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FULL PAPER

Does body mass index outperform body weight as a surrogate parameter in the calculation of size-specific dose estimates in adult body CT?

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Objective: To assess the value of body mass index (BMI) in comparison with body weight as a surrogate parameter for the calculation of size-specific dose estimates (SSDEs) in thoracoabdominal CT.

Methods: 401 CT examinations in 235 patients (196 chest, 205 abdomen; 95 females, 140 males; age 62.5 ± 15.0 years) were analysed in regard to weight, height and BMI (kg m^{-2}). Effective diameter (D_{eff} , cm) was assessed on axial CT images. The correlation between BMI, weight and D_{eff} was calculated. SSDEs were calculated based on D_{eff} , weight and BMI and lookup tables were developed.

Results: Overall height, weight, BMI and D_{eff} were 172.5 ± 9.9 cm, 79.5 ± 19.1 kg, 26.6 ± 5.6 kg m^{-2} and 30.1 ± 4.3 cm, respectively. There was a significant correlation between D_{eff} and BMI as well as weight ($r = 0.85$ and $r = 0.84$; $p < 0.05$, respectively). Correlation was significantly

better for BMI in abdominal CT ($r = 0.89$ vs $r = 0.84$; $p < 0.05$), whereas it was better for weight in chest CT ($r = 0.87$ vs $r = 0.81$; $p < 0.05$). Surrogated SSDEs did not differ significantly from the reference standard with a median absolute relative difference of 4.2% per patient (interquartile range 25–75: 3.1–7.89, range 0–25.3%).

Conclusion: BMI and weight exhibit a significant correlation with D_{eff} in adult patients and can be used as surrogates in the calculation of SSDEs. Using the herein-developed lookup charts, SSDEs can be calculated based on patients' weight and BMI.

Advances in knowledge: In abdominal CT, BMI has a superior correlation with effective diameter compared with weight, whereas weight is superior in chest CT. Patients' BMI and weight can be used as surrogates in the calculation of SSDEs.

INTRODUCTION

The volumetric CT dose index (CTDI_{vol} , mGy) and the dose-length product (DLP, mGycm) are the two most common parameters used to describe radiation exposure from CT examinations. The CTDI_{vol} is defined as CTDI_w normalized to the pitch factor. DLP is calculated by multiplying CTDI_{vol} with the length of the scan volume. The value of both, CTDI_{vol} and DLP in regard to the actual radiation exposure is limited, as CTDI_{vol} only accounts for the radiation output within a defined volume based on a phantom. Size-specific dose estimates (SSDEs) have been introduced by the American Association of Physicists in Medicine (AAPM) in 2011.¹ Four independent research groups performed either phantom measurement as well as Monte Carlo simulations and provided size-dependent conversion factors. These factors can be used to correct CTDI_{vol} according to patients' habitus. Different methods to assess SSDEs were provided, whereas diameter measurements on axial CT images and calculation of the

effective diameter (D_{eff}) were considered the most accurate.¹ Automatic measurements and calculation of D_{eff} has not been integrated into modern CT scanners so far. Furthermore, SSDE values are not part of the digital imaging and communications in medicine radiation dose structured report.

Owing to the limitations of CTDI_{vol} as a parameter for patient dose exposure, dose estimates taking into account patients' habitus have gained ever more importance. To manually calculate SSDEs, measurements require the original CT images which may not always be available, e.g. in dose registry analysis or when assessing patients' lifetime radiation dose exposure retrospectively.^{2,3} If images are available, the whole-body circumference has to be in the field of view in order to calculate SSDEs using D_{eff} . This might not always be the case, e.g. in spine-CT studies or CT examinations of obese patients. Nevertheless, dose data taking into account patient's habitus are desirable, and

therefore research has been performed to establish surrogate methods using patients' characteristics. Recently, a method to surrogate SSDEs in paediatric patients was introduced.⁴ A high correlation between D_{eff} and body weight was demonstrated and a lookup table was provided to calculate SSDEs from patients' weight in paediatric patients to simplify the SSDE method.⁴

It has been hypothesized that body mass index (BMI) might be superior to body weight as a surrogate parameter for SSDEs because it also takes the patients' height into account. To our knowledge, the value of BMI as a surrogate parameter for D_{eff} in the calculation of SSDEs has not been investigated so far.

