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ESTIMATION OF RADIATION DOSE TO THYROID GLAND FROM HEAD COMPUTED TOMOGRAPHY: A PILOT STUDY

Radiological Technology

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ABSTRACT

Computed Tomography (CT) scans are invaluable tools in medical diagnostics, offering detailed imaging of various anatomical regions. However, concerns regarding radiation exposure, particularly to radiosensitive organs like the thyroid, have prompted to estimate and evaluate the radiation dose to thyroid gland from head CT scans. The amount of radiation exposure varies depending on several factors including the specific type of CT scan, the settings used during the scan, and the individual's size and age. The results were compared with studies reporting thyroid doses from head CT scans, including dose measurements, dose estimation methods, and dose-reduction techniques. The estimated average thyroid dose from the OSLD measurements in the present study was 0.939+- 0.072 mGy. Though findings of the study is similar to the reported thyroid doses from head CT scans, it is observed that there is a wide variability influenced by scanner technology, scanning protocols, patient characteristics, and anatomical considerations. Understanding thyroid doses from head CT scans is essential for optimizing imaging protocols and minimizing radiation risks without compromising diagnostic efficacy. Establishing local/ regional and national diagnostic reference levels (DRL) is a recommended way forward. Efforts to further minimize radiation exposures especially in pediatric, women and sensitive populations are highly needed. Further large scale multi-centric studies in the region are highly recommended so that the cumulative population radiation dose may be reduced by refining dose estimation techniques, implementing dose-reduction strategies, and assessing long-term health outcomes to ensure safe and effective CT imaging practices.

KEYWORDS

Thyroid dose, head CT, OSLD, DRL

INTRODUCTION

Computed tomography (CT) of head is a tool of great diagnostic value in many clinical conditions and in trauma. Thyroid gland is a radiosensitive organ in the near vicinity of the field of view in head CT scans. In CT examinations, the highest doses to the thyroid gland result primarily from neck and chest scans, and to a lesser extent scattered photons from head scans [1]. The increased use of CT examinations increases thyroid doses and it is of higher risk due to higher radio sensitivity. It is of concern due to the potential risk of thyroid cancers at low doses [2].The thyroid gland cannot be shielded from the scattered radiation dose originates inside the body using external contact shields and hence essential to have an estimate of radiation dose to thyroid from head CT scans [3]. The primary aim of the present study was to estimate the radiation dose to the skin surface of the thyroid gland during head CT scans. Optically stimulated luminescent dosimeters (OSLD) nanoDotTM were used for the dose measurements. Age, sex, scan length, mAs, kVp, pitch, CT dose index, and dose-length product (DLP) [4] were collected.

To estimate the radiation risk involved in diagnostic radiological procedures, it is very important to quantify the scatter dose absorbed by the surrounding organs [5, 6]. Regarding radiation safety and protection, there is a lack of awareness and knowledge among medical professionals as well as general public. The radiation doses and the potential radiation effects are generally under estimated by referring physicians, regardless of their area of practice [7-11]. It is important to balance and optimize the radiation risks for young patients due to their long life expectancy. It is also essential for medical professionals and the general public to be aware and get better educated about radiation risks associated with radiological procedures especially CT examinations. Radiation doses to out of field organs from scatter radiation have been estimated by use of computational simulation models and phantom measurements. It is mostly not directly measured [12].

These estimations may not be accurate for varying demographics like ethnicity, build etc. due to differences in experimental setup specifications and assumptions. Mostly the dose estimates and risk analysis are based on fixed geometry and the assumed shape of the phantoms and hence the interpretation of the real radiation effects can deviate considerably. It is observed that the radiation doses in overweight and obese patients and mostly underestimated by phantom measurements and simulations. Therefore, for an accurate estimation of radiation doses in the regional population the best way is a direct in-vivo dosimetry.

Radiosensitive organs such as the thyroid are at a higher risk of radiation-induced stochastic effects and are highly susceptible to radiation-induced carcinogenesis especially among the young due to a long life expectancy and in females [13]. Stochastic effects are the primary radiation effects, where the thyroid gland cells get mutated with the radiation interaction [14]. The present study was designed to estimate the radiation dose to the thyroid during head CT scans, by measurements using commercially available optically stimulated luminescence dosimeter (OSLD) in a cohort representing regional population.

MATERIALS AND METHODS

Radiation dose measurements were performed for 180 head CT scans done on a 128 Slice CT scanner using optically stimulated luminescent dosimeters (OSLD) nanoDotTM taped appropriately to the skin overlying the lobes of the thyroid gland. Written informed consent was obtained from all patients in accordance with guidelines set forth by the institutional board of the hospital. The ethics and research committee approved the study and a written consent was obtained from all patients prior to the procedure.

Appropriate exposure factors were selected for each of the examination. A commercial OSLD system with Al2O3: C nanoDots as an active radiation detector and InLight microStar® (Landauer Inc., Glenwood, IL, USA) as a readout assembly was used to assess radiation doses to the thyroid in the present study. 10mm×10mm×2mm was the external dimensions of the encapsulated OSLD in light-tight plastic holder. These OSLDs were suitable for measurement of scatter radiation due to their sensitivity to energies as low as 5 keV with an accuracy of ±10% in the diagnostic energy range. The dosimeters were calibrated in the same exposure conditions and the readouts were adjusted for the background.

