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Research Article

Comparison of Radiation Dose Parameters Between LDCT and SDCT in Pediatric Brain CT Protocols

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Abstract:

Brain imaging is the most common form of CT scan for kids, which shows how important it is to have protocols that use low radiation doses to lower the chance of harm. This is important since kids are more sensitive to radiation than adults. The study aimed to compare parameter CT low-dose protocol and parameter a standard-dose protocol. The objective of this study was to perform a comparative analysis of parameter values between pediatric head CT protocols utilizing low-dose and standard-dose techniques.
This was cross-sectional study. A total of 100 CT scans of the head, Albatol teaching Hospital In the diyala governorate. SPSS software version 2019 was used to analyze the results. The results showed a significant difference in both radiation dose and examination time between the standard and low-dose protocols ($p > 0.05$), with a lower radiation dose recorded in the low-dose protocol group, while no statistically significant differences were recorded in examination length between the two groups ($p = 0.7342$). The low-dose CT protocol significantly reduced radiation exposure in pediatric patients by lowering CTDIvol, DLP, and effective dose, while also decreasing tube current and scan time. Scan length showed no significant influence on dose reduction.

1. Introduction

In the past few years, the number of children in the United States who have had computed tomography (CT) scans has gone up a lot, mostly because of the introduction of advanced spiral CT equipment [1]. This technology makes imaging more accurate and quick, which means that kids don't need as much anesthesia during exams. It also has many clinical benefits, such as giving extensive information on the body's structure, helping doctors make life-saving decisions, and cutting down on the need for extra, expensive surgeries that aren't necessary[2][24]. CT imaging equipment has come a long way in terms of technology. At first, scanners could only handle four slices, but now most of them can handle 64 slices, and some can handle up to 256 slices. This change has made diagnoses much more accurate, especially in terms of geographical and temporal resolution, which has improved the quality of pediatric diagnostics[3][28][30]. Brain imaging is the most common form of CT scan for kids, which shows how important it is to have protocols that use low radiation doses to lower the chance of harm. This is important since kids are more sensitive to radiation than adults[4][5].
Youngsters are more sensitive to radiation than adults, so the consequences of radiation exposure in youngsters are especially worrisome, Because kids' bodies are smaller, their cells divide faster, and they are still growing, the effective radiation dose they get is usually larger than that of an adult[6][23]. These things make it more likely that kids will have cancer in the long run. Furthermore, since children live longer, there is more time for damage from radiation to show up [7][8][27]. Additionally, excessive quantities of radiation can damage organs and tissues, which raises the risk of cancer [1]. Radiologists and doctors can lower radiation doses by using specific imaging techniques for certain body parts and disorders. This ensures that the images are of diagnostic quality acceptable while exposing the patient to as little radiation as possible, Because of methods to lower radiation exposure are very important in pediatric medical imaging[9][26]. In the end, the best way to solve this problem is to

fully understand all the aspects that affect image quality and radiation doses. This includes coming up with new methods that lower radiation exposure without lowering the accuracy and usefulness of the diagnosis[10][31].The computed tomography dose index (CTDI) and dose-length product (DLP) volume are standard global radiation exposure indices used to measure radiation dose. However, both CTDIvol and DLP estimate dose based on two fixed volumes of an acrylate resin phantom[11]. therefore, a correction for the patient's anatomy is required, such as the scale-by-volume dose estimate (SSDE), a concept developed by the American Association of Physicists in Medicine (AAPM) [12]. Every maker of CT scanners gives estimates of CTDI vol and DLP on a summary sheet of the radiation dose for each CT scan based on the imaging technique used and the measurements made with the acrylic phantom [13][25][29].

2. Method

This cross-sectional study was performed in Albatol teaching Hospital, Data was collected within 5 months between Jan 2025 to May 2025, data were collected for 100 patients they underwent examinations using two different types of CT scanners, The patients were equally divided into two groups: the first group underwent a low-dose head CT scan, while the second group underwent a standard-dose head CT scan. with ages between 1 and 12 years old. Exclusion criteria were a KV value greater than or less than 100, abnormal scans, patients aged over 12 years or older than 1 year, and distorted examinations.

