

Estimating the Absorbed Dose to THYROID during Chest wall Radiotherapy

Seid Ali Asghar Terohid, Vahid Fayaz

Abstract—Thyroid cancer's overall contribution to the worldwide cancer burden is relatively small, but incidence rates have increased over the last three decades throughout the world. This trend has been hypothesised to reflect a combination of technological advances enabling increased detection, but also changes in environmental factors, including population exposure to ionising radiation from fallout, diagnostic tests and treatment for benign and malignant conditions. The Thyroid dose received apparently shielded by cerrobend blocks was about 8cGy in 100cGy Expose .

Keywords—Absorbed Dose, Thyroid, Radiotherapy

I. INTRODUCTION

RADIO THERAPY for certain cancers, including head and neck, lung, lymphoma/leukaemia, breast and brain, can expose the thyroid to 0.25 Gy [1]. In the Childhood Cancer Survivor Study, the highest thyroid doses were observed among children first treated for Hodgkin lymphoma [2]. As discussed above, thyroid risk in this study increased with dose up to 20 Gy, after which point there was a decline in the risk [2]. Thyroid cancer is one of the most common second cancers after radiotherapy for Hodgkin lymphoma during childhood and significant increased risks of thyroid cancer have been observed from 5 to more than 40 years after childhood radiotherapy (reviewed in Ref. [3]). Bhatia et al. [4] estimated the cumulative incidence of thyroid cancer to be 4.4% at 30 years after childhood treatment for Hodgkin lymphoma. (See previous reviews for a more detailed discussion of radiotherapy-related thyroid cancer [3],[5],[6]. In addition to cancer treatment, radiotherapy for the treatment of benign conditions, including (but not restricted to) Tinea capitis, hemangioma, and enlarged thymus, has been clearly associated with increased thyroid cancer risk (reviewed in Ref. [7]).

II. THYROID CANCER

According to the WHO, thyroid malignancies are classified as carcinomas, which are by far the most common thyroid malignancies, sarcomas, lymphomas and even less frequent tumours including metastases to the thyroid. This review will focus on thyroid carcinomas, their aetiology, genes that seem

to play a role in their pathogenesis, and clinical aspects, diagnostic and therapeutic ones as well [9]. Four types of thyroid cancer comprise more than 98% of all thyroid malignancies: papillary thyroid carcinoma (PTC), follicular thyroid carcinoma (FTC), both of which may be summarised as differentiated thyroid carcinoma (DTC), undifferentiated (anaplastic) thyroid carcinoma (UTC) and medullary thyroid carcinoma (MTC) [10].

III. RADIATION-INDUCED CANCER

Radiation effects on the thyroid gland were first reported in the 1920s in thyrotoxic patients administered radiotherapy [11]. Later, radioactive iodine was used to reduce the basal metabolic rate in patients with cardiac diseases (congestive heart failure and angina). The first reports on hypothyroidism following radiotherapy for head and neck cancer were published in the 1960s [12]-[14].

More recent examples of the human experience with radiation-induced cancer include the following [15]: thyroid cancer has been observed in children who received radiotherapy for what was thought to be an enlarged thymus. The thyroid was included in the treatment field, and both malignant and benign thyroid tumors have been observed. Breast cancer is also elevated in these individuals [16]-[19].

As recently as the 1950s, it was common practice to use x-rays to epilate children suffering from tinea capitis (ringworm of the scalp). An increased incidence of thyroid cancer from this practice was first reported by Modan and his colleagues in Israel, who treated a large number of immigrant children from North Africa in whom ringworm of the scalp reached epidemic proportions. There was also a significantly increased risk of brain tumors, salivary gland tumors, skin cancer, and leukemia mortality. A comparable group of children in New York for whom x-rays were used for epilation before treatment for tinea capitis show quite different results. There were only two malignant thyroid tumors in addition to some benign tumors. There is, however, an incidence of skin cancer around the face and scalp in those areas also subject to sunlight. The skin tumors arose only in white children, and there were no tumors in black children in the New York series [18]-[23].

