Assessment of Effective Dose from Brain CT

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Introduction

Computerized tomography (CT) can provide detailed information to diagnose, plan, treat and evaluate many cases in adults and children. Additionally, detailed images provided by CT may eliminate the need for exploratory surgery.

The X-Ray dose used in CT is higher than the used in radiography, but is still generally low. The risk from the radiation dose in CT is relatively low. As a general rule, the higher the radiation dose, the greater the risk.

Radiation dose from CT procedures varies from patient to patient. A particular radiation dose will depend on the size of the body part examined, type of procedure, type of CT equipment, and its operation.

Because different tissue and organs have varying sensitivity to radiation exposure, the actual radiation risk to different body parts varies too. Effective dose is used when referring to the radiation risk averaged over the entire body. We studied the dose originated from brain CT exams and reaching various body organs.

The amount of radiation dose received by a patient during brain CT, is calculated by each scanner and compared to a calculation made by Virtualdose software.

Two comparisons were made in this study:

1. Dose variation between two different CT scanners.
2. Dose variation between two CT scanners and Virtualdose software.

The importance of the study stems from the following:

1. This study is the first of its type in assessing radiation dose variation between different CT scanners manufactures installed in Palestine.
2. Assessing radiation dose originating from different types of CT scanners.
3. Comparing radiation dose originating from installed CT scanners with Virtualdose calculation software.

Literature review

In the last decade both the number of powerful CT scanners and the number of patient investigations increased with a consequent increase of the patient radiation dose. There are large dose variations (more than 10 fold) among individual CT centers and it remains true if they include the same model of CT scanners.(1)

A recent study by Aldrich and Williams (2) quantified changes in numbers of radiology exams at Vancouver General Hospital from 1991 to 2002 and examined the correlation to the radiation dose received by the pt. In addition to a 4-fold increase in CT exams, they also found that the average annual effective dose per patient almost doubled during the study period, from 3.3 mill siveret (mSv) in 1991 to 6.0 mSv in 2002. Other studies have described the average axial scanning effective dose for various regions of the body as 6.2 mSv. [3] Aldrich and Williams concluded that CT is the largest contributor to patient dose in radiology. This could be because more CT scanners are in use and their performance has been enhanced, along with increasing indications for CT exams.

In 2003 it was estimated that up to 29% of all CT units in the United States where capable for performing multidetector spiral scans, and it is likely that this number is much higher now.

Other study for radiation dose for routine clinical adult brain CT: variability on different scanner at one institution, done by Tracy A. Jaffa[4], Jenny K. Hoang, Terry T. Yoshizumi, Greta Toncheva, Carolyn Lowery and Carl Ravin in August 2010.

Twenty metal semiconductor dosimeters were placed in the brain of male anthropomorphic phantom scanned three times with a routine clinical brain CT protocol on four scanners from one manufacturer in four configurations. Absorbed organ doses were measured for skin, cranium, brain, lens of eye, mandible and thyroid.

Organ dose ranges were as follows: cranium, (2.57-3.47 centigray (cGy)); brain (2.34-3.78 cGy); lens (2.51-5.03 cGy), mandible (0.17-0.48 cGy) and thyroid (0.03-.028 cGy).

Statistically significant differences between scanners with respected to dose were recorded for brain and lens ($p<0.05$). Effective dose ranged from 1.22 to 1.86 mSv.

CT of the brain should be performed with careful head positioning and shielding of the orbits. These precautions are especially important for patients who need repeated scanning and for pediatric patients.

Methodology

3.1. Introduction:

Effective dose measured by two CT scanners was compared to show any differences in organ doses. Also, a comparison between effective dose measured by two CT scanners and Virtualdose software was carried out to assess conformation of measurements between software and CT scanners.

The study was conducted in:

1. AL-AHLI Hospital, Hebron City.
2. Palestinian medical complex, Ramallah City.

3.2. CT scanners used for comparison include:

1. GE Discovery CT 750 HD, AL-AHLI Hospital.
2. Philips brilliance 64 slices, Palestinian medical complex.

Parameters of each scan during routine Head CT scan are listed in Table1.

Table1: CT Scanners Parameters.

Parameters	GE	Philips
Kvp	120	120
mAs	200-320	350
Collimation	20mm	40mm
CTDIw*	29.63-33.93	35.58

*CTDIw: Computed tomography dose index weighted.

Data were collected from 60 adult patients from two hospitals. Brain CT examinations were retrospectively used to calculate the effective dose using Virtualdose software.

3.3. Calculation Software:

Virtualdose is a radiation dose tracking and reporting software tool for radiologists, radiological technologists, medical physicists, regulators, manufactures and researchers who are interested in tracking and managing CT radiation dose.(5)

Anthropomorphic phantoms constructed from tissue-equivalent materials have historically been used to provide a physical representation of the body's anatomy and attenuation characteristics for radiation dosimeter studies. In order to provide a representation of the human anatomy, these commercially available phantoms typically use three tissue equivalent materials imitating bone, lung, and soft tissue.(6)

3.4. Measurements:

Effective dose values from Brain CT were used. Factors used for software calculation were extracted from each scanner. Factors include:

1. Computed tomography dose index volume (CTDIv).
2. Type of CT scanners.
3. Pitch.
4. MAs.

5. Kvp.
6. Collimation.

Virtualdose-software uses CTDIw, which is calculated using the following formula:

$$CTDIw = CTDIv*pitch$$ [7]

We also used effective dose values measured by each CT scanner to be compared with calculated values from software.

To make a comparison between the effective dose between CT scanners and Virtualdose – software, we need to calculate the effective dose from CT scanners which use Dose Length Product (DLP), it's calculated from the following formula:

$$ED = k*DLP$$ [7]

ED: Effective Dose.

K: Constant= 0.0021

Table2: Average factors, used for Brain CT Scan.

Location	Average Kvp	Average mAs
Ramallah	120	264.77
Hebron	120	203.9

Results and Discussion

Effective dose comparison between GE and Philips scanners and between Virtualdose program and each scanner was compared. Results show some differences in total effective dose and in thyroid dose. Effective dose trends are shown in Figs. 1-5.

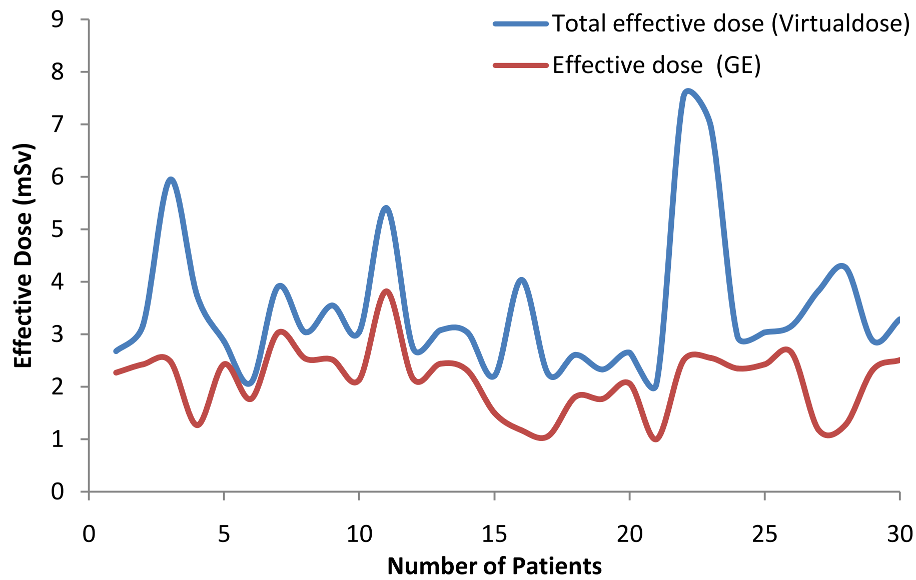

Figure 1: Effective dose fluctuations between Virtualdose program and GE scanner in Al-Ahli Hospital, Hebron.

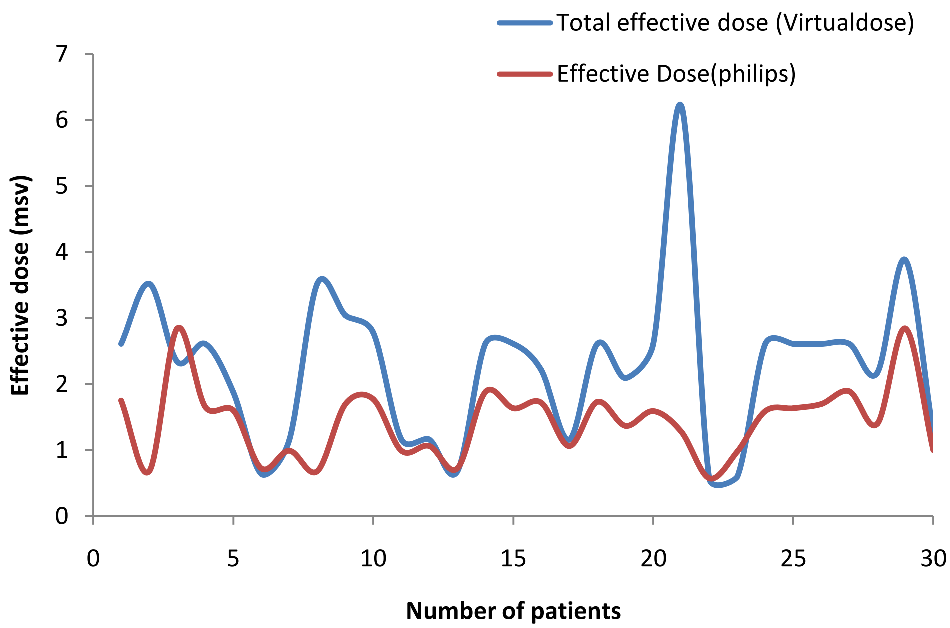

Figure 2: Effective dose fluctuations between Virtualdose and Philips in Ramallah.

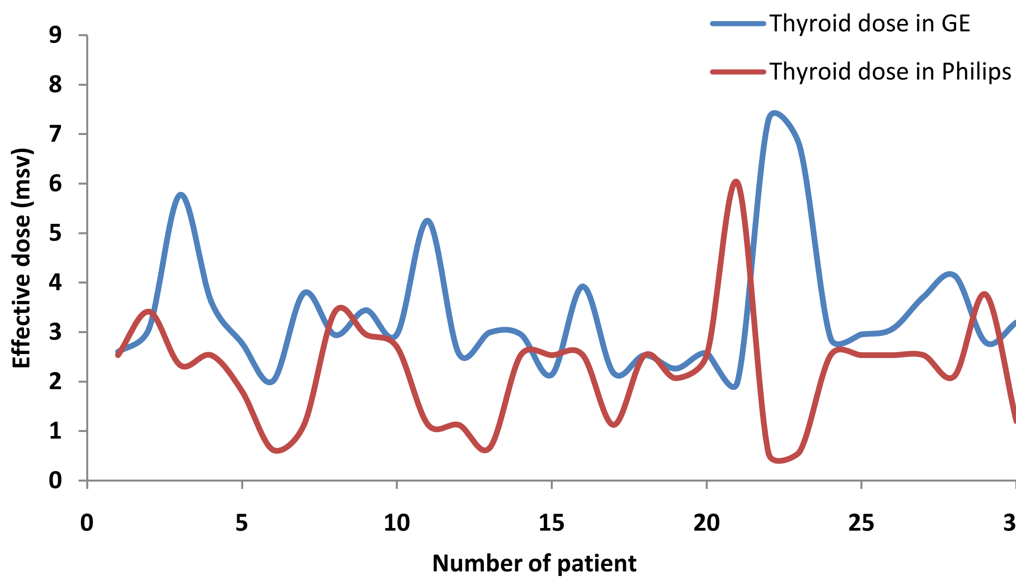

Figure 3: Thyroid effective dose measurement by Virtualdose Software for GE and Philips.

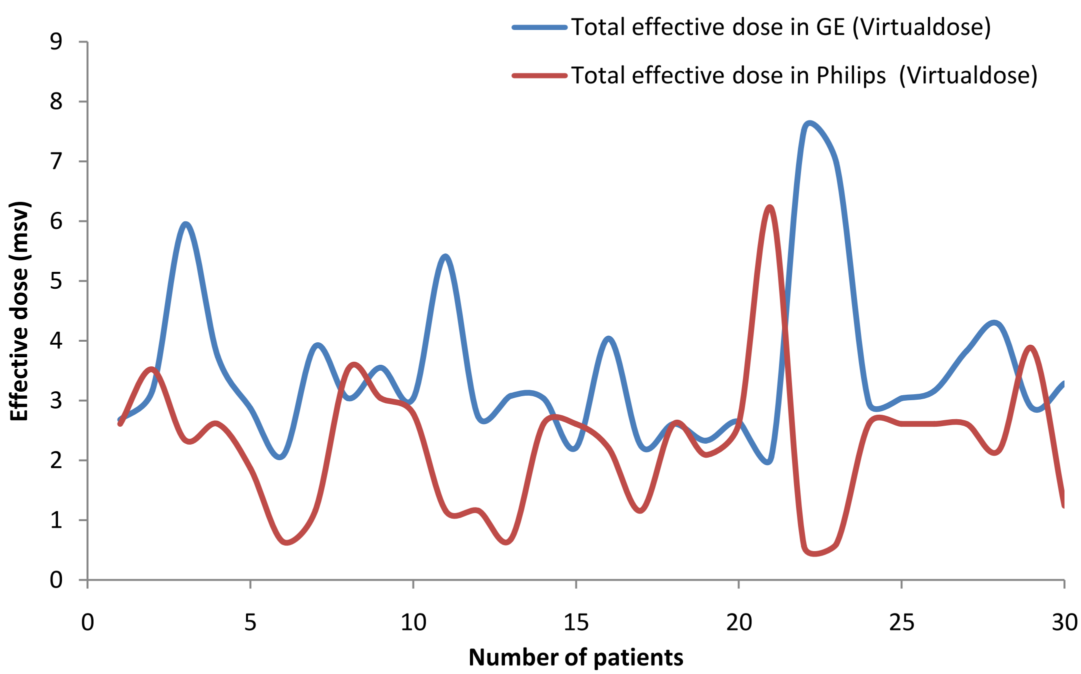

Figure 4: Effective dose measurement for GE and Philips by Virtualdose Software.

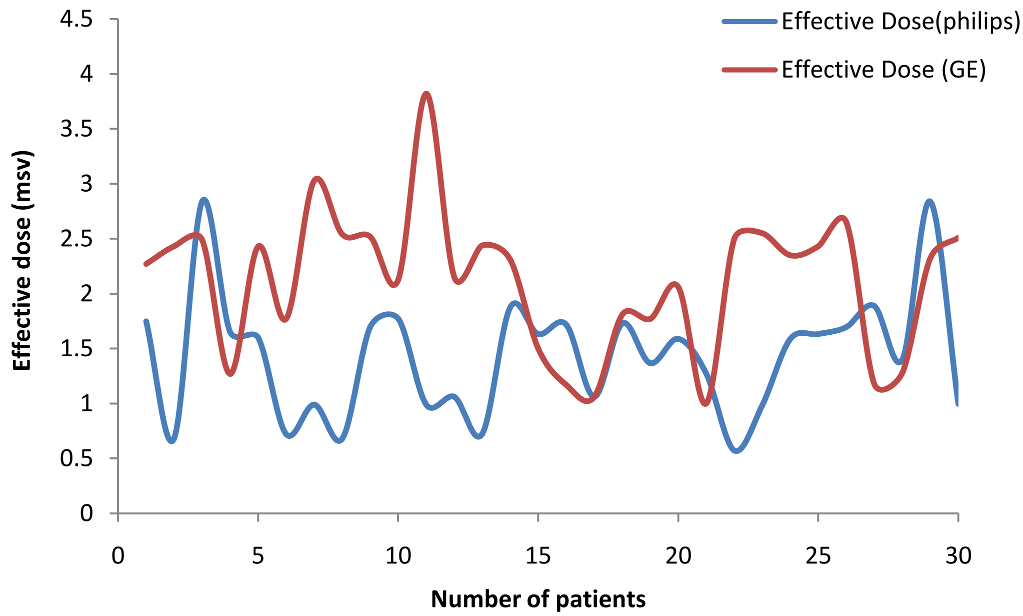

Figure 5: effective dose between GE and Philips.

For statistical analysis, Origin Pro 8.1 software was used to calculate the average, standard deviation, and variance of samples. Subsequent statistical tests for any differences in variance between the two scanners, and also between scanners and Virtualdose - software was carried out. Results are given in Tables 3 and 4.

Table 3: Average, ST.DIV and variance of all ED.

Effective Dose (ED)	Average	ST.DIV	Variance
Philips ED(CT scanner)	1.43	0.56	0.31
GE ED(CT scanner)	2.12	0.64	0.41
Philips- ED(Virtualdose)	2.27	1.18	1.39
GE ED (Virtualdose)	3.48	1.35	1.83
Thyroid ED: Philips Vs. (Virtualdose)	2.22	1.14	1.31
Thyroid ED: GE Vs.(Virtualdose)	3.37	1.31	1.72

Table 4: Type of difference between population variance.

Effective Dose Comparison	Difference
GE scanner Vs. Philips scanner	NOT significantly different
GE Virtualdose Vs. Philips Virtualdose	NOT significantly different
GE scanner Vs. GE Virtualdose	significantly different
Philips scanner Vs. Philips Virtualdose	significantly different
Thyroid dose: GE and Philips (Virtualdose)	NOT significantly different

Conclusions

After we collected data from two CT scanner installed at two hospitals located in Ramallah and Hebron cities, effective dose was calculated by Virtualdose software. We found that effective dose in GE scanner which is located in Hebron City was higher than that found in Philips scanner utilized in Ramallah Hospital. Although MAS used for dose calculations in Virtualdose software was higher for Philips Scanner, calculated effective dose was higher for GE. This might be due to a difference in patient related factors such as weight, in addition to the type of CT equipment utilized and its operation. It was not possible to collect data of weight in both CT scanner.

All comparisons checked for statistical differences showed normal distribution, except for a comparison made between the effective dose from Virtualdose software and each CT scanner. Perhaps one of the most important reasons for this difference is that CT scanner deals with a real human body, but the Virtualdose software deals with an anthropomorphic phantom.

Based on statistical analysis, ED did not differ between the two scanners utilized in the study. Also, thyroid dose did not differ highly. However, calculated and measured ED had a considerable and significant difference, which might be related to inherent scanner and patient factors.

The influence of such factors should be further investigated to accurately find and assess patient dose while undergoing Brain CT exams.

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