The OSLD readout is representative of the radiation dose at the skin surface of neck over the thyroid gland. To calculate the radiation dose to the thyroid, organ dose conversion factor is used to multiply the measured dose [15]. The organ dose conversion factors were estimated using a locally fabricated anthropomorphic heterogeneous phantom in a setting same as the examination settings [16].

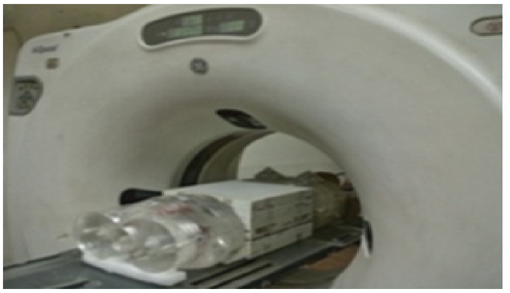

Figure 1: In-house fabricated anthropomorphic heterogeneous phantom for estimation of organ dose conversion factors

RESULTS AND DISCUSSION

One hundred and eighty patients, 100 men and 80 women were included in the study. The mean age of the patients was 51+/- 16. Adult patients who underwent head CT only were included in the study. In this prospective study radiation dose to thyroid was estimated using OSLD measurements and CT characteristics, such as CTDIvol, DLP, patient size, scanning length, tube current and potential were also noted. A measurement of the radiation dose due to the primary and scatter radiation per slice of tissue expressed in mGy is termed as CTDI. DLP provides a measurement of the total amount of dose to the entire scan coverage and expressed in mGy.cm. To estimate the dose received by the thyroid gland, OSLD measurements were carried out. In this study, Factors including tube voltage, tube current, slice thickness, and contrast amount were considered in assessing radiation exposure. It was observed that CTDIvol, DLP, and effective dose values varied slightly between males and females. They are useful metrics for optimization and setting DRLs for CT [17, 18]. It is also understood from the observations that the effective dose is dependent on the variation in exposure and patient parameters and hence important to optimize the CT acquisition protocols individually to reduce radiation doses received by the patients while maintaining the image quality to ensure accurate diagnosis. The estimated average thyroid dose from the OSLD measurements in the present study was 0.939+- 0.072 mGy which is comparable to other published results of similar studies and on a lower side [1, 19, 20].

The radiation dose to thyroid estimated in the present study could be used as a potential reference to guide in the assessment of the risk-benefit ratio of a head CT examination in adults by the clinicians. For instance, risks of radiation exposure from a diagnostic CT scan are less likely to be significant for cancer patients of head and neck aged over 50 years who undergo multiple neck CT examinations for staging and assessment of treatment response. On the other hand, for younger patients who had to be evaluated with head CT for possible trauma, posttraumatic injury or infection, the thyroid dose and cancer risk considerations are critical [21, 22]. An estimated 1 in 8100 women who had a routine head CT scan at age 40 years (1 in 11 080 men) will develop cancer from that CT scan [23, 24]. The incidence of thyroid cancer is more probable due to its higher radio sensitivity. The absorbed dose to the thyroid may be secondary factor in estimation of the corresponding carcinogenic risk, the most important factors are patient age at the time of exposure and sex [2]. Hence, adopting strategies for dose reduction in pediatric head CT scans, such as the use of pediatric-specific protocols, iterative reconstruction techniques, and dose-tracking software are of greater importance.

Despite the recognized importance and need for DRLs, very few have set DRLs and there is a complete lack of pediatric DRLs. Only in about one fifth of the countries are the existing DRLs based on own national patient dose surveys [25]. In India, a diverse country with substantial variations in affordability and availability of advanced computed tomography systems, no unified or controlled attempt is made to establish national DRLs for head CT or other radiological examinations.

In this study, dose measurements were performed for 180 adult patients who underwent head CT scans in a single CT machine. This may not be a highly accurate representation of the regional population. Further studies shall be conducted for each of the CT machines in all associated hospitals of the institute as well as other centers in the city at the least to further study and optimize the effects of CT scanner technologies, imaging protocols and CT scanner settings. In this study, the thyroid doses were estimated, a long term follow up is essential to assess the effects of radiation doses to the thyroid clinically in the chosen cohort of patients.

CONCLUSIONS

CT scans are essential part of diagnostic workup in various clinical conditions. Awareness of radiation doses to the thyroid from head CT scans is crucial for optimizing imaging protocols, minimizing radiation risks, and ensuring patient-specific care. In order to establish the regional/local dose reference levels for head CT scans, patient radiation dose data set needs to be created after optimizing the protocols followed for various procedures. Optimizing the practices and dose measurements helped to bring down the patient doses. Regular update of knowledge and training are essential for lowering radiation dose to the patients as well as to the professionals.

As inferred from the literature review, regular follow up helps in significantly reducing the set DRLs. A large scale multi-centric study in the region is highly recommended so that the cumulative population radiation dose may be reduced.

By advancing the understanding of thyroid doses from head CT scans, it is intended to enhance patient care, improve radiation protection measures, contribute to evidence-based decision-making in clinical radiology, and setting up of local or national DRLs for the procedure by laying the groundwork for optimizing imaging protocols and ensuring the safe and effective use of CT imaging in clinical practice.

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