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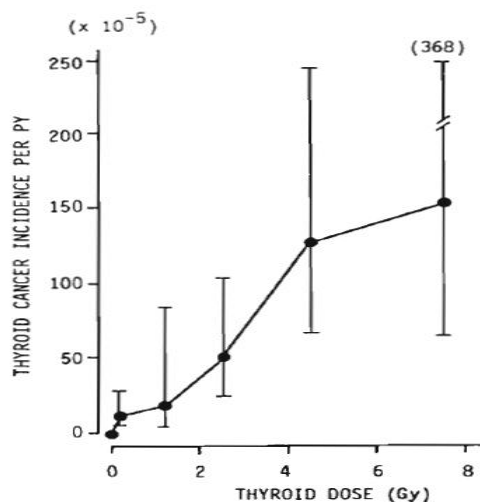


Fig. 1 cancer incidence per person-year (PY) as a function of the radiation dose in the t. Rates adjusted for gender, ethnicity, and interval after irradiation. Error bars represent 90% confidence limits. (From Shore RE, Woodard E, Hildreth N, et al.: tumors following thymus irradiation. JNCI 74:1177-1184, 1985, with permission.)

IV. MATERIAL AND METHOD

A Primus linac (Siemens, Germany) High Energy X-ray machine of the Mahdih Radiotherapy and Oncology, Hamadan, Iran was 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*3.7mm*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 mmol HCl/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 $\pm 3\%$. 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 [24].

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 tumour, 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 tumour to achieve local tumour control, whilst trying to spare surrounding normal tissue.

V. RESULT

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

A. Transmission 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.

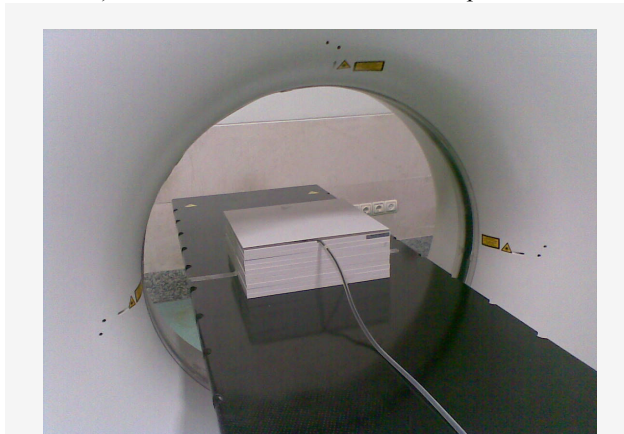


Fig. 2 phantom placed in CT scan device

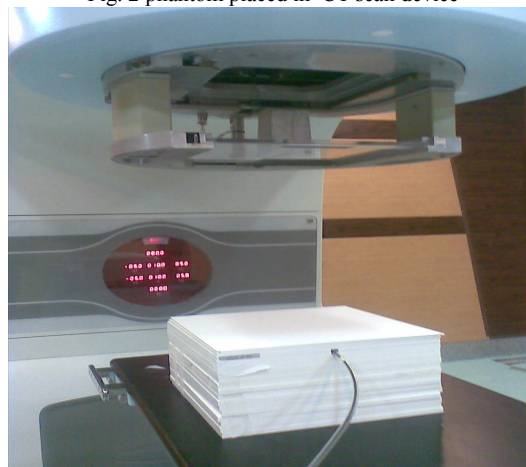


Fig. 3 placement of Tissue equivalent phantom on a flat linear accelerator

B. 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.

TABLE I
THYROID ABSORBED DOSE MEASUREMENTS PER 100 cGy, THE SCATTERED X-
RAYS OF CHEST RADIOTHERAPY FIELD USING TLD

absorbed dose (cGy)	distance from Beside of Field (cm)	TLD
8.352	4	1
8.352	6	2
7.7952	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

VI. CONCLUSION

The thyroid gland is an organ of high sensitivity for radiation carcinogenesis, at least in children; in adults, radiation is much less efficient in inducing thyroid cancer. The malignant tumors that have been produced, however, consistently have been of a histologically well-differentiated type, which develops slowly and often can be removed completely by surgery or treated successfully with radioactive iodine if metastasized; consequently, these tumors show a low mortality rate. It is estimated that about 5% of those with radiation-induced thyroid cancer die as a result.

The Thyroid dose received apparently shielded by cerrobend blocks was about 8cGy in 100cGy Expose three main contributions in the Absorbed Dose to Thyroid During Radiotherapy:

- Due to primary photon beam transmitted through the block : 4 percent for 8 cm cerrobend blocks
- 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.

The use of cerrobend Block, on Thyroid show that reduced the absorbed dose to the Thyroid by 2 to 3 times.

