

A. Scater X-Ray

Thirty- four thermoluminescent dosimeter chips (TLD-100) fabricated by Harshaw Chemical Co., Solon, USA, in the form of lithium fluoride, were placed in an adult male tissue-equivalent RANDO human phantom. Three TLDs were used to measure background radiation. The irradiation of organs outside the primary beam is mainly due to X-rays scattered within the linac head such as collimator scatter, Tray scatter and cerrobend scatter.

TABLE I
GONADS MEN ABSORBED DOSE MEASUREMENTS PER 100 CGY, THE SCATTERED X- RAYS OF ABDOMINAL AND PELVIC RADIOTHERAPY FIELD (35*35 CM) USING TLD

absorbed dose (cGy)	Distance from field edge (cm)	TLD
8.431	4	1
8.547	6	2
7.812	8	3
7.1688	10	4
7.308	12	5
6.3336	14	6
5.0808	16	7
3.9672	18	8
2.9928	20	9
1.392	22	10
0	24	11

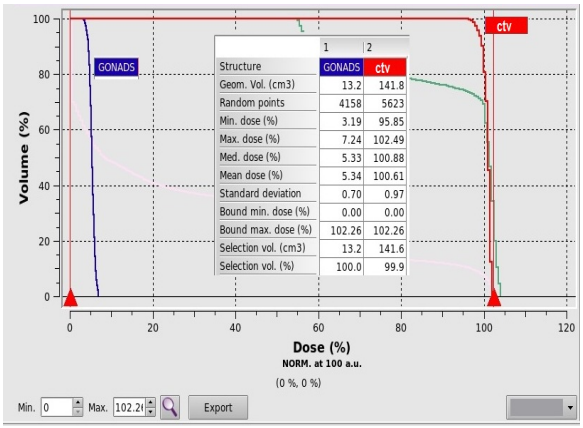

Fig. 3 Dose–volume histogram of the mean testicular dose with standard deviations for adult male tissue-equivalent RANDO human phantom , A dose of 100 cGy (red line) to the CTV Radiation dose to unshielded testes (35*35cm) 6cm from field edge

V. Conclusion

Fractionated doses to testes below 1 Gy allow a complete recovery of spermatogenesis within 9 to 18 months [17], [18] but higher gonadal exposure up to 2 Gy can lead to azoospermia for 2-5 years [16], [19]. Tetsicular doses exceeding 2Gy can result in a permanent reduction of reproductive capacity [17], [20].

During radiotherapy treatment, critical organs are shielded using lead and cerrobendblocks. The gonads men dose received apparently shielded by cerrobend blocks was about 8cGy in 100cGy Expose two main contributions in the Absorbed Dose to gonads men during pelvic Radiotherapy that gonads placed in radiation Field.

1. Due to primary photon beam transmitted through the block : 4 percent for 8 cm cerrobend blocks
2. Due to scattered photons and contamination electrons : 3 up 4.5 percent, Dependent on cerrobend block Size, These two factors collectively cause the increase with increasing field size, energy, and block size.

Radiotherapy for Abdominal and pelvic without any gonadal protection using the medium and maximum field sizes can cause prolonged azoospermia or even permanent infertility. The use of lead cups around the testes together with a conventional inferior field border block reduced the testicular dose by more than 70%. Despite the aforementioned significant reduction of gonadal exposure, the radiation dose to shielded testes can still exceed the threshold of 1 Gy when the distance from the inferior field edge is smaller than 9.5 cm and the maximum field size is applied. The above data can be adopted to anticipate the absorbed dose to testes and the associated risk for infertility from Abdominal and pelvic.

Even if the placement of gonad shield can reduce the testicular dose and the associated detriment risks, efforts should always be made to minimize the gonadal exposure in young individuals with many decades of life ahead who may wish to father children.

An effective approach to reduce the scattered dose to testes is to use the smallest Abdominal and pelvic field possible because of the considerable increase of testicular dose with the increase of treatment volume.

The above can be accomplished, if the treatment planning procedure is performed by experienced radiotherapists in the management of Abdominal and pelvic disease.

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