Absorbed Dose Measurement in Gonads during Abdominal and Pelvic Radiotherapy

Sadegh Masoudi, Ali Asghar Yousefi, Somayeh Nourollahi, Fatemeh Noughani

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 radiation 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].

II. THE EFFECT OF RADIATION ON FERTILITY

The effect of radiation on fertility is not apparent immediately, because the post spermatogonial 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 spermatogonial 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 floride (LiF) Thermoluminescent Dosimeters (TLD-100) chips (3.7mm*3.7mm*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, 60Co 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. Transmission Factor X-Ray

For transmission Factor X-Ray, a 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.

<table>
<thead>
<tr>
<th>Absorbed dose (cGy)</th>
<th>Distance from field edge (cm)</th>
<th>TLD</th>
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</tr>
<tr>
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<td>2</td>
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</tr>
</tbody>
</table>

Fig. 1 phantom placed in CT scan device

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

A. Scatter 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.
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.

**REFERENCE**