Acquisition parameters:

Including the kV, mAseff, scan time, Total DLP, CTDIvol were obtained from dose report sheets into PACS Figure (1). Head CT scans were performed using an image acquisition field of view ranging from 16 to 23 cm.

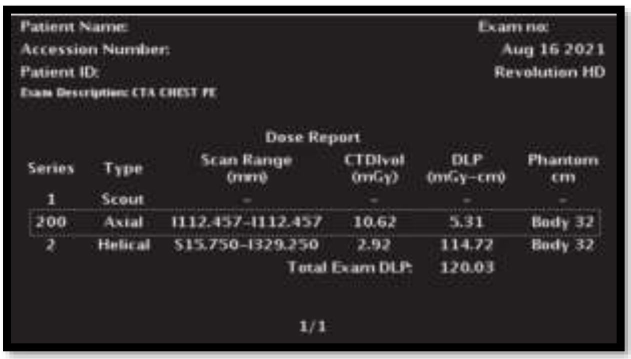

Figure 1. *CT Dose Report for Head Scan Showing Scan Rang ,CTDIvol and DLP Values*

Radiation Dose:

The CTDIvol and dose length product (DLP) were used as dose indices for CT and collected from PACS in the dose report and Radiometric software version 3.4.2. The DLP is calculated by multiplying the CTDIvol by the scan length, and the effective dose (ED) is calculated by multiplying the DLP by the conversion factor (k; mSv mGy−1 cm−1) for the head (0.0021), which is specific to age and the region of scanning.

Characteristics of Patients:

The Table 1. Participants characteristic for CT scanned patients is shown 50 patients including 26 females and 24 males were scanned by standard CT and 50 patients including 22 females and 28 males were scanned by low dose ct. The age of patients ranged from 1 to 12 years.

Table 1. *Characteristics of Patients in this study.*

Factor		Standard dose CT	Low dose CT
Gender	Male	24 (48.00%)	28 (56.00%)
	Female	26 (52.00%)	22 (44.00%)
Age groups (year)	Mean ±SD	6.46 ±3.31	5.20 ±3.53
Total		50	50

Image Acquisition Protocols:

CT scanning parameters for both devices are shown in Table 2. for standard dose protocol,Table 3. for low dose protocol. All CT scans were performed according to routine protocols, and all data collection was performed once.

Analysis of Dose in standard CT:

Table 2. summarizes the dose parameters for the 50 children CT protocols with a minimum value of total dose (488.4 mGy.cm) and a maximum dose of (1110.6 mGy.cm) was recorded. With average value (761.5±167 mGy.cm)

Regarding the CTDIv average value 39±9mGy, which had the largest dose of 59 mGy, and the smallest of (24 mGy).the average effective dose value was (1.599 ± 0.351 mGy), with a maximum dose 2.332 mGy, and the minimum dose (1.026 mGy).while The electric current mean values recorded were 330.22±32.8 mA, with the highest value recorded 402 mA, and the lowest value recorded 258 mA The mean for scan length was 19±2 cm, with the highest length at (23 cm) and the lowest length at 16 cm. The recorded scan time (s) value for t 50children protocols was 27.7±3.6 s and maximum time recorded 39.12 s, minimum time recorded 20.19 s.

Table 2. CT scan parameter for standard dose protocol.