Therefore, the aim of this study was to assess the value of BMI compared with body weight as a surrogate parameter in the calculation of SSDEs in adult clinical abdominal and chest CT.

METHODS AND MATERIALS

Patients

This retrospective study was approved by the local ethics committee. 235 patients (137 males, 98 females; mean patient age 62.5 ± 15.0 years) who underwent 401 clinical CT examinations (196 chest, 205 abdomen) were retrospectively included in this study. CT examinations were performed on three different CT scanners (Definition AS+, Definition Flash and Definition AS with sliding gantry; Siemens AG, Healthcare Sector, Forchheim, Germany). Automated tube current modulation (CareDose 4D; Siemens AG, Healthcare Sector) was activated on all scanners.

Measurements

Diameter measurements were performed on a standard picture archiving and communications system workstation (IDS 7; Sectra Medical Systems GmbH, Linköping, Sweden) by two radiologists (blinded, with 2 and 4 years' of experience with abdominal and chest CT) in consensus mode. Both radiologists were blinded to patients' demographic data. Measurements were performed according to the recommendations of the AAPM report 204 in the axial CT images.¹ Scan volume ranged from the supra-aortic branches to the bottom of the liver for chest CT and from the bottom of the lung to the common femoral arteries for abdominal CT. For method standardization, all measurements were performed on mid slice images of the scan volume according to previous studies.⁵

The largest anterior–posterior diameter (D_{ap}) and lateral diameter (D_{lat}) were measured (Figure 1) and used to calculate D_{eff} :

$$\sqrt{D_{\text{ap}} \times D_{\text{lat}}} \quad (1)$$

Patients' weight and height were routinely assessed by the technician at the time of CT examination and documented in the patient protocol in the picture archiving and communications system. All data were extracted from the patient protocol and verified using the digital patient record. In this study, BMI was calculated using the equation provided by the World Health Organization: $\text{BMI} = \text{weight height}^{-2}$.⁶ CTDI_{vol} was extracted from the patient protocol.

Size-specific dose estimates calculation

As the reference standard, SSDEs were calculated according to the recommendations of the AAPM report 204 based on diameter measurements on axial CT images and calculation of D_{eff} . The conversion factors from the lookup table provided by report 204 and D_{eff} were used to assess SSDEs.¹

Correlation coefficients were calculated for D_{eff} and BMI; D_{eff} and weight; D_{eff} and height; and D_{eff} and age (Figures 2–5) for chest CT and abdominal CT. Regression equations for D_{eff} and BMI as well as D_{eff} and body weight were used to determine D_{eff} values ($D_{\text{eff_bmi}}$; $D_{\text{eff_weight}}$) based on the corresponding BMI and body weight for every patient. Values for either BMI or weight were inserted into the regression equations to calculate the corresponding $D_{\text{eff_bmi}}$ and $D_{\text{eff_weight}}$. The lookup chart from report 204 was used to calculate the corresponding conversion factor using D_{eff} , $D_{\text{eff_weight}}$ and $D_{\text{eff_bmi}}$.¹ Lookup tables were prepared to enable the calculation of SSDEs using weight as a surrogate parameter in chest CT and using BMI as a surrogate parameter in abdominal CT (more information is given in the Results section, the Size-specific dose estimates subsection).

Absolute and relative differences between surrogated SSDEs and the reference standard per patient were assessed. Correlation between relative SSDE difference per patient and patient's weight, height and BMI was determined.

Data analysis

IBM SPSS® Statistics v. 21 for Windows® (IBM Corp., New York, NY; formerly SPSS Inc., Chicago, IL) was used for statistical analysis. Statistical significance is set to $p < 0.05$. Correlation was calculated using Pearson correlation coefficient. A Kolmogorov test was performed to test for normality. Fisher's Z transformation with the extension published by Steiger⁷ was used to compare correlations. To perform the calculations, we used a software tool provided by Lee and Preacher⁸ (Stanford University). Student's t -test was used to compare normal distributed values. A Mann–Whitney U test was performed as

Figure 1. Measurement of lateral and anteroposterior diameter to calculate effective diameter.