REFERENCES

- [1] National Council on Radiation Protection and Measurements. Scientific Committee 6e2 on Radiation Exposure of the U.S. Population. Ionizing radiation exposure of the population of the united states: recommendations of the national council on radiation protection and measurements. Bethesda, MD: National Council on Radiation Protection and Measurements;2009.
- [2] Bhatti P, Veiga LH, Ronckers CX, et al. Risk of second primary thyroid cancer after radiotherapy for a childhood cancer in a large cohort study: an update from the childhood cancer survivor study. *Radiat Res* 2010;174:751e752.
- [3] Ng AK, Kenney LB, Gilbert ES, Travis LB. Secondary malignancies across the age spectrum. *Semin Radiat Oncol* 2010;20 (1):67e78.
- [4] Bhatia S, Yasui Y, Robison LL, et al. High risk of subsequent neoplasms continues with extended follow-up of childhood Hodgkin's disease: report from the Late Effects Study Group. *J Clin Oncol* 2003;21(23):4386e4394.
- [5] Sinnott B, Ron E, Schneider AB. Exposing the thyroid to radiation: a review of its current extent, risks, and implications. *Endocr Rev* 2010;31(5):756e773.
- [6] United Nations. Scientific Committee on the Effects of Atomic Radiation. Sources and effects of ionizing radiation: United Nations Scientific Committee on the Effects of Atomic Radiation: Volume I: Sources - Report to the General Assembly Scientific Annexes A and B 2008. New York: United Nations.
- [7] Ron E. Cancer risks from medical radiation. *Health Phys* 2003;85(1):47e59.
- [8] S.J. Schonfeld, C. Lee, A. Berrington de Gonz alez"Overview Medical Exposure to Radiation and Thyroid Cancer" *Clinical Oncology* 23 (2011) 244e250
- [9] Oliver Gimm , Mini-review "Thyroid cancer" *Cancer Letters* 163 (2001) 143±156
- [10] B.M. Wenig, C.S. Heffess, C.F. Adair, Atlas of endocrine pathology, W.B. Saunders Company, Philadelphia, PA, 1997.
- [11] Cannon CR. Hypothyroidism in head and neck cancer patients: experimental and clinical observations. *Laryngoscope* 1994;104:1–21.
- [12] Einhorn J, Wilkholm MG. Hypothyroidism after external irradiation of the thyroid region. *Radiology* 1967;88: 326–8.
- [13] Felix H, Dupre N, Drap_eM, Court L. Incidence _a long terme d'une radiotherapie pour cancer du larynx, sur l'aparition d'un myxoedeme. *Lyon Med* 1961;93:1043–50.
- [14] Markson JL, Flatman GE. Myxedema after deep X-ray therapy to the neck. *South Med J* 1965;1:1228–30.
- [15] Hall, Eric J.; Giaccia, Amato J" Radiobiology for the Radiologist, 6th Edition" Copyright ©2006 Lippincott Williams & Wilkins
- [16] Ron E, Lubin JH, Shore RE, et al.: cancer after exposure to external radiation: A pooled analysis of seven studies. *Radiat Res* 141:259-277, 1995
- [17] Rotblat J, Lindop P: Long-term effects of a single whole-body exposure of mice to ionizing radiations: II. Causes of death. *Proc R Soc Lond B Biol Sci* 154:350-368, 1961
- [18] Saenger EL, Thoma BE, Tompkins EA: Leukemia after treatment of hyperthyroidism. *JAMA* 205:855-862, 1968
- [19] Sankila R, Garwicz S, Olsen JH, et al.: Risk of subsequent malignant neoplasms among 1,641 Hodgkin's disease patients diagnosed in childhood and adolescence: A population-based cohort study in the five Nordic countries. *J Clin Oncol* 14:1442-1446, 1996
- [20] Shore RE, Hildreth N, Woodard E, Dvoretzky P, Hempelmann L, Pasternack B: Breast cancer among women given x-ray therapy for acute postpartum mastitis. *J Natl Cancer Inst* 77:689-696, 1986
- [21] Shore RE, Woodard E, Hildreth N, Dvoretzky P, Hempelmann L, Pasternack B: Thyroid tumors following thymus irradiation. *J Natl Cancer Inst* 74:1177-1184, 1985
- [22] Stewart A, Kneale GW: Changes in the cancer risk associated with obstetric radiography. *Lancet* 1:104-107, 1968
- [23] Stewart A, Webb J, Hewitt D: A survey of childhood malignancies. *Br Med J* 1:1495-1508, 1958
- [24] Busuoli G. General characteristics of TL materials. In: Oberhofer M, Scharmann A, editors. Applied thermoluminescence dosimetry: lectures of a course held at the Joint Research Centre, Ispra, 12–16 November 1979, 87. Bristol: Adam Hilger Ltd; 1981. [fig. 5.4(c)].