ORIGINAL ARTICLE

Thyroid Cancer Risk in Patients Undergoing 64 Slice Brain and Paranasal Sinuses Computed Tomography

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Abstract

Purpose: Computed Tomography (CT) is a fundamental part of diagnosis of diseases. During CT examinations organs in and out of scanned volume are exposed to ionization radiation. The aim of this study was Estimation Thyroid cancer risk in Patients who Underwent 64 Slice brain and paranasal sinuses CT scan.

Materials and Methods: with permission from the authors and editor, data related to thyroid dose of 40 patients in Mazyar *et al.*'s paper was used and by using Biological Effects of Ionizing Radiation (BEIR)VII model thyroid cancer risk was calculated for different ages at exposure in male and female.

Results: In both brain and paranasal sinuses CT, ERR values in female patients were twice as many as those in male patients. At age range from 20 to 40 years, ERR was considerably more than at age range 40-60 years since young patients are more radiosensitive than old patients.

Conclusion: The calculations of ERR indicate that PNS and brain CT increase the theoretical risk of thyroid cancer incidence. Although the ERR values are low, impacts on the thyroid cancer incidence should not be disregarded.

Keywords: Thyroid Cancer Risk; Biological Effects of Ionizing Radiation VII Model; Computed Tomography; Brain Computed Tomography; Paranasal Sinuses Computed Tomography.

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1. Introduction

Nowadays, medical radiation is a fundamental part of diagnosis and treatment of diseases. National Radiological Protection Board (NRPB) reported that 90% of the radiation is associated with X-ray examinations [1].

In the UK population, Computed Tomography (CT) contribution from medical exposure was 47% in 2001/2002. This amount increased by 2 to 4 folds compared to 1997/1998 [2].

The main advantage of CT is high low-contrast resolution compared to radiography, nuclear medicine, and ultrasonography that is an important reason for this modality [3].

In 1998 and 1999, at the University of New Mexico, Health Sciences Center evaluated diagnostic radiology procedures. The results showed these procedures increased nearly 60% during the last decade, and CT examinations increased rapidly to 81% compared to the last decade. After abdominal/pelvic CT, head CT was the highest percentage of all CT examinations (33.7%). The age distribution of patients undergoing CT examination showed the most number belonged to 36-50 year-old group [4].

During radiology procedures, organs near the exposed areas received scatter dose one of the most important complications of which can refer to carcinogenesis. In head and neck, the most sensitive organ to ionization radiation is thyroid gland, and significant contribution from incidence of thyroid cancer was related to head CT examination, especially in childhood [5].

Incidence of thyroid cancer has dramatically grown over the past decades worldwide; the reasons for increasing this cancer is still unclear, but they may be due to life style, sexuality, certain inherited genetic syndromes and medical exposure [6].

The rapid development of Multi Detectors Computed Tomography (MDCT) in the late 20th century resulted in quick increase in CT use in current decades. This high CT use has caused an increase in thyroid cancer incidence, especially in women. These pieces of evidence show that we should not deny cancer incidence by utilizing CT [7].

In CT examination, organs placed in or out of scanned volume can be exposed to damage. For organs out of scanned volume, received dose is a consequence of scatter radiation. The measure of scatter radiation produced around the CT scan devices varies depending on the manufacturing company, characteristics of tubes (KVp, mAs, pitch, and etc.), CT protocols, the number of detectors, and slices [8-10]. The aim of this study was to estimate the thyroid cancer risk in patients undergoing CT scan in brain and Paranasal Sinuses (PNS).

2. Materials and Methods

In this study, thyroid absorbed dose in Mazyar *et al.* related to 40 patients range from 40 to 85 years old, who underwent brain and sinus CT scans, was used [11, 12]. Using these dose of patients, thyroid cancer risk was calculated during nominated CT examinations.

Imaging protocols in Mazyar's paper were done by 64 sliced CT scan (Siemens, Germany). Scanning conditions for brain scan were as follows: kV = 120, mAs = 200, slice length = 1.2 cm, FFD = 160 Cm, total scanning time = 8 s, and the length of the scanned area was ranging between 12.5 and 13 Cm, rotation time = 0.5 s, slice number=7–8, based on the patient. Furthermore, scanning conditions for sinus scan were as follows: kV = 100, mAs = 90, slice length = 1.2 Cm, FFD = 160 Cm, total scanning time for uni directional scan = 6 s and total scanning time for bi directional scan = 8 s, rotation time = 0.5 s, slice number = 6–7. In addition, the lengths of scanning area according to the patient for uni directional and bi directional sinus scans were 12–13.5 Cm and 13–14 Cm, respectively.

In order to measure thyroid dose during CT in these examinations, Thermo Luminescence Dosimeter (TLD) was used, and to measure the thyroid dose, for each patient, three TLD tablets were placed on the skin area of thyroid gland by anti sensitivity glue. Table 1 indicates the mean doses of thyroid radiation in PNS and brain CT scan using TLD [11].

Table 1. Measured mean dose of thyroid by TLD in Mazyar *et al.* study

CT examination	Minimum absorbed dose by thyroid (mGy)	Maximum absorbed dose by thyroid (mGy)	Mean (mGy)	SD
Brain	0.69	0.91	0.8	0.05
PNS	0.53	0.74	0.66	0.05

For the estimation of thyroid cancer risk, Biological Effects of Ionizing Radiation (BIER)VII model was used [12]. This model is based on the analysis of atomic bomb survivors and is used for doses below 1Gy and low LET radiation. For the estimation of cancer risk, parameters such as Excess Absolute Risk (EAR) and Excess Relative Risk (ERR) are used. For thyroid cancer, BEIR VII committee just used ERR model for calculation risk.

$$ERR(D,s,e,a) = B_S D \exp\,[\gamma(e-30/10](\frac{a}{60})^{\eta}$$

Where, D, e, and a are the average organ dose, age at exposure and attained age (any age which cancer risk is calculated), respectively. Table 2 indicates other parameters like B_S, γ, and η depending on the type of model (EAR or ERR). B_S, ERR at age-at-exposure 30 and attained age 60, tends to be larger for females than males, γ = -0.4 implies the radiogenic risk of cancer at age e falls by about 25% for every decade increase in age-at-exposure up to age 30, and η = -1.4 implies the ERR is almost 20% smaller at attained age 70 than at age 60. ERR, in this model is independent of attained age and is reported for 10,000 people; therefore, ERR for ages at exposure (from 20 to 60) was calculated.

Table 2. Parameter values for ERR in BEIR VII models

	B_{male}	B_{female}	γ	η
Thyroid	0.53	1.05	-0.4	None

3. Results

In paranasal sinuses CT examination, thyroid glands are closer to radiation field compared to brain CT, but the thyroid underwent 21% more dose in brain CT rather than PNS CT that can be due to low dose protocol and scan time in PNS CT.

ERR data of thyroid cancer for PNS and brain CT from age at exposure of 20 to 60 years for male and female are given in Figure 1. ERR for thyroid at these ages at exposure is calculated for 10,000 people. These values show the risk of thyroid cancer in young people exposed to medical radiation.

These ages show that younger patients would be at a higher risk of thyroid cancer at the time of exposure and older patients at a lower risk. The ERR values are the lowest for PNS CT in male patients and the highest for brain CT for females.

In both brain and sinus CT, ERR values in female patients were twice as many as those in male patients. The most ERR of thyroid cancer was related to brain CT in female patients. At age range from 20 to 40 years old, ERR was considerably more than at age range 40-60 years old since young patients are more radiosensitive than old patients.

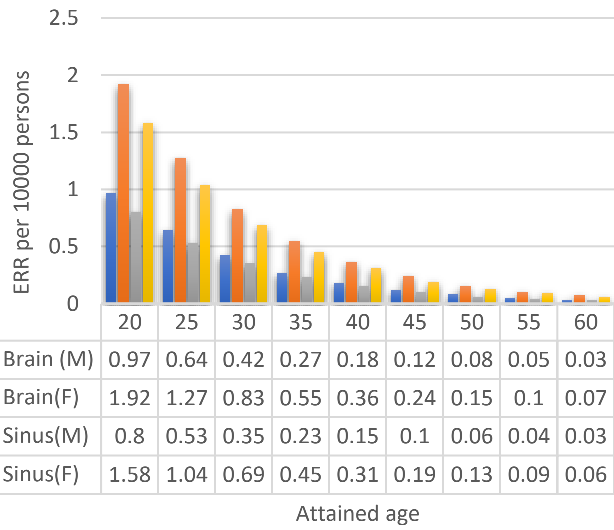

Figure 1. ERR/mGy in 10,000 people for brain and sinus CT in males and females at different ranges of age from 20 to 60 years old

4. Discussion

In this study, thyroid cancer risk is estimated in patients undergoing brain and sinus CT. In head CT examination, box scan in sinus CT was closer to thyroid gland rather than brain CT; apparently, people might expect thyroid cancer risk to be higher in sinus CT, but it did not happen. The reasons for that were the administration of different exposure technique, low scan volume and short time.