Figure 2. Correlation between effective diameter (D_{eff}) and body mass index (BMI).

a non-parametric test. Data are reported as mean $\pm$ standard deviation with ranges and 95% confidence intervals (95% CIs) or as median with 25–75% interquartile ranges (IQR 25–75). To evaluate the error of the surrogate methods per patient, median absolute relative difference per patient {formula: $[\text{absolute value}(\text{surrogated SSDE} - \text{reference SSDE})]/\text{reference SSDE} \times 100$ } and the respective IQR 25–75 was calculated.

RESULTS

Patients' characteristics and diameter measurements

Patient demographics are listed in Table 1. Mean D_{eff} calculated using the manual measurements was 30.1 ± 4.3 cm (95% CI: 29.7–30.5 cm). Mean $D_{\text{eff_weight}}$ was 30.0 ± 3.6 (95% CI: 29.7–30.4 cm) compared with 30.1 ± 3.6 cm for $D_{\text{eff_bmi}}$ (95% CI: 29.7–30.4 cm).

Figure 3. Correlation between effective diameter (D_{eff}) and weight.

Figure 4. Correlation between effective diameter (D_{eff}) and age.

Absolute difference for $D_{\text{eff_weight}}$ and $D_{\text{eff_bmi}}$ from D_{eff} was 1.86 ± 1.49 cm (median absolute relative difference: 4.8%; IQR 25–75: 2.5–9.2%) and 1.87 ± 1.36 cm (median absolute relative difference: 5.1%, IQR 25–75: 2.8–8.9%), respectively. This absolute difference could be reduced to 1.64 ± 1.32 cm (median absolute relative difference: 4.5%, IQR 25–75: 2.2–7.6%) when surrogating D_{eff} using weight in chest CT studies and BMI in abdominal CT studies. Detailed results from diameter measurements are shown in Table 1.

Correlations

There was a significant correlation between body weight and BMI ($r = 0.86$, $p < 0.0001$, 95% CI 0.84–0.89) for all CT examinations. Similarly, in all examinations, D_{eff} correlated significantly with BMI ($r = 0.85$, $p < 0.0001$, 95% CI 0.82–0.88) and body weight ($r = 0.84$, $p < 0.0001$, 95% CI 0.81–0.87).

Figure 5. Correlation between effective diameter (D_{eff}) and size.

Table 1. Patient characteristics and results from diameter measurements

	Overall	Abdominal CT	Chest CT
Number (<i>n</i>)	401	205	196
Weight (kg)	79.5 ± 19.1 (44–160)	80.0 ± 19.6 (44–160)	78.9 ± 18.5 (44–160)
Height (cm)	172.5 ± 9.9 (149–196)	172.4 ± 10.0 (149–196)	172.6 ± 9.8 (149–196)
Age (years)	62.5 ± 15.0 (22–90)	62.6 ± 14.9 (22–90)	62.5 ± 15.2 (22–90)
BMI (kg m ⁻²)	26.6 ± 5.6 (14.9–49.4)	26.9 ± 5.9 (14.9–49.4)	26.4 ± 5.4 (14.9–49.4)
BMI <20 kg m ⁻² , (<i>n</i>)	31 (14.85–19.91)	17 (14.9–19.9)	14 (14.9–19.9)
BMI 20–25 kg m ⁻² , (<i>n</i>)	145 (20.20–24.97)	72 (20.2–25.0)	74 (20.1–25.0)
BMI 25–30 kg m ⁻² , (<i>n</i>)	137 (25.19–29.98)	68 (25.2–30.0)	69 (25.1–30.0)
BMI 30–35 kg m ⁻² , (<i>n</i>)	53 (30.07–34.60)	27 (30.1–34.6)	26 (30.1–34.6)
BMI >35 kg m ⁻² , (<i>n</i>)	35 (35.43–49.38)	21 (35.1–49.4)	14 (35.1–49.4)
Diameter (axial, anteroposterior) (cm)	25.5 ± 4.2	25.3 ± 4.8	25.8 ± 3.3
Diameter (axial, lateral) (cm)	35.2 ± 4.9	35.9 ± 5.5	35.1 ± 4.2
<i>D</i> _{eff} (cm)	30.1 ± 4.3	30.0 ± 4.9	30.1 ± 3.5
<i>D</i> _{eff_weight} (cm)	30.0 ± 3.6 ^a	30.1 ± 3.7 ^a	30.1 ± 2.9
<i>D</i> _{eff_bmi} (cm)	30.1 ± 3.6 ^a	30.1 ± 4.3	29.9 ± 3.4 ^a

