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Establishment of Local Diagnostic Reference Levels for Pediatric Neck CT at Nine University Hospitals in South Korea

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Objective: To establish local diagnostic reference levels (DRLs) for pediatric neck CT based on age, weight, and water-equivalent diameter (WED) across multiple university hospitals in South Korea.

Materials and Methods: This retrospective study analyzed pediatric neck CT examinations from nine university hospitals, involving patients aged 0–18 years. Data were categorized by age, weight, and WED, and radiation dose metrics, including volume CT dose index ($CTDI_{vol}$) and dose length product, were recorded. Data retrieval and analysis were conducted using a commercially available dose-management system (Radimetrics, Bayer Healthcare). Local DRLs were established following the International Commission on Radiological Protection guidelines, using the 75th percentile as the reference value.

Results: A total of 1159 CT examinations were analyzed, including 169 scans from Institution 1, 132 from Institution 2, 126 from Institution 3, 129 from Institution 4, 128 from Institution 5, 105 from Institution 6, 162 from Institution 7, 127 from Institution 8, and 81 from Institution 9. Radiation dose metrics increased with age, weight, and WED, showing significant variability both within and across institutions. For patients weighing less than 10 kg, the DRL for $CTDI_{vol}$ was 5.2 mGy. In the 10–19 kg group, the DRL was 5.8 mGy; in the 20–39 kg group, 7.6 mGy; in the 40–59 kg group, 11.0 mGy; and for patients weighing 60 kg or more, 16.2 mGy. DRLs for $CTDI_{vol}$ by age groups were as follows: 5.3 mGy for infants under 1 year, 5.7 mGy for children aged 1–4 years, 7.6 mGy for ages 5–9 years, 11.2 mGy for ages 10–14 years, and 15.6 mGy for patients 15 years or older.

Conclusion: Local DRLs for pediatric neck CT were established based on age, weight, and WED across nine university hospitals in South Korea.

Keywords: Diagnostic reference level; Computed tomography; Neck; Children; Pediatric

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INTRODUCTION

Pediatric neck CT is an essential diagnostic tool for assessing congenital anomalies, infections, neoplasms, and trauma in children. Given pediatric patients' heightened sensitivity to ionizing radiation, optimizing radiological procedures to ensure both safety and diagnostic efficacy is vital. Diagnostic reference levels (DRLs) serve as benchmarks for optimizing radiation dose levels, aiming to reduce exposure while preserving image quality.

DRL establishment involves gathering and analyzing radiation dose data to set benchmarks distinguishing typical from atypical dose levels. These benchmarks are critical for improving radiation protection and optimizing CT protocols, especially in pediatric imaging, where risks from radiation exposure are more significant due to increased radiosensitivity and longer life expectancy.

In South Korea, optimizing radiation doses in pediatric imaging is increasingly prioritized as medical exposure rates have risen considerably. In 2022, the effective dose (ED) per capita was 2.75 mSv, approximately three times higher than the ED of 0.93 mSv in 2007 and 4.8 times higher than the ED per capita reported by the 2020/2021 United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) report [1,2]. Additionally, a survey conducted in South Korea found that 9.8 CT scans were performed per 1000 children in 2017, up from 9.0 CT scans per 1000 children in 2012 [3].

Studies in South Korea have established DRLs for pediatric CT, focusing on brain, chest, and abdominopelvic scans [4-6]. These studies highlighted dose variability across institutions and the need for optimized protocols. However, no DRLs for pediatric neck CT have been published, despite the frequency of these scans, particularly for patients who undergo multiple CT examinations, such as oncology patients.

This study aims to analyze radiation dose and CT scan parameters for pediatric neck CT across nine South Korean university hospitals to establish local DRLs. Patients were grouped by age, body weight, and water-equivalent diameter (WED) to provide a comprehensive analysis and ensure the DRLs' applicability across diverse patient demographics.

MATERIALS AND METHODS

This retrospective study received Institutional Review Board approval from each participating hospital (IRB No. 04-2022-024), with informed consent waived due to the minimal risk involved.

Data Collection

CT examinations were gathered from nine university hospitals where board-certified radiologists, members of the Korean Society of Pediatric Radiology, managed pediatric neck CT protocols. The inclusion criteria were: age at examination ≤18 years, contrast-enhanced neck CT for soft tissue evaluation, CT examinations following each institution's routine protocol, images of clinically acceptable quality as determined by the pediatric radiologists, and CTs with available localizer radiographs and dose reports.

Localizer radiographs, axial CT images, and dose reports were retrospectively collected from March 2023, aiming to acquire up to 50 CT examinations per age group. Patient body weight was sourced from electronic medical records or estimated based on contrast media dosage. Information regarding iterative reconstruction and automatic tube voltage selection was recorded per institution.