AS				
Parameter	**Mean**	**Std**	**Max**	**Min**
Kv	100	0.0	100	100
mAseff	330.22	32.8	403	258
Scan time (s)	27.7	2.0	39.1	20.1
CTDIv (mGy)	39.8	8.6	58.5	24.4
Total DLP (mGy.cm)	761.5	167.3	1110.6	488.4
Effective dose(mSv)	1.599	0.351	2.332	1.026

Analysis of Dose in low dose CT:

Table (3) presents the minimum dose achieved,329.76 mGy.cm with the maximum dose recorded (682.5mGy.cm). the mean of CTDIvol was 27.4±3.36 mGy, with values ranging from 19.12 mGy to 33.93 mGy.
and the effective dose value was 1.107±0.185mGy, with a minimum dose of 1.433mGy, and the maximum dose 0.692mGy.The scan length had a mean of 19±2 cm, with ranging from 16 cm to 23 cm .The average scan time was 21.27±3.25sec and maximum time recorded 24.12 sec and minimum dose recorded 5.16 sec. The mean of tube current 280.48±32.5 mA ,with ranging between 208 mA and 353 mA.

Table 3. CT scane parameter of low dose protocols

Low dose CT				
Parameter	**Mean**	**std**	**max**	**min**
Kv	100	0.0	100	100
mAseff	280.48	32.5	353	208
Scan time (s)	21.27	3.25	24.12	5.16
CTDIv (mGy)	27.4	3.36	33.93	19.12
Total DLP (mGy.cm)	527.3	87.3	682.5	329.76
Effective dose(mSv)	1.107	0.185	1.433	0.692
Scan length(cm)	18.21	1.32	23.0	15.0

Statistical analysis:

The Statistical Packages of Social Sciences-SPSS (2019) program was used to detect the effect of difference groups in study parameters. T-test was used to significant compare between means. Chi-Square test was used to significant compare between percentage. Estimate of Correlation coefficient between difference variables in patient groups in this study. Statistical analysis was considered significant whenever the P-value was equal to or less than 0.05.

3. Result

A total of 100 patients with a standard weight of 60 ± 15 kg and aged between 1and 12 years old were collected in PACS to evaluate radiation risk and image quilty. The CTDIvol, DPL,and effective dose (ED) are standard dose metrics for evaluating and comparing CT scanners or protocols.When comparing between standard-dose and low-dose CT protocols, it was found that the values of The radiation dose (CTDI) standard protocol (39.82±8.61 mGy),was lager than low-dose protocol . in the table (4) about (1.45 times.) with a p-value of ($8.22 * 10^{-14}$). The table (5) showes the radiation dose yield (DLP), an important indicator for estimating the total exposure of dose (527.3 ± 87.3), was significantly lower in the low-dose protocol compared to the standard protocol (761.5 ± 167.3), with a p-value.($4.49*10^{-13}$), reflecting the effect of the low-dose protocol in reducing radiation exposure .Base in table(6) indicated the effective dose (Ed) value decreased significantly from 1.599 ± 0.351 mSv to 1.107 ± 0.185 mSv, with a statistical significance of ($4.69*10^{-13}$), indicating a significant decrease in effective dose affects the clinical value of low-dose CT protocols in reducing in radiation risk to children. for the Table(7) The electrical current (mAs) value in the low-dose protocol (280.48±32.5) was lower than in the standard-dose protocol Percentage (15.07%), with a p-value of ($1.65*10^{-11}$), indicating statistical significance difference.in Table(8) In terms of examination time, the examination time was significantly faster in the low-dose protocol compared to the standard protocol, about (6.44s) with a probability value of ($1.56*10^{-19}$). Conversely,no significant difference was observed in the scan length between the two groups, as the values were close (19.2 ± 1.8 vs. 19.18 ± 1.78 cm) with a probability value of 0.956, indicating the homogeneity of this factor between the two protocols. It is important and essential to ensure that it does not affect the radiation dose or image quality. Therefore, it can be said that the difference in the effective dose or image quality is the result of real changes in the protocol itself (such as the dose settings or the technique used) Shown at table (4,5,6,7,8,9).

Table 4. *Comparison of CTDIv Values Between Standard and Low Dose CT Protocols*

Group/ Type	Mean ±SD	(Min. – Max.)
Standard dose CT	39.82 ±8.61	24.4 – 58.5
Low dose CT	27.40 ±3.36	19.12 – 33.93
T-test	9.52 **	--
P-value	0.0001	--
** (P≤0.01).		

Table (5): *Comparison of Total DLP (mGy*cm) Values Between Standard and Low Dose CT Protocol.*

Group/ Type	Mean ±SD	(Min. – Max.)
Standard dose CT	761.50 ±167.33	488.4 – 1110.6
Low dose CT	527.31 ±87.30	329.76 – 682.50
T-test	53.089 **	--
P-value	0.0001	--
** (P≤0.01).		

Table 6. *Comparison of Effective dose(mSv) Values Between Standard and Low Dose CT Protocols*

Group/ Type	Mean ±SD	(Min. – Max.)
Standard dose CT	1.599 ±0.352	1.026 – 2.332
Low dose CT	1.107 ±0.185	0.692 – 1.433
T-test	8.86 **	--
P-value	0.0001	--
* (P≤0.05).		

Table 7. *Comparison of mAseff Values Between Standard and Low Dose CT Protocols*

Group/ Type	Mean ±SD	(Min. – Max.)
Standard dose CT	330.22 ±32.80	258 – 403
Low dose CT	280.48 ±32.50	208 – 353
T-test	13.027 **	--
P-value	0.0001	--
** (P≤0.01).		

Table 8. *Diffrent of Scan time(s) Values Between Standard and Low Dose CT Protocols*

Group/ Type	Mean ±SD	(Min. – Max.)
Standard dose CT	27.71 ±2.00	20.1 – 39.1
Low dose CT	21.27 ±325	5.16 – 24.12
T-test	22.4 **	--
P-value	0.0001	--
** (P≤0.01).		

Table 9. *Comparison of Scan length(cm) Values Between Standard and Low Dose CT Protocols*

Group/ Type	Mean ±SD	(Min. – Max.)
Standard dose CT	19.06±1.72	16.0 – 22.0
Low dose CT	18.21±1.32	23.0 – 15.0
T-test	0.699 NS	--
P-value	0.7342	--
NS: Non-Significant		

Base at table 10. shows varying significant correlations between the total absorbed dose (Total DLP) and technical variables in both the standard and low-dose protocols. There was a very strong correlation with the effective dose (r = 0.99) and CTDIv (r = 0.91 and 0.84), reflecting the direct relationship between these values and the radiation dose. There was also a moderate correlation with the electrical current in the standard protocol (r = 0.52) and a stronger correlation in the low protocol (r = 0.83). The correlation with scan time was insignificant in the standard protocol (p = 0.2514) and moderately significant in the low protocol (r = 0.45, p = 0.001). On the other hand, scan length appeared to be more strongly associated with DLP in the low protocol (r = 0.71) than in the standard protocol (r = 0.39).

Table 10. *Estimate of Correlation coefficient between Total DLP and others parameter in CT scan*

Variables	Total DLP			
	Standard dose CT		Low dose CT	
	Correlation coefficient-r	P-value	Correlation coefficient-r	P-value
mAseff	0.52 **	0.0001	0.83 **	0.0001
Scan length	0.17 NS	0.2514	0.45 **	0.001
CTDIv	0.91 **	0.0001	0.84 **	0.0001
Effective dose	0.99 **	0.0001	0.99 **	0.0001

Scan time	0.39 **	0.0049	0.71 **	0.0001
** (P≤0.01), NS: Non-Significant.				

4. Discussion

The study aimed to compare pediatric head CT with a low-dose (fixed-kV) protocol and a standard-dose (fixed-kV) protocol. The low-dose protocol group demonstrated a significant reduction in radiation dose indices (CTDIvol: 31.19% lower; total DLP: 30.77% lower).

The results are consistent with previous studies using other dose reduction methods. One study Priyanka et al (2024) showed a significant difference in radiation dose between the standard and low-dose protocols, with the low-dose protocol significantly reducing the effective dose, particularly in the one- to five-year-old age group.

Another study R. Rashma et al (2024) reported an 81.8% mean dose reduction using a volume conversion factor. These results are also consistent with those published by Nakai et al (2023), which showed, using the half-dose protocol (80 kV and 130 mA), a significant reduction in CTDI and DLP values in the 1-15 year age group and achievable diagnostic quality.

In addition to the reductions in CTDI and DLP values, the current study also demonstrated a 30.77% reduction in effective dose (ED) in the low-dose protocol compared to the standard protocol. From a clinical perspective, this result is consistent with recent research indicating the need to restrict the effective dose during CT scanning, particularly when the current study includes highly radiosensitive groups, such as children, whose dosimetric absorption characteristics exhibit significantly greater penetration rates than adults and, therefore, require a narrower safety margin regarding biological interaction [3].

The results of this study were also consistent with what was reported by fatma et al (2020) In a comparative between the standard protocol (3.48 ± 0.45 mSv) and the low-dose protocol (1.04 ± 0.1 mSv) combined with adaptive statistical iterative reconstruction (ASIR), a 70% reduction in mean effective dose was achieved with the low-dose ASIR protocol, demonstrating the ability of advanced reconstruction to compensate for dose-related diagnostic results and improve radiation safety when combined with effective dose-reduction techniques.

According to this study, the tube current (mA) in the standard-dose protocol was also 15% higher than that in the low-dose protocol. This difference in mA is one of the key technical factors explaining the higher CTDI (DLP) in the standard-dose group. It is well established that the relationship between mAs and radiation dose is linear; a 50% increase in tube current results in a similar dose increase [21]. A previous study He did it Udayasankar et al (2008) supports this result, showing that reducing the mA from 250 to 100 significantly reduces the radiation dose to organs, highlighting the importance of controlling this parameter when optimizing dose.

Also agree with Greffier et al (2016) clear decrease in the value of mAseff It also resulted in a significant decrease in the radiation dose.Another important factor contributing to the efficiency of this low-dose protocol in this study was the scan time, which was found to be statistically significantly lower, with an average difference of approximately 6.44 seconds between the standard protocol and the low-dose protocol. This is particularly useful in pediatric imaging, as shorter and faster scan times reduce the risk of motion artifacts caused by patient movement and reduce scan repetition.

In addition to the above, technical recommendations Zacharias et al (2013) indicate that using a helical mode instead of axial mode, shortening tube rotation times (approximately 0.5 seconds), and shortening the time from scan start to data collection are necessary steps to reduce motion artifacts and increases scanning speed.

Finally, the current study found no significant difference in scan length between the two protocols, with values being similar (19.2 ± 1.8 vs. 19.18 ± 1.78 cm) (p = 0.956). This is consistent with the results Curtis et al (2019) on low-dose abdominal imaging, which also showed no change in scan length. This homogeneity reinforces the fact that scan length was equal between groups, indicating that the observed differences in dose metrics or image quality are due to protocol parameters and not to external factors such as scan length, which is a variable typically controlled by radiologists.

5. Conclusion

The investigation assessed 100 children (aged 1–12 years, median weight 60 ± 15 kg) in order to compare low and standard-dose CT protocols. The radiation dose (CTDIvol) of the standard protocol was significantly greater, 1.45 times with p valu (p< 0.001) . In a comparable manner, the dose-length product (DLP) and effective dose (ED) were also significantly less in the low-dose group (p < 0.001), indicating a substantial reduction in radiation exposure, The reduction in effective dose was from 1.599 ± 0.351 mSv to 1.107 ± 0.185 mSv. Tube current (mAs) was also lower (p < 0.01), being lower by roughly 15%. The low-dose protocol also reduced the time for examination by 6.44 seconds (p < 0.001), thus improving efficiency. scan length reduction did not have an impact on either dose reduction (p = 0.956).

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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