BMI, body mass index; *D*_{eff}, effective diameter; *D*_{eff_bmi}, effective diameter calculated from body mass index; *D*_{eff_weight}, effective diameter calculated from weight.

^aValues in italics were calculated with the corresponding correlation equations for the whole data set.

Ranges are shown in parenthesis.

Nevertheless, there was no statistical significant difference between these correlation coefficients (*z*-score: 0.776, *p* = 0.44).

For abdominal CT, *D*_{eff} and BMI (*r* = 0.89; *p* < 0.0001, 95% CI 0.85–0.91) correlated significantly better than *D*_{eff} and body weight (*r* = 0.84; *p* < 0.001, 95% CI 0.79–0.87) (*z*-score: 3.053, *p* = 0.002).

For chest CT, *D*_{eff} and body weight (*r* = 0.87; *p* < 0.0001, 95% CI 0.83–0.90) correlated significantly better than *D*_{eff} and BMI

(*r* = 0.81; *p* < 0.0001, 95% CI 0.76–0.86) (*z*-score: 3.238, *p* < 0.001).

Correlation was comparable for male and female patients in abdominal CT (BMI: *r* = 0.90, respectively; weight: *r* = 0.86 vs *r* = 0.83; *p* = 0.32). Correlation was significantly better for BMI in female patients in chest CT (BMI: *r* = 0.88 vs *r* = 0.82; *p* = 0.03), whereas there was no significant difference for weight (*r* = 0.87 vs *r* = 0.85; *p* = 0.45). There was no significant difference between correlation of BMI and *D*_{eff} and

Figure 6. Bland–Altman plots for effective diameter (*D*_{eff}) calculation based on weight (a, *D*_{eff_weight}) and body mass index (BMI) (b, *D*_{eff_BMI}) compared with *D*_{eff} calculation based on diameter measurements.

Figure 7. Box plots of calculations of size-specific dose estimate (SSDE) based on manual diameter measurements, body weight and body mass index (BMI).

weight and D_{eff} in chest CT of female patients ($r = 0.88$ vs $r = 0.87$, $p = 0.64$).

Overall there was no statistically significant correlation between D_{eff} and age ($r = 0.02$; $p = 0.6$, 95% CI -0.07 to 0.12). There was a significant correlation for D_{eff} and height for chest CT ($r = 0.33$; $p < 0.0001$, 95% CI 0.2 – 0.45), whereas there was no significant correlation for D_{eff} and height in abdominal CT studies ($r = 0.08$; $p = 0.2$, 95% CI -0.06 to 0.22). Correlation between the different surrogate parameters and D_{eff} are illustrated in Figures 2–5. The regression equations for weight in chest CT studies and BMI in abdominal CT studies were:

Weight in chest CT: $y = 0.1626x + 17.265$.

BMI in abdominal CT: $y = 0.7374x + 10.225$.

Bland–Altman plots for the calculation of $D_{\text{eff_bmi}}$ and $D_{\text{eff_weight}}$ compared with manually measured D_{eff} indicate a good agreement between both methods (Figure 6a,b).

Size-specific dose estimates

Mean CTDI_{vol} was 6.1 ± 3.1 mGy. Mean SSDE values were 7.28 ± 2.76 mGy for the reference standard (diameter

measurements; 95% CI 7.0 – 7.6 mGy), 7.35 ± 3.05 mGy (95% CI 7.1 – 7.6 mGy) for body weight as a surrogate parameter and 7.33 ± 2.90 mGy (95% CI 7.1 – 7.6 mGy) for BMI as a surrogate parameter. There was no significant difference between surrogated SSDEs and the reference standard (weight: $p = 0.76$; BMI: $p = 0.81$) (Figure 7).