Patient Grouping

Patients were categorized by age, weight, and WED to facilitate analysis. Age groups included: <1 year, 1–4 years, 5–9 years, 10–14 years, and ≥15 years. Weight groups were classified as <10 kg, 10–19 kg, 20–39 kg, 40–59 kg, and ≥60 kg. WED groups were segmented into <14 cm, 14–14.9 cm, 15–15.9 cm, 16–16.9 cm, and ≥17 cm.

Data Processing

A commercially available automatic dose management system (Radimetrics, Bayer Healthcare, Radimetrics, Bayer Healthcare, Leverkusen, Germany) was used to retrieve CT parameters, including peak tube voltage (kVp), automatic exposure control (AEC), scan mode, pitch, rotation time, and radiation dose metrics, such as the volume CT dose index ($CTDI_{vol}$), dose length product (DLP), and ED. ED was automatically calculated using International Commission on Radiological Protection (ICRP) 103 tissue weighting factors and a built-in mathematical phantom. $CTDI_{vol}$ and DLP were referenced to a 16 cm polymethyl methacrylate (PMMA) phantom as DRL quantities. Values from the 32 cm PMMA phantom were converted to the 16 cm PMMA phantom equivalent by multiplying by a factor of 2. Outlier detection excluded abnormal body weight, WED, $CTDI_{vol}$, and DLP values in each hospital and age group. The Tukey method identified outliers, defined as values more than three times the interquartile range.

Setting of the Local DRLs

Local DRLs were set following ICRP recommendations [7]. The median DRL quantity served as the typical value for each group and institution. The local DRL was defined at the 75th percentile value, while the achievable dose (AD) was the 50th percentile of typical values across institutions.

WED Measurement

WED measurements followed the American Association of Physicists in Medicine (AAPM) Task Group 220 guidelines [8]. The WED reflecting patient habitus weighted by voxel attenuation coefficients relative to water, provides improved metrics over geometric diameter. The following equation was used to calculate the WED:

$$Dw = 2\sqrt{\frac{A_w}{\pi}} = 2\sqrt{[\frac{1}{1000}\,\overline{CT(x,y)_{ROI}} + 1]\,\frac{A_{ROI}}{\pi}}$$

where A_w is the water-equivalent area, $\overline{CT(x,y)_{ROI}}$ is the mean CT number in the region of interest (ROI), A_{ROI} is the total ROI area. All axial CT images were included, with the mean value representing the WED for each examination. Measurements were automated using a Python 3 script [9].

Statistical Analysis

Descriptive statistics summarized the characteristics of CT examinations and radiation dose metrics, with DRL quantities and ED expressed as median, minimum, maximum, 25th, and 75th percentiles. The Jonckheere-Terpstra test assessed trends between kVp and age, weight, and WED. Multivariable regression analysis evaluated the impact of automatic tube voltage selection and AEC on $CTDI_{vol}$ and DLP, adjusting for age, weight, and WED groups. Statistical analyses were conducted using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA), MedCalc Statistical Software, version 22.009 (MedCalc Software Ltd., Ostend, Belgium), and R, version 4.1.3 (R Core Team, R Core Team, Vienna, Austria).

RESULTS

Patient Characteristics

A total of 1221 CT examinations were collected from nine institutions, distributed as follows: 175 from Institution 1, 133 from Institution 2, 131 from Institution 3, 142 from Institution 4, 151 from Institution 5, 109 from Institution 6, 165 from Institution 7, 132 from Institution 8, and 83 from Institution 9. After outlier detection, 1159 examinations remained, with 169 scans from Institution 1, 132 from Institution 2, 126 from Institution 3, 129 from Institution 4, 128 from Institution 5, 105 from Institution 6, 162 from Institution 7, 127 from Institution 8, and 81 from Institution 9. Of these, 673 were performed on male patients and 486 on female patients. The average patient age was 8.2 ± 5.8 years (range: 0–18 years), and the average body weight was 33.0 ± 21.6 kg (range: 2.4–99.2 kg). The water-equivalent diameter (WED) averaged 11.5 ± 1.9 cm. Patient demographics are summarized in Table 1, with additional details provided in Supplementary Tables 1, 2.

Distribution of Radiation Dose Metrics

Pooled Data Analysis

Overall, the mean $CTDI_{vol}$ was 7.6 ± 4.7 mGy (median: 5.9 mGy), and DLP was 213.8 ± 166.1 mGy·cm (median: 148.6 mGy·cm). Both CTDI and DLP values showed an upward trend with increasing age, weight, and WED. For age groups, CTDI ranged from 4.53 mGy in patients <1 year to 12.59 mGy in patients ≥15 years, while DLP values ranged from 84.12 mGy·cm to 407.21 mGy·cm. Similar patterns were observed across weight and WED groups. Detailed distributions can be found in Supplementary Figure 1. Weight was significantly correlated with $CTDI_{vol}$ and DLP

Table 1. Summary of patient demographics

Age group	Number of examinations	Sex, male:female	Weight, kg, mean ± SD (range)*	WED, cm, mean ± SD (range)
<1 yr	139	78:61	7.0 ± 2.4 (2.4–11.2)	12.1 ± 1.2 (9–14)
1–4 yrs	249	139:110	14.9 ± 3.4 (7.4–25.0)	13.9 ± 0.9 (11–17)
5–9 yrs	275	176:99	25.2 ± 7.1 (10.1–53.1)	14.8 ± 1.0 (12–17)
10–14 yrs	258	162:96	49.8 ± 14.5 (11.5–99.2)	16.1 ± 1.5 (11–21)
≥15 yrs	238	118:120	59.7 ± 13.6 (23.6–96.4)	16.8 ± 1.4 (14–22)

*Weight was not available for 16 patients at Institution 8.
SD = standard deviation, WED = water-equivalent diameter

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(*P* < 0.01). In pooled analysis, ED averaged 1.7 ± 1.3 mSv for male patients and 1.9 ± 1.4 mSv for female patients. Supplementary Table 3 presents ED distributions by age group.

Institution-Specific Analysis

While the overall trend of increasing $CTDI_{vol}$ and DLP with higher age, weight, and WED was consistent across institutions, notable variability was observed within and between institutions (Fig. 1). For example, Institution 3 had the highest max/min ratio of $CTDI_{vol}$ and DLP in the 1–4 years age group, with ratios of 10.7 and 17.9, respectively, whereas Institution 4 had the lowest max/min ratio in the same age group, with a $CTDI_{vol}$ max/min ratio of 1.2

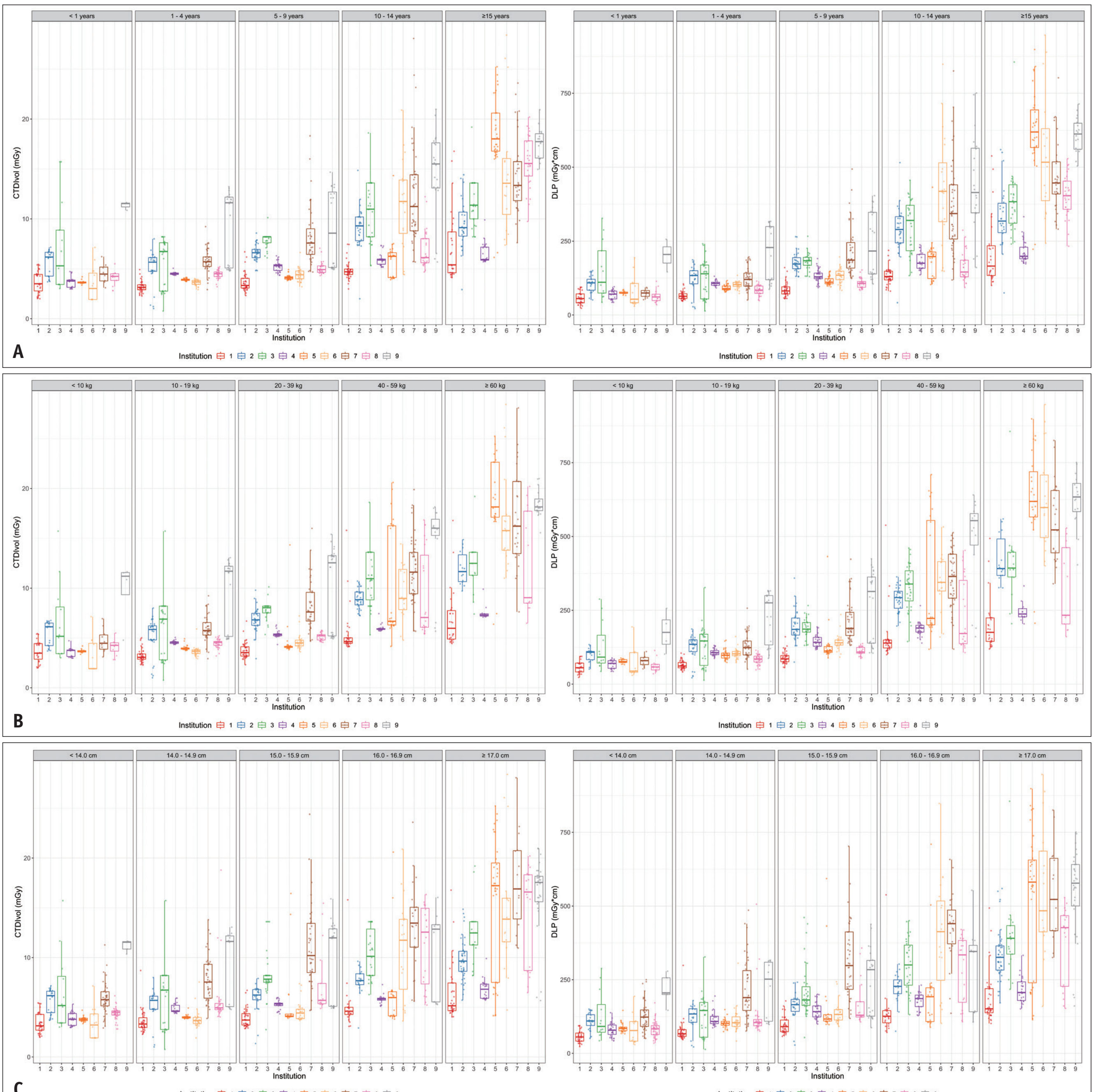

Fig. 1. Distribution of $CTDI_{vol}$ and DLP by **(A)** age, **(B)** weight, and **(C)** WED across institutions. $CTDI_{vol}$ and DLP values are referenced to a 16 cm PMMA phantom. $CTDI_{vol}$ = volume CT dose index, DLP = dose length product, WED = water-equivalent diameter, PMMA = polymethyl methacrylate

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(Supplementary Tables 4-6). Inter-institution variation in typical values showed that the highest max/min ratio for $CTDI_{vol}$ was 5.8 in the <10 kg weight group, and for DLP, it was 4.5 in the 10–19 kg weight group (Table 2).

Local DRLs

Figure 2 shows the distribution of typical values by age, weight, and WED groups. Table 2 summarizes the AD and local DLRs, for each group. For patients weighing <10 kg, the DRL for $CTDI_{vol}$ was 5.2 mGy and for DLP was 91.4 mGy·cm. In the 10–19 kg group, these values rose to 5.8 mGy for $CTDI_{vol}$ and 134.7 mGy·cm for DLP. Patients in the 20–39 kg range had DRLs of 7.6 mGy for $CTDI_{vol}$ and 186.1 mGy·cm for DLP. For the 40–59 kg weight group, DRLs increased to 11.0 mGy for $CTDI_{vol}$ and 344.6 mGy·cm for DLP, and in patients weighing ≥60 kg, the highest DRLs were recorded: 16.2 mGy for $CTDI_{vol}$ and 598.0 mGy·cm for DLP. Table 3 provides a comparison with previously published DRLs [10-13].

Summary of CT Scan Techniques

The majority of CT examinations (90.7%) were conducted in helical mode, with a few exceptions in which axial mode was used, primarily at Institution 5. Most scans (81.2%) utilized low kVp (≤100 kVp), with 46.5% using kVp ≤80. Higher kVp values were more common in older, heavier, and larger WED groups ($P < 0.01$) (Fig. 3). Pitch values ranged from 0.4 to 1.5, with 73% of scans using a pitch factor less than 1. Rotation times varied from 0.25 to 1.00 seconds, with 65.2% of scans having a rotation time of ≤0.5 seconds.

AEC was applied in 92.7% of the CT examinations. Automatic tube voltage selection, used in Institutions 1, 2, and 8, significantly reduced $CTDI_{vol}$ ($P < 0.001$) and DLP ($P < 0.001$), whereas AEC showed non-significant reductions in these metrics ($P = 0.070$ and $P = 0.158$, respectively). Iterative reconstruction techniques were used at eight institutions, primarily employing hybrid iterative reconstruction with mild-to-moderate blending factors. Scan length increased with age, weight, and WED groups, ranging from 18.3 ± 3.5 cm in the youngest age group to 32.3 ± 4.9 cm in the oldest. Differences in scan length across institutions were statistically significant ($P < 0.01$). The distribution of scan length by age group is shown in Supplementary Figure 2.

DISCUSSION

This study presents the findings of a dose survey of pediatric neck CT examinations conducted across nine university hospitals in South Korea, establishing local DRLs for various age, weight, and WED groups. Our results

Table 2. Summary of AD and local DRLs

Group variable	Specific group	$CTDI_{vol}$, mGy*				DLP, mGy·cm*			
		AD	Local DRL	Interquartile range	Max/min ratio	AD	Local DRL	Interquartile range	Max/min ratio
Age group	<1 yr	4.2	5.3	1.7	3.8	74.3	108.8	47.8	3.8
	1–4 yrs	4.5	5.7	1.8	3.7	106.9	133.4	44.2	3.6
	5–9 yrs	5.3	7.6	3.2	2.6	134.4	183.7	72.7	2.7
	10–14 yrs	9.3	11.2	5.1	3.3	289.3	343.5	168.5	3.2
	≥15 yrs	13.4	15.6	6.5	3.3	403.4	517.1	199.4	3.7
Weight group, kg	<10	4.3	5.2	1.5	5.8	76.4	91.4	33.1	4.0
	10–19	4.6	5.8	1.9	3.8	106.6	134.7	37.0	4.5
	20–39	5.3	7.6	3.1	3.5	141.4	186.1	73.7	3.7
	40–59	8.8	11.0	4.3	3.5	292.9	344.6	102.7	4.0
	≥60	12.5	16.2	7.2	3.0	393.0	598.0	204.9	3.6
WED group, cm	<14.0	4.5	5.8	2.0	3.7	84.4	110.0	25.6	3.7
	14.0–14.9	4.9	6.7	2.7	3.5	108.6	145.4	41.6	3.8
	15.0–15.9	5.7	7.8	3.4	3.2	141.4	181.2	51.8	3.3
	16.0–16.9	10.1	12.6	6.6	2.9	299.9	346.0	153.6	3.5
	≥17.0	13.9	16.9	7.3	3.4	426.9	522.3	196.4	3.9

*The $CTDI_{vol}$ and DLP were referenced to a 16 cm PMMA phantom. To convert the dose metrics from the 32 cm PMMA phantom to the 16 cm PMMA phantom, they were multiplied by a factor of two.
AD = achievable dose, DRL = diagnostic reference level, $CTDI_{vol}$ = volume CT dose index, DLP = dose length product, PMMA = polymethyl methacrylate, WED = water-equivalent diameter

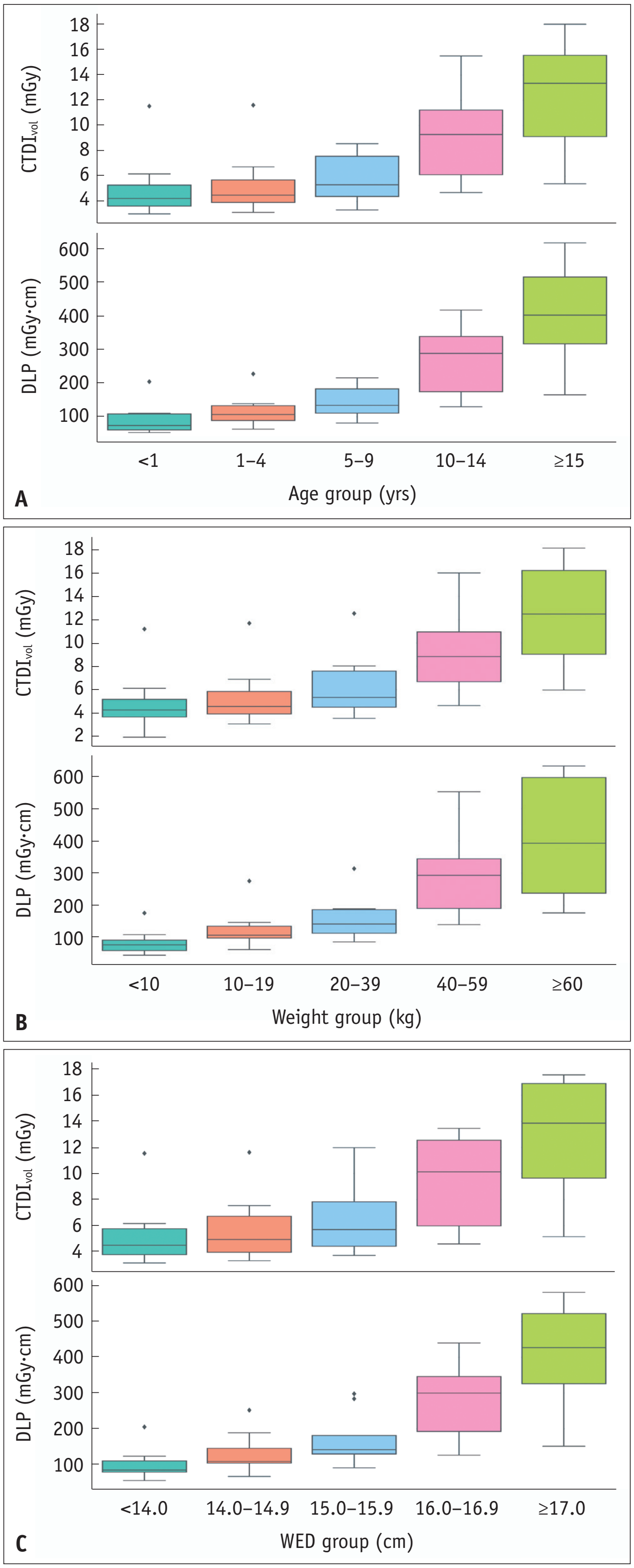

Fig. 2. Distribution of typical values across nine institutions by **(A)** age, **(B)** weight, and **(C)** WED groups. $CTDI_{vol}$ and DLP values are referenced to a 16 cm PMMA phantom. WED = water-equivalent diameter, $CTDI_{vol}$ = volume CT dose index, DLP = dose length product, PMMA = polymethyl methacrylate

indicate that the AD and local DRL for both $CTDI_{vol}$ and DLP increase with age, weight, and WED. For the age group 5–9 years, the local DRL for $CTDI_{vol}$ is 7.6 mGy (AD: 5.3 mGy) and 11.2 mGy (AD: 9.3 mGy) for the age group 10–14 years. In the weight group of 20–39 kg, the local DRL for $CTDI_{vol}$ is 7.6 mGy (AD: 5.3 mGy), while for the weight group of 40–59 kg, it is 11.0 mGy (AD: 8.8 mGy). Additionally, for the WED group of 15.0–15.9 cm, the local DRL for $CTDI_{vol}$ is 7.8 mGy (AD: 5.7 mGy), increasing to 16.9 mGy (AD: 13.9 mGy) for the WED group of >17 cm.

A significant strength of this study is its comprehensive approach to establishing DRLs based not only on age groups but also on weight and WED. Traditionally, DRLs for pediatric imaging studies are based on age groups to reflect children's growth. However, there is concern that age alone should not be the criterion for establishing DRLs in pediatric imaging, as there are significant variations in body habitus and composition even within the same age group. This variability can lead to suboptimal radiation dose estimation and optimization, potentially compromising patient safety and image quality. Weight and WED are more precise parameters for grouping patients, as they directly reflect body size and composition, crucial factors in determining appropriate radiation doses [14-16]. International guidelines acknowledge that while age can be used as an additional parameter during the transition period, weight and body size should be the primary criteria for establishing DRLs because of their impact on radiation dose accuracy [7,15]. Our study advocates for the adoption of weight and WED as the primary parameters for establishing pediatric DRLs, which not only enhances the precision of radiation dose optimization but also aligns with international guidelines, ultimately improving patient safety and diagnostic image quality in pediatric CT imaging. Based on these findings, we recommend that future national DRLs in South Korea incorporate weight and size criteria, in addition to age, to ensure more accurate and tailored optimization in pediatric imaging.

Comparison of our study's local DRL for pediatric neck CT is limited by the lack of published DRLs specifically for this procedure, as most data focus on cervical spine evaluations. The only comprehensive pediatric neck CT DRLs from multiple institutions are from Kanal et al. [10], based on American College of Radiology data from the USA. Our local DRL is consistently higher; for children under 1 year, we reported 5.3 mGy for $CTDI_{vol}$ compared to Kanal et al.'s [10] 3.8 mGy. Similarly, for ages 5–9 years, our DRL is 7.6 mGy, while Kanal

Table 3. Comparison of DRL of neck CT scans

Group	This study		Kanal et al., 2022 [10]		Khafaji et al., 2024* [12]		Kanal et al., 2017 [11]		Steuwe et al., 2020* [13]	
	Pediatric		Pediatric		Pediatric		Adult		Adult	
	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP
Age group										
<1 yr	5.3 (4.2)	108.8 (74.3)	3.8 (2.5)	58 (41)	4.72 (1.4)	34.04 (100.08)				
1–4 yrs	5.7 (4.5)	133.4 (106.9)	4.4 (3.4)	88 (65)						
5–9 yrs	7.6 (5.3)	183.7 (134.4)	6.3 (4.6)	137 (98)	5 (3.37)	113.71 (68.56)				
10–14 yrs	11.2 (9.3)	343.5 (289.3)	11 (7.8)	270 (198)	10.6 (5.45)	332.7 (151.92)				
≥15 yrs	15.6 (13.4)	517.1 (403.4)	14 (10)	385 (300)						
Weight group, kg										
<10	5.2 (4.3)	91.4 (76.4)								
10–19	5.8 (4.6)	134.7 (106.6)								
20–39	7.6 (5.3)	186.1 (141.4)								
40–59	11 (8.8)	344.6 (292.9)								
≥60	16.2 (12.5)	598 (393)								
WED group, cm							20 (15)	572 (431)		
<14.0	5.8 (4.5)	110 (84.4)					18 (14)†	509 (377)†	16.8 (14.4)‡	548.6 (500.8)‡
14.0–14.9	6.7 (4.9)	145.4 (108.6)								
15.0–15.9	7.8 (5.7)	181.2 (141.4)								
16.0–16.9	12.6 (10.1)	346 (299.9)								
≥17.0	16.9 (13.9)	522.3 (426.9)								

The numbers in parentheses represent the achievable doses (50%). The $CTDI_{vol}$ and DLP are referenced to a 16 cm PMMA phantom and presented in mGy and mGy·cm, respectively.
*Data were collected from a single institution, †Values of 14–18 cm (WED) in the adult population, ‡Values for 13–17 cm (WED) in the adult population. The numbers were converted to 16 cm PMMA phantom-referenced values by multiplying by a factor of 2.
DRL = diagnostic reference level, $CTDI_{vol}$ = volume CT dose index, DLP = dose length product, PMMA = polymethyl methacrylate, WED = water-equivalent diameter

et al. [10] reported 6.3 mGy. A similar trend was observed when comparing our results with Khafaji et al. [12] in Saudi Arabia, where our local DRL was 7.6 mGy versus 5.0 mGy. Although the university hospitals in this study follow strict CT protocol management, our local DRL was unexpectedly higher than those reported in other countries, where similar settings had shown lower local DRL in previous studies [5].

As expected, our pediatric local DRL was significantly lower than adult DRLs. Recently published adult neck CT DRLs in South Korea were 27.5 mGy for $CTDI_{vol}$ and 884.1 mGy·cm for DLP, while our ≥15 years group reported 15.6 mGy for $CTDI_{vol}$ and 517.1 mGy for DLP [17]. Although pediatric WED-based comparisons are limited, Kanal et al. [11] reported 20 mGy for adult neck CT in the WED 14–18 cm group, compared to our 16.9 mGy for WED >17 cm in patients ≥15 years. Steuwe et al. [13] reported similar DRLs for the WED 13–17 cm group in Germany.

Although our local DRL for pediatric patients was higher than those reported in the United States, they were significantly lower than adult DRLs, even for the ≥15 years age group and similar WED categories. This discrepancy may be attributed to differences in CT imaging protocols between pediatric- and adult-focused hospitals. While we did not directly compare pediatric radiation doses from adult-focused hospitals, it is likely that the differences in dose reflect variations in optimization strategies. Pediatric patients are more vulnerable to the stochastic effects of ionizing radiation, necessitating more stringent optimization practices. Notably, the use of automatic tube voltage selection was associated with lower $CTDI_{vol}$ and DLP values. Techniques such as lower kVp, automatic tube voltage selection, iterative reconstruction, and emerging deep-learning-based reconstruction likely contribute to dose reduction. The implementation of these advanced techniques suggests a stronger focus on dose optimization in pediatric CT imaging among radiologists and technicians working in pediatric-focused hospitals.

Our study revealed significant variations in radiation doses across institutions, even within the same age group, as evidenced by the max/min ratios and interquartile

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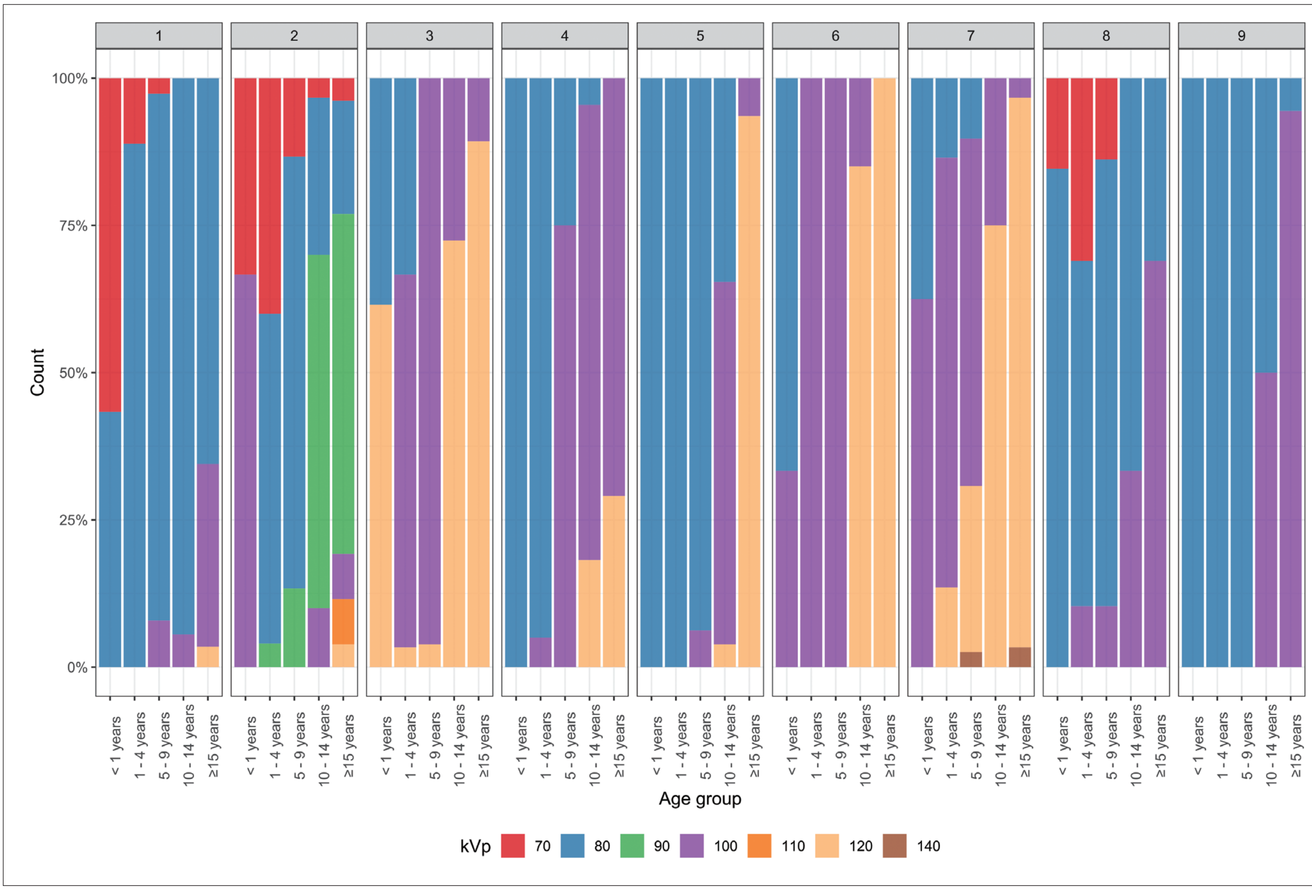

Fig. 3. Distribution of kVp across age groups and institutions. Automatic tube voltage selection was applied by Institutions 1, 2, and 8.

ranges of typical values for $CTDI_{vol}$ and DLP (Table 2). For instance, the max/min ratio for $CTDI_{vol}$ in the weight group of less than 10 kg was particularly pronounced at 5.8, and the interquartile ranges increased with age, weight, and WED. Furthermore, substantial variations were observed within the same age, weight, and WED groups within each institution (Supplementary Tables 4-6). While inter-institutional variability may relate to the type of CT scanner used, patient size, desired noise level for acceptable image quality, and application of dose-reduction techniques [18], intra-institutional variability among patients with similar characteristics likely reflects lack of standardized protocols or improper adherence to them. Human and technical errors may also contribute to these differences.

This study has several limitations. First, the analysis did not account for the clinical indications for CT scans. Second, as the study focused on establishing local DRL from a limited number of hospitals, further studies involving more institutions are needed to develop national DRLs. Additionally, the subjective assessment of image quality by pediatric radiologists may introduce variability. Incorporating objective image quality measures in future studies would improve consistency. Finally, the exclusion of geographic measurements from localizer radiographs limits the practical use of size-specific DRLs during CT examinations.

In conclusion, our study established local DRLs for pediatric neck CT based on age, weight, and WED groups across nine university hospitals in South Korea. We also found significant variations in radiation doses both within and across institutions. Further studies are needed to address these variabilities, and regular updates of DRLs should be implemented to ensure the optimization of pediatric CT scans.

Supplement

The Supplement is available with this article at https://doi.org/10.3348/kjr.2024.0689.

Availability of Data and Material

The datasets generated or analyzed during the study are included in this published article and its supplement.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Jae-Yeon Hwang, Jisun Hwang, Hee Mang Yoon. Data Curation: Jisun Hwang, Hee Mang Yoon, Jae-Yeon Hwang, Ji Eun Park, Sun Kyoung You, Young Jin Ryu, So Mi Lee, Yun Young Lee, Young Hun Choi. Formal Analysis: Jisun Hwang, Hee Mang Yoon, Jae-Yeon Hwang, Seok Kee Lee. Funding Acquisition: Jae-Yeon Hwang, Young Hun Choi, Seok Kee Lee. Investigation: Jisun Hwang, Hee Mang Yoon, Jae-Yeon Hwang. Methodology: Jisun Hwang, Hee Mang Yoon, Jae-Yeon Hwang. Project Administration: Jae-Yeon Hwang, Young Hun Choi. Resources: Jisun Hwang, Hee Mang Yoon, Jae-Yeon Hwang, Ji Eun Park, Sun Kyoung You, Young Jin Ryu, So Mi Lee, Yun Young Lee, Young Hun Choi. Software: Jae-Yeon Hwang, Seok Kee Lee. Supervision: Ji Eun Park. Validation: all authors. Visualization: Jae-Yeon Hwang, Jisun Hwang, Hee Mang Yoon, Seok Kee Lee. Writing—Original Draft: Jisun Hwang, Hee Mang Yoon, Jae-Yeon Hwang. Writing—Review & Editing: all authors.

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