ERR values showed that the risk of thyroid cancer would be higher in young patients exposed to CT examination. By increasing age at exposure of patients, ERR is reduced exponentially in each examination for males and females.

In BEIR VII model, unlike other organs, thyroid is independent of attained age and just depends on dose and age at exposure. Based on our calculations, ERR/mGy in brain CT was more than PNS CT and in females, it was almost twice as many as in males. As we calculated, the most ERR belonged to young patients, and with increasing age, the ERR was decreased exponentially.

For patients exposed after 40 years of age, the risk of thyroid cancer is very low compared to before 40 years of age. Therefore, performing techniques for reducing the dose of thyroid and consequently ERR of thyroid for younger patients is necessary.

As investigated, radiation effects are sex-specific, and long-term radiation sensitivity in females is higher than that in males. The most common radiation-exposure associated with morbidities in females and males was related to thyroid [13]. According to our calculation of ERR, the risk of thyroid cancer for female patients was higher than that for males in each examination.

Among 680,000 childhood patients under 20 years of age that had undergone CT examination, cancer incidence after nearly 10-year follow-up was 24% greater than unexposed children. Increase in cancer was generally due to irradiation [14].

Monte Carlo simulation showed that for brain and paranasal sinuses CT in children, thyroid cancer risks are 65 and 36 per million patients, respectively. Results of this simulation considered the risk of thyroid cancer low, but we should not neglect the cancer risk for sensitive organs outside scanned box [15].

In a study with the aim of estimating thyroid cancer risk in patients who underwent coronary angiography using 64-slice multi-detector CT, results showed that Life time Attributable Risk (LAR) for thyroid in females was 3-4 folds that in male patients, and the range of 20-30 years old had the most LAR although LAR for 20-year-old patients was 2.5 folds that of 30-year-old patients in both genders [16].

For decreasing received dose and consequently thyroid cancer risk, performing some factors which affect the quantity of exposure can reduce thyroid cancer risk. These factors include mAs, kVp, filtration, and distance. Received dose has a direct relationship with the proportion of the mAs and square of kVp [17].

In Mazyar's study, using low dose protocol in PNS CT (kV = 100, mAs = 90 versus kV = 120, mAs = 200 for brain CT) for decreasing eyes dose significantly resulted in bringing down the risk of thyroid cancer. Using low dose protocol instead of standard protocol for paranasal sinuses by reducing mAs from 100 to 40 resulted in reduction of thyroid dose by nearly 40% without significant effect on image quality.

In CT for organs which are out of scanned box, received dose of these organs are consequences of scatter and leakage radiation. Scatter radiation in Multi-Detectors CT(MDCT) scanners were evaluated in different manufacturing companies. In brain CT, thyroid dose in 64-MDCT GE scanner was lower than 64-MDCT Siemens scanner (0.05 cGy vs 0.12 cGy). Increasing dose in Siemens scanner was related to gantry tilt [18]. Also comparison of thyroid dose in head and neck CT by using 16-MDCT with sequential and spiral modalities, it was found that dose in spiral modality was more than that in sequential modality [19].

Therefore, for reducing thyroid cancer risk in PNS and brain CT examinations, in addition to lead shielding, performing some techniques like reducing tube current, using a short geometry scanner, decreasing scanning length and time, and sequential modality can be effective.

5. Conclusion

The calculations of ERR indicate that PNS and brain CT increase the theoretical risk of thyroid cancer incidence. ERR of thyroid cancer incidence up to 0.02% was associated with brain and PNS CT. Brain CT may have a favorable impact on thyroid cancer risk in younger patients. Although the ERR values are low, impacts on the thyroid cancer incidence should not be disregarded.

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