Using the dedicated chest and abdominal CT correlation equations for the calculation of SSDEs separately, the value for $D_{\text{eff_weight}}$ in chest CT was 5.61 ± 2.07 mGy (95% CI 5.3 – 5.9 mGy) and for $D_{\text{eff_bmi}}$ abdominal CT was 8.97 ± 2.58 mGy (95% CI 8.6 – 9.3 mGy).

SSDEs per patient using the overall correlation differed from the reference standard by a median of 4.4% for weight (mean of 6.73%, range abdominal 0 – 25.5% , range chest 0 – 23.9%) and 6.5% for BMI (mean 6.85%, range abdominal 0 – 29.4% , range chest: 0 – 20.2%). The median absolute relative difference was improved to 4.2% (mean 5.97%, range abdominal: 0 – 25.3% , range chest: 0 – 23.9%) when using the dedicated regression equations for weight in chest CT studies and for BMI in abdominal CT studies (Table 2). There was no significant correlation between body weight, BMI or height and the variation of surrogated SSDEs per patient (weight: $r = 0.1$; BMI: $r = 0.1$ and height $r = 0.02$; $p > 0.05$, respectively).

The provided lookup charts (Tables 3 and 4) can be used to calculate SSDEs based on patients' weight in chest CT and BMI in abdominal CT.

DISCUSSION

This study documented a significant correlation between body weight and D_{eff} as well as BMI and D_{eff} in adult CT examinations of the abdomen and chest. Overall, correlation was slightly, but not significantly, increased for BMI compared with body weight. Detailed analysis revealed a significantly improved correlation for weight compared with D_{eff} in chest CT studies and for BMI to D_{eff} in abdominal CT studies. Although overall the calculation of SSDEs using either method as a surrogate parameter did not differ significantly from calculations of SSDEs based on axial diameter measurements, mean difference per patient was improved when using weight for chest and BMI for abdominal CT studies. Therefore, we created lookup charts, which can be used to

Table 2. Median absolute relative difference (%) and interquartile range (25–75%) of size-specific dose estimates per patient for the different regression equations

Regression equation used	Overall	Abdominal CT	Chest CT
BMI (chest + abdominal) ^a	6.5 (3.4–10.5)	6.6 (3.4–10.5)	5.5 (3.5–10.4)
Weight (chest + abdominal) ^b	4.4 (3.4–10.0)	7.3 (3.5–11.8)	4.1 (3.1–7.7)
BMI (abdominal) ^c	4.2 (3.1–7.9)	7.0 (3.4–10.3)	–
Weight (chest) ^d	–	–	3.9 (3.0–7.5)

BMI, body mass index.

All values are given in percent of SSDE calculated with the reference standard.

^aRegression equation for BMI (chest + abdominal): $y = 12.976 + 0.6414x$.

^bRegression equation for weight (chest + abdominal): $y = 15.204 + 0.187x$.

^cRegression equation for BMI (abdominal): $y = 10.225 + 0.7374x$.

^dRegression equation for weight (chest): $y = 17.265 + 0.1626x$.

Table 3. Conversion factors to calculate size-specific dose estimates in abdominal CT using body mass index (BMI) as a surrogate parameter

BMI (kg m^{-2})	Conversion factors
10	1.93
11	1.88
12	1.83
13	1.78
14	1.73
15	1.68
16	1.64
17	1.59
18	1.55
19	1.51
20	1.47
21	1.43
22	1.39
23	1.35
24	1.32
25	1.28
26	1.25
27	1.21
28	1.18
29	1.15
30	1.12
31	1.09
32	1.06
33	1.03
34	1.00
35	0.97
36	0.95
37	0.92
38	0.90
39	0.87
40	0.85
41	0.83
42	0.81
43	0.78
44	0.76
45	0.74
46	0.72
47	0.70

calculate SSDE values using weight and BMI as surrogate parameters in case diameter measurements cannot be performed.

Initially, the SSDE concept was introduced to correct the scanner indicated CTDI_{vol} value according to the patients' constitution.^{1,9} This has to be performed because radiation exposure of patients depