Original

Evaluating the Necessity and Radiation Risk of Brain CT Scans Requested by the Trauma Emergency Department

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ABSTRACT

Background: Numerous Computed Tomography (CT) scan requests for trauma patients have raised serious concern about the impacts of radiation such as radiation-induced cancers.

Objective: This study aimed to evaluate the necessity rate of requested head CT scans for traumatic patients and to ultimately estimate the risk of radiation-induced brain cancer.

Material and Methods: In this retrospective analytical study, traumatic patients, who had undergone a head CT scan in a two-month period from August 23 to October 22, 2018, were considered as the study population. Two radiologists reviewed each patient individually to evaluate the rate of normal and abnormal cases. Dose length product in milligrays (mGy) was utilized to calculate the effective dose (ED) in millisieverts (mSv), resulting in an assessment of the risk of radiation-induced brain cancer using ICRP 103.

Results: Among 523 scans, 460 patients (88%) received normal reviews, while only 47 patients (9%) had findings related to their current trauma. The mean effective dose value was 1.05±0.36 mSv. Risk of the radiation induced brain cancer was calculated to be 0.037 and 0.030 new cancer cases in 10000 males and females per Gy, respectively.

Conclusion: Final results demonstrated that a significant number of traumatic patients undergoing a CT scan are in fact, healthy. Such reckless usage of CT and consequently the excess exposure could result in a dramatic rise in cancer rates. The need to limit unnecessary CT scan usage and keeping the radiation given to patients as low as reasonably achievable (ALARA) when collecting essential diagnostic data is more critical than ever.

Keywords

Neoplasms, Radiation-Induced; Trauma; Tomography, X-Ray Computed; Diagnostic Imaging

Introduction

Since Computed Tomography (CT) has significantly improved, it is a frequent modality among radiology experts [1]. In 2017, an annual of 72 million CT scans were performed in the United States [2]. It is estimated that this number increases by nearly 10% every year [3]. Factors such as availability, efficiency, and non-invasive nature along with high image resolution and diagnostic accuracy have turned CT scan into a gold standard for different medical observations [1, 4]. CT scan imaging can have significant benefits such as improving certainty in diagnoses, reducing hospitalization and mortality rates [5]. While a CT scan can be obtained from various body parts such as thorax, abdomen, extremities[6], the use of it as a fast yet accurate method for evaluation of trauma cases, especially traumas to head, is an international trend [7]. This trend becomes even more favorable when it's noted that head trauma is the main cause of death or hospitalization of almost 10 million people annually as reported by World Health Organization (WHO) [8].

As compared to conventional radiography, CT scan delivers a much higher radiation dose, making it responsible for a major proportion of medical exposure [7, 9-11]. For instance, only 4% of performed diagnostic studies in Britain included CT scans, making up over 40% of medical radiation dose [12]. The average absorbed dose from a single CT scan can range from 2 to 20 millisieverts (mSv), with a mean of 2 mSv for a head CT and 10 mSv for an abdomen or pelvis examination [2]. The absorbed dose from a single brain CT scan is equivalent to performing 38 posterior-anterior (PA) chest radiographs or the natural background radiation absorbed in a 3-month period in the United States [13]. This suggests that CT scan is more likely to induce malignancies such as different cancers [14-16]. As claimed by De González et al., almost 30 thousand cancers are induced due to the ever-growing usage of CT scan in the United States [17]. The absorbed radiation dose from a single head CT scan is capable of inducing a malignant tumor in the brain. This dose is even more life-threatening to children as they have a higher radiation sensitivity with a longer life span to develop side effects [9, 18, 19].

This threat becomes more critical considering that most of the CT scans performed all over the world are unjustifiable and acting as a mean to increase the radiation dose exposed to a patient [4, 13, 20, 21]. Just like other countries worldwide, rates of unnecessary CT requests are also extremely high in Iran. As claimed by a study conducted in Isfahan, Iran, almost 80% of CT scan requests were unjustifiable [22]. This rate was 88% in another study conducted in Shiraz, Iran [23].

This study aimed to evaluate the rate of brain CT scans performed on traumatic but healthy patients and the unnecessary dose imposed on society in the trauma emergency department of Ayatollah Mousavi Teaching hospital in Zanjan, Iran, within a two-month period. Ultimately the Risk of Radiation-Induced Cancer (RRIC) was carefully calculated and announced.

Material and Methods

Study population

In this retrospective analytical study, the required data was collected under the supervision and approval of the Health and Biomedical Information System of Zanjan University of Medical Sciences (Ethics code: IR.ZUMS.REC.1398.361). Hospital's picture archiving and communication systems (PACS), were utilized to extract the medical data of patients, who had visited the trauma emergency department of Ayatollah Mousavi, a teaching hospital for two months from August 23 to October 22, 2018. Besides, patients who were not categorized as "trauma emergency cases" or did not require a head CT scan, were excluded. Also, patients with unrelated pathological findings to the current trauma such as surgical and/or post-trauma traces, calcifications, or any other stochastic findings were considered "Normal". "Abnormal" patients had findings directly related to their recent trauma and therefore needed medical attention. Interpretations were done by a radiologist and revised by another radiologist for maximum reliability and accuracy.

Data collection

More than one thousand patients visited the emergency department in the given period. Among them, the patients, who referred to the "Trauma Emergencies" and underwent a brain CT scan, were included in the study. Finally, 550 patients with their information, including ID, age, sex, date of visit (day or night), dose length product (DLP) due to scan and CT scan images were stored, listed, and carefully reviewed. The time and date of patient registration were considered as a source for corresponding data. All of the scans were performed by a 16 slice SOMATOM Siemens CT scanner (Siemens Health-care, Erlangen, Germany).

Radiation Dose calculation

Firstly, DLP (mGy) was extracted from PACS. Secondly, the effective dose (ED) in millisieverts (mSv) was calculated by multiplication of the DLP by the proper conversion factor (k) based on the patient's age (Equation 1). Table 1 shows the k factors used based on the patient's age, and the relative k value was extracted from the AAPM report NO.96 [24].

$$\text{Effective Dose (mSv)} = k \times DLP \quad (1)$$

Table 1: Dose Length Product (DLP) to effective dose conversion factors based on patient's age for Head Computed Tomography (CT) scan (Values are obtained from the The American Association of Physicists in Medicine (AAPM) report NO.96).

Patients' Age (years)	Conversion factor (mSv mGy^{-1} cm^{-1})
0	0.011
1	0.0067
2-5	0.0040
6-10	0.0032
More than 10	0.0021

The Risk of Radiation-Induced Cancer (RRIC)

The risk of radiation-induced brain cancer was assessed using the International Commission of Radiological Protection report number 103 (ICRP 103) [25] for Asian people.

In order to calculate the risk of primary cancer induced by radiation, the ratio of mean effective dose to mean DLP (mSv/Gy) was calculated for the study population according to ICRP 103 and Sohrabi et al, [26].

Then the risk of radiation induced new cancer cases per 10000 people per Gy (RRIC) was calculated using equation 2.

$$\text{RRIC}\left(\text{new cases per 10000 persons per Gy}\right) = \text{NCRC} \times \text{mSv/Gy} \quad (2)$$

NCRC is the Normal Cancer Risk Coefficient for the brain which is 0.0157 and 0.0131 for men and women respectively based on ICRP 103.

Statistical analysis

All of the calculations and analyses were conducted using IBM SPSS statistics version 20 (SPSS Inc. Chicago, USA). The results are represented as mean ± standard deviation (SD) or number (percentage). Independent T-test was used for the statistical analysis. A value of $P<0.05$ was considered statistically significant.

Results

Of all the patients, who had visited the trauma emergency department of Ayatollah Mousavi, a teaching hospital from August 23 to October 22, 2018, 550 patients met the inclusion criteria of our study. 367 of cases (66.7%) were male patients with a mean age of 33.61±21.89 years and 183 cases (33.3%) were female patients with 36.71±21.31 years of mean age. The mean age for the study population was 34.64±21.73. 440 (80%) scans were acquired during day shifts while the remaining scans (110 scans (20%)) were performed during night shifts.

Among all the 550 desired cases, images

of 27 patients were missing in PACS due to unknown reasons. Hence, they were excluded from further reports and analysis. Between the remaining 523 valid patients, 460 patients (88%) received normal reviews, while only 47 patients (9%) had noticeable findings related to trauma and thus were considered abnormal. The mean value of the effective dose in mSv given to the study population was 1.05±0.36, which was 1.080±0.37 and 1.001±0.33 mSv for men and women, respectively.

Among all 47 abnormal patients, the following criteria were observed: 1) 25 patients (4.8%) were diagnosed with subperiosteal hematoma, 2) 7(1.3%) patients showed evidence of contusion hematoma, 3) 4 cases (0.8%) had subarachnoid hematoma while only 1(0.2%) case of epidural hematoma was observed and among all, and 5) 10 cases (1.9%) included bone fractures. 16 patients (3.1%) were rated diagnostically unevaluable by the reporting radiologists.

Based on statistical analysis, there was no statistically significant difference between the ED of patients examined during day shifts and night shifts (*P-value>0.05*). Also, there was no statistically significant difference between the ED of normal and abnormal rated patients (*P-value>0.05*).

The results revealed a statistically significant difference between the ED received by male patients (1.08±0.37) and that of female patients (1.00±0.33) (*P-value<0.05*). Moreover, the mean ED of unevaluable scans was greater than the mean ED of evaluable scans (1.33±0.59 and 1.04±0.36 respectively, *P-value<0.05*). Figure 1 represents a summary of mean effective doses in different classifications of patients in this study.

The Risk of Radiation-Induced Cancer (RRIC)

In new brain cancer cases, RRIC was 0.037±0.04 and 0.030±0.05 in 10000 people per Gy for men and women, respectively, i.e. each Gy of exposure given to the study population causes 37 new cases of brain cancer in 10 million men and 30 new cases of brain cancer in 10 million women.

Discussion

The extensive use of CT scan has caused

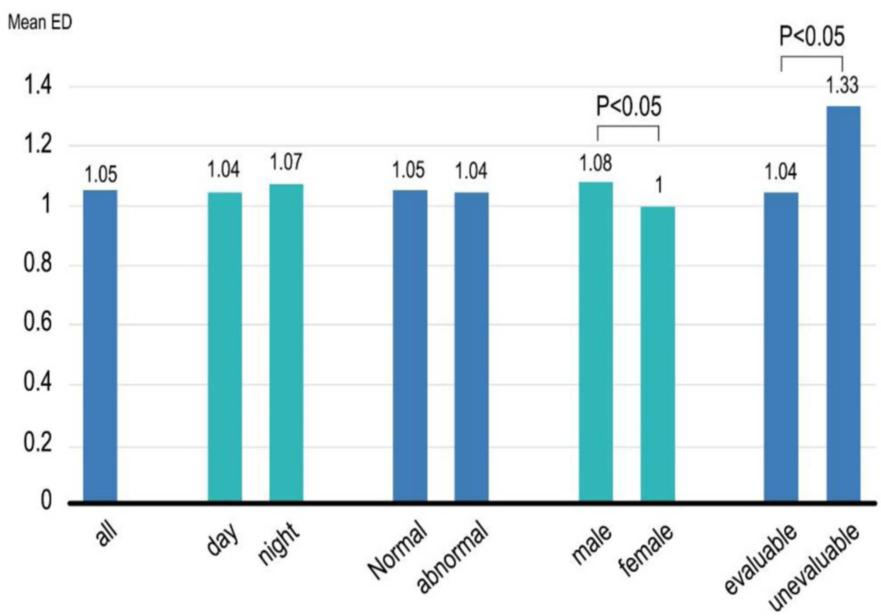

Figure 1: A summary of the mean effective doses (ED) in different groups of the study population

growing concern about the undesired side effects of radiation. This study was carried out to review the number of necessary scans based on their results and to estimate the harmful effects of radiation due to performed scans. Final results suggested that almost 67% of the studied population were men, which was twice the number of women. This statistic shows that men may face more risks and physical traumas in their daily lives than women. in Iran. Men built 72% of study population in the study conducted by Chaparian et al. [22], while only 55% of the study population undergoing brain CT scans were men in Masjedi's study in Yazd, Iran [13]. Another study in Shiraz showed a value proximal to Masjedi's study, in which the number of men and women were almost the same for 167 patients [23]. In a study in Turkey, 53% of the study population were men [21]. Results also demonstrated that the mean age of study population was 34.64±21.73 years totally, which was 45.17 ± 21.73 for Chaparian et al. [22], 45±19 for Tatar et al. [21], and 55±27 for Masjedi et al, [13].

The calculated mean value of ED for a brain CT scan was 1.05 mSv, which is as close as possible to the value observed and announced in [13]. This value is lower than the average dose suggested by Schultz et al. (2 mSv) [2] and Schegerer et al. (1.6 mSv) [27]. This diversity could be caused by the usage of different CT scanners, different scan protocols, and/or different exposure factors, etc. Also, body habitus differences can support the difference in effective doses. Statistical analysis showed a significant difference in the ED absorbed by men and women (*P-value*>*0.05*), claiming that men receive higher doses of radiation, resulting in more danger of radiation-induced diseases like cancer compared to women. Probable reasons for this outcome are different from the anatomy of the male and female body such as differences in head size. As mentioned above, 16 patients had diagnostically unevaluable CT scans due to incomplete scan, patient movement, and low scan quality. These scans do not provide adequate information to the treating physicians and also result in an effective dose of 27% more than the evaluable scans. (*P-value*>*0.05*). Based on our findings, the mean value of ED for scans performed in day shifts was 1.04, while that was 1.07 mSv for night scans. Statistical analysis proves that there was no significant difference between the ED and the time of scan acquisition (*P-value*>*0.05*). To the best of our knowledge, no other study has compared the ED of scanned patients in the day and night shifts.

The rate of normal CT scans was carefully calculated. 88% of CT scans were reported normal without any specific abnormaloties, and therefore were considered unnecessary. Among abnormal scans, subperiosteal hematoma, bone fracture, and contusion hematoma were the most frequent findings. There was no statistically significant difference between the mean ED of Normal and abnormal scans. (*P-value*>*0.05*)

The rate of unjustifiable CT scans was 81% in the study by Chaparian et al. [22] and 88% in the study by Haghighi et al. [23] in Iran. Similar studies in different countries suggest similar results as well [20, 21, 28]. These results demonstrate that not only a huge amount of budget and time was spent, but also patients received major unnecessary doses, resulting in more concern about the patients as the present study examined the patients during just two months. It should be noted that the results of this study (the incidence of brain cancer in 37 men per one million men and 30 women per one million women) are obtained by analyzing the CT scans performed in one of the hospitals in Zanjan province in only a period of two months. Considering that during the years 2016 to 2018, only 58 cases of brain cancer were identified in Zanjan province [29] and comparing it with the findings of this study and that the number of CT scans performed in a year or a decade is much greater than in this study, and the increasing number of CT scans, we can conclude the in a not too distant future we will probably face a full-blown catastrophe related to radiation-induced brain cancers.

Conclusion

Final results demonstrated that many CT scans conducted on the patients are not necessary, resulting in more exposure to the radiation and a rise in cancer rates. Thus, it is recommended to limit the unnecessary usage of CT scans, i.e. we should adhere to the ALARA principle (as low as reasonably achievable) more than ever.

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Conflict of Interest

None

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