Assessment of CT Dose Indices (CTDI and DLP) in Head CT Examinations Across Patient Age Groups on a Siemens 16-Slice CT Scanner

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ABSTRACT

Background: The crucial medical imaging equipment known as computed tomography (CT) produces fine-grained cross-sectional images of the body. Due to the increased dosages connected with CT scans, however, radiation exposure worries have surfaced. Dose measures are employed to address this, such the Dose-Length Product (DLP) and the Computed Tomography Dose Index (CTDI). For high-resolution head imaging, the Siemens 16-slice CT scanner is available from Siemens, a top manufacturer of CT scanners. The best possible diagnostic results are achieved while minimizing needless radiation exposure and placing a high priority on patient safety when radiation doses are customized based on the patient's age.

Objective: Comparison of dose received in patient of different age groups undergoing CT Head.

Method: This prospective study was conducted in the radiology department, where 102 patients were included. Patients were segregated according to age group and gender. Further on behalf of age groups evaluation of the CTDI and DLP Values was done.

Result: Patients in group A had the greatest average CTDI (62.34 mGy) and DLP (1062.73 mGycm) in the study, followed by group B (61.49 mGy, 1016.6 mGycm), group D (63.35 mGy, 964 mGycm), and group C (62.48 mGy, 959.52 mGycm). Patients between the ages of 0 and 20 years received larger doses because their smaller bodies needed more radiation for a sufficient picture quality, which led to higher CTDI and DLP values.

Conclusion: Younger patients had higher radiation doses because of the necessity to adjust the CT scanner's parameters for smaller bodies.

KEYWORDS: Radiation dose, Computed Tomography Dose Index, Dose reference levels, Dose Length Product, X-Ray.

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INTRODUCTION

The term "CT scan" is frequently used to refer to computed tomography. A patient is exposed to a small x-ray beam that is quickly spun around the body which produces signals that the machine's computer analyses to produce cross-sectional images of the body. Because they contain more information than regular x-rays, these slices are known as tomographic images. The machine's computer first gathers several succeeding slices. Images can be digitally "stacked" to create a three-dimensional image of the body, making it simpler to recognize and pinpoint both fundamental components and potential tumors or anomalies [1]. G.N Hounsfield of EMI Laboratories in England and Allan Cormack of Tufts University in Massachusetts, both South African natives, created CT in 1972. Hounsfield and Cormack later received the Nobel Peace Prize for their work in science and medicine [2]. There are 16 slices of the CT Siemens Somatom scope. All scans, including angiography, are carried out during this CT. The technical details include a gantry width of 70 cm, a tube tilt of 30 degrees, and a 24-row adaptive detector array. Using milli-Grey (mGy) units, every contemporary computed tomography (CT) scanner shows a value known as the CT dose index-volume (CTDI-vol). The scanner determines the CTDI-vol based on the radiation emission of the scan, because the output of most modern scanners is altered depending on the size and density of the subject, which varies from patient to patient [3] The dose length product (DLP) measures the radiation output or exposure of a CT tube in milligreycm. In contrast to the volume CT dose index (CTDI vol), which indicates the dosage through a slice of an appropriate phantom, this one measures the total CT dose. Consideration is given to the length of radiation emission along the z-axis [4]. Data gathered when scanning a 16- or 32-cm phantom is used to calculate CTDI vol. In essence, it shows the results of a scanner. Although DLP, a scan length component, and CTDI vol. are reasonable approximations for absorbed radiation, they do not accurately reflect the patient's real dose [5] A CT head (CT brain) is an imaging procedure that uses computed tomography to examine the brain and related cranial structures. Some indicators demand the inclusion of a contrast-enhanced phase even though the examination is typically completed without contrast [6]. Head CT scans use specialized x-ray technology to identify brain tumors, aneurysms, hemorrhages, and other symptoms associated with strokes, aneurysms, and severe headaches [7]

A computed tomography is a less painful, non -invasive treatment, it has some hazards because a CT scan exposes a person to radiation, there is a chance that the person can acquire cancer because of excessive radiation doses [8]. Dosimetry tests are carried out in terms of the CT Dose Index (CTDI), which is a standardized way to assess how much radiation a CT scanner emits and enables users to compare how much radiation different CT scanners emit [9]. The CTDI is calculated by scanning a sizable tube inside the CT machine. The measurement equipment is positioned at the Centre of the tube and slightly below the surface since the radiation is not uniform from the tube's edge to its Centre. (The "100" in CTDI100 denotes the length of the radiation measurement apparatus at the time the CTDI is calculated for a specific scanner.) The CTDI calculation uses the assumption that radiation decreases linearly from the outer to the inner region and is expressed as CTDI = (1/3) * radiation Centre + (2/3) * radiation periphery. This value is then divided by the scan length to obtain the CTDI per slice. CTDI, which stands for dosage of the tissue in that slice, is determined by the pitch, tube current, kV, and body size (more on that later). DLP is a different dose index that calculates how much radiation will be received by a patient overall during a CT scan. The CTDIvol and the size of the scanned area are both considered. Divide the scan length by the CTDI volume to get the DLP.

DLP = Scan length x CTDIvol

The DLP provides a radiation dosage estimate that is proportional to the actual dose the patient really received. DLP readings are given in milli-grey centimeters (mGy cm). CTDI and DLP are important measurements in CT imaging since they help assess and compare radiation exposures among various CT scanners and procedures. They help medical professionals strike a balance between the benefits of CT scans for diagnosing conditions and radiation protection and dosage reduction [10].

As a dose descriptor in CT, the computed tomography dose index (CTDI) is used. The first quantity as a references dose for a single axial rotation is weighted computed tomography dose index (CTDIw):

CTDIw = 1/3 CTDI center +2/3 CTDI periphery (mGy)

CTDIc denotes the dosage in central hole and CTDIp is the mean dose of the four phantom parameter holes. A volume CTDI calculation is performed in spiral mode:

When calculating CTDIvol, use the formula – CTDIvol = CTDIw / pitch (mGy). Where pitch is the ratio of table increment each rotation to the beam width [11].

Dose Metrics

Most often one will encounter varying metrics when examining the dose of CT scan that:

- CT dose index (CTDI)
  - Measured in mGy
  - Standardized measured of dose output
  - Best used to compare CT scanners
- CTDIvol
  - CT dose index that measures radiation per slices of tissue using a reference phantom.
- Dose Length Product (DLP)
  - Measured in mGy×cm
  - Product of the CTDIvol and scan length
  - Factors in the length of the scan to show overall dose output
- Size specific dose estimate (SSDE)
  - Measured in mGy
  - Measure of absorbed dose but not effective dose (12)

AIM & OBJECTIVE

Aim

“Measurement of CT doses (CTDI and DLP) of CT head according to the patients age group on siemens 16 slice CT scanner”

Objectives

1. The purpose of this study was to examine variations in volume computed tomography dose index (CTDI) and dose length product (DLP) values according to patient age group for CT head.
2. To determine CTDI and DLP values for each age groups.

MATERIAL & METHODOLOGY

Study Duration:

This study was carried out over a period of 2 year. This data was collected from September 2022 to March 2023 in the department of Radiology.

Study type and design:

It is a prospective and comparative study of CTDI and DLP dose measuring was done on patients involved in CT Head and then compare the CTDI and DLP volume according to the age groups of the patients and then the result was calculated. All the CTDI and DLP were calculated using Computed Tomography (CT).

Inclusion Criteria

1. Patients of all age group & gender.

Exclusion Criteria

1. Pregnant patients.
2. Repeat scans

Sample size: A convenient sample of 102 patients were taken.

Methods: Data was collected in all aspect. Firstly, patients were segregated according to age group and sex and only CT head patients were included and after that CTDI and DLP volume were calculated using data gathered by CT scan and compared the gathered data according to age group of patients.

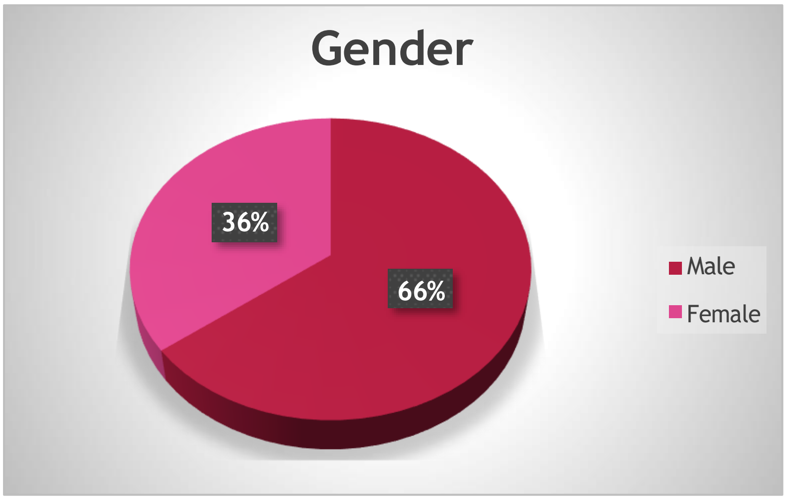
Setting and resources: CT scanner (Siemens 16 slice Somatom scope).

RESULT

In this prospective study 102 patients underwent for NCCT head. Table 5.1 shows that out of 102 patients, 66 were male (64.70%) and 36 were female (35.29%).

Table 5.1: Distribution of Gender

GENDER	FREQUENCY	PERCENTAGE
Male	66	64.70%
Female	36	35.29%
Total	102	100%



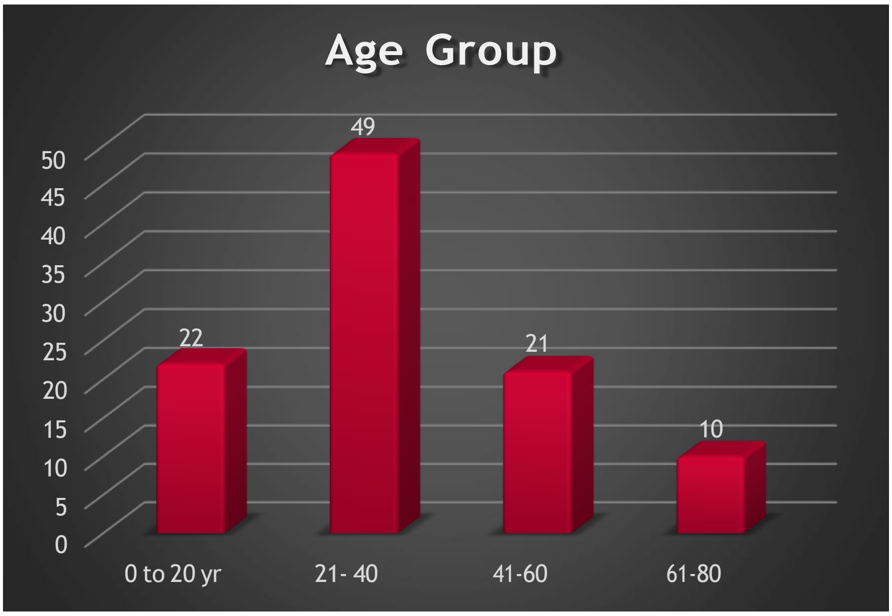
Graph 5.1: Showing distribution of Gender with the help of pie chart 36% were female and 66% were male

Table 5.2 shows the age of the patients studied range from 1 years to 80 years.

Table 5.2: Age distribution of study population

Age groups	Frequency	Percentage
0 -20	22	21.56%
21- 40	49	48.03%
41-60	21	20.58%
61-80	10	9.80%
Total	102	100.00%

The total population was divided into four groups, Group A includes patients aged between 0 – 20 years (21.56%), Group B includes patients between 21 – 40 years (48.03%), Group C includes patient aged between 41 – 60 years (20.58%), Group D includes patients age between61 - 80years (9.80%).



Graph 5.2: Shows age distribution of study population

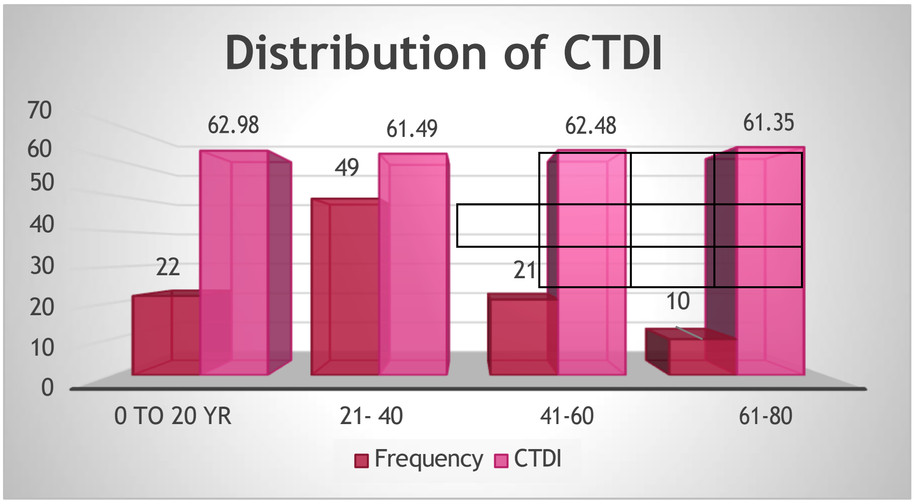
Patients in group A received average CTDI 62.98mGy and DLP average dose of 1062.73mGy × cm, patients in group B received average CTDI 61.49mGy and DLP average dose of 1016.6 mGy ×cm, patients in group C received CTDI 62.48mGy and DLP average dose of 959.52 mGy×cm and patients in group D received average CTDI 61.35mGy and DLP average dose of964.90 mGy×cm. As the table 5.3 (a) and (b) shows CTDI and DLP with age group.

Table 5.3:(a) shows average CTDI with age group

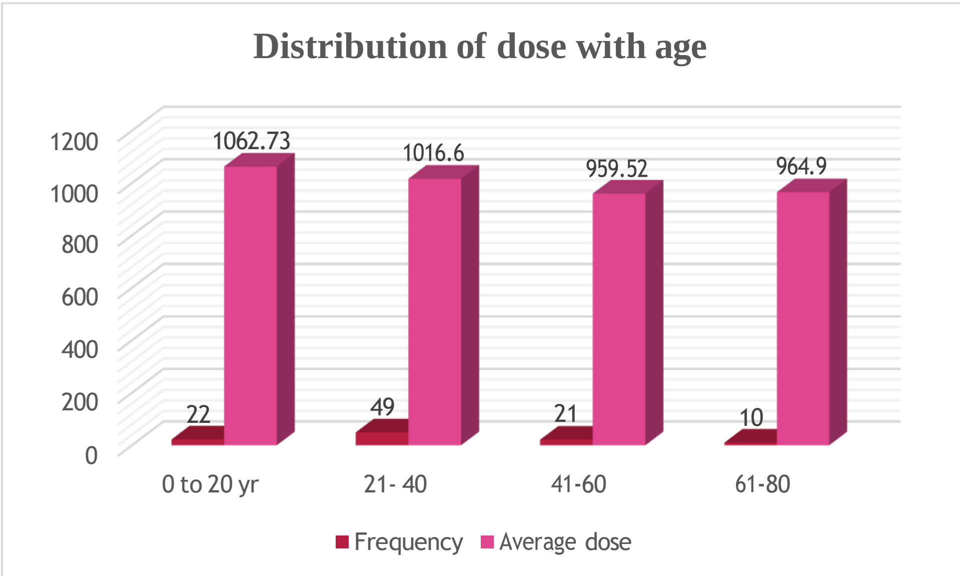
Age group	Frequency	CTDI
0 -20 yr	22	62.98 mGy
21- 40	49	61.49
41-60	21	62.48
61-80	10	61.35

Table 5.3:(b) shows average dose (DLP)with age group

Age group	Frequency	Average dose
0 to 20 yr	22	1062.73 mGy ×cm
21- 40	49	1016.6
41-60	21	959.52
61-80	10	964.9



Graph 5.3: (a)shows distribution of average CTDI in patients



Graph 5.3: (b)shows distribution of average dose (DLP) in patients

It is found that patients in group A received highest average CTDI and DLP of 62.98mGy and 1062.73mGy×cm respectively followed by group B with average CTDI 61.49mGy and DLP of 1016.6mGy×cm,group D received average CTDI 61.35mGy and DLP of 964mGy×cm and lastly group C with average CTDI 62.48mGy and DLP of 959.52mGy×cm.Overall, it is seen that patients age between 0-20years receives more dose compared to other age groups.

Patients who are children typically have smaller bodies than adults, the settings of CT scanner are customized for adult patients since the machines are made to deliver images of consistently high image quality. The radiation beams used in CT scans may need to be increased when imaging smaller bodies to ensure adequate picture quality, leading to greater CTDI and DLP values.

DISCUSSION

This prospective study of literatures states that collaboration with five authors, have given that firstly Okeji et al. undertook a study to assess the amount of dose absorbed and protocols applied during CT head examination. 251 patients got brain CT scans for the study, with 78.5% of them utilizing the helical scan mode and 21.5% using the axial scan mode. The average CTDI and DLP values were found to be 76.60, 21.43 mGy, and 1285.76, 458.73 mGycm for the axial scan mode and 97.40, 37.52 mGy, and 1760.24, 790.23 mGycm, and mGycm for the helical scan mode, respectively. These readings exceeded the dosage values for the European Commission committee on radiation safety. The faster image capture and the capacity to get thinner slices without reconstruction, which removes the interslice loss of data or information, are the authors' explanations for why helical scan mode is preferred [12,13]. Elmahdi et al. was the author evaluated the radiation exposure related to 64-slice CT brain exams in Sudan. The study discovered that the hospital's CT techniques were highly standardized and resembled those from prior studies. However, this study did not consider altering scan techniques to account for patient size. The authors emphasized that effective dose and average dose measurements, such as CTDI or DLP, may only provide partial information on radiation dangers. Effective dosage ought to be the preferred unit for partial exposure. The CTDI, DLP and effective dose values in the data from the two hospitals indicated minor changes, with somewhat greater values seen in one facility compared to the other [14]. This study proposed by Erem et al. with the goal of identifying Uganda's national diagnostic reference levels (NDRLs) for CT exams. 574 patients from seven healthcare facilities participated in the study. The investigation discovered that none of the institutions had the ability to determine doses for patients based on their size. For volume-weighted CTDI values, the median LDRL values varied from 56.02 mGy for head CT [15]. Zira et al., the author had concentrated on developing clinical indication-based diagnostic reference levels (DRLs) for pediatric head CT exams in Nigeria. The study found notable differences in reported DRLs between centers and age groups and highlighted a big gap in optimization techniques among clinical institutions. The study emphasized the significance of modifying examination techniques to limit radiation dose when readings the third DRL quartile. Trauma/seizures, cerebral abscess, hydrocephalus, and examination of intracranial space occupying lesion were some of the clinical justifications for pediatric head CT scans that were noted [16]. Lu et al. had examined on pediatric CT doses in the Shanghai metropolitan area. The CTDI value falls with tube voltage, and the authors suggested that for infants and young children, a lower tube voltage be used to lessen the effective dose while retaining diagnostic quality. The study also emphasized the necessity to optimize scan parameters for kids with thin bodies to reduce radiation dose and highlighted variability in CTDI values across various CT machine models [17].

In this prospective study total of 102 patients underwent non-contrast computed tomography (NCCT) head scans. The study duration was of 2 years and aimed to analyze the distribution of patients based on gender and age groups, as well as the average CTDI and DLP doses received by each group. The result show that out of 102 patients ,66weremale (64.70%) and 36 were female (35.29%). The total population was divided into four group: Group A (0-20 years) with 21.56% of patients and Group B (21-40 years) with 48.03%, Group C include (41-60 years) with 20.58% and Group D (61-80 years) with 9.80%. When analyzing the average CTDI and DLP doses for each group, it was found that patients in group A received the highest average CTDI of 62.98 mGy and DLP of 1062.73 mGy ×cm. Group B had an average CTDI of 62.48 mGy and DLP of 959.52 mGy× cm, and Group C had an average CTDI of 62.48 mGy and DLP of 959.52 mGy ×cm, Group D had an average CTDI of 61.35mGy and DLP of 964.90 mGy cm. The results indicate that patients in Group A (0-20 years) received the highest average CTDI and DLP doses, followed by Group B (21-40 years) and Group C (41-60 years). This finding suggests that patients in the younger age group received a relatively higher radiation dose compared to other age groups. The higher radiation doses observed in Group A can be attributed to the fact that children typically have smaller bodies compared to adults. CT scanners are generally designed and calibrated to deliver images of consistently high quality for adult patients. when imaging smaller bodies, such as those of children, the setting of the CT scanner may need to be adjusted to ensure adequate image quality. This adjustment may require increasing the radiation beams used in CT scans, leading to higher CTDI and DLP values. It is important to consider the radiation doses received by different patient groups, especially in the case of pediatric patients. While CT scans provide valuable diagnostic information, radiation exposure should be minimized and optimized for each patient. Imaging protocols should be monitored to the patient’s age, size and clinical indications to ensure that the benefits of the scan outweigh the potential risks associated with radiation exposure. The study showed that patients in the younger age group (0-20 years) received higher average CTDI and DLP doses during NCCT head scans compared to other age group, this can be attributed to the need for adjustments in CT scanner settings to accommodate smaller bodies to obtain high-quality images. Radiation safety and dose optimization remain crucial consideration in CT imaging, particularly in pediatric patients.

CONCLUSION

The gender and age distribution of patients, as well as the typical CTDI and DLP doses received by each group, were all examined as part of this study. According to the findings, younger patients (0–20 years) were exposed to higher radiation doses than older patients. The reason for this is that to accommodate smaller bodies and provide high-quality images, CT scanner parameters must be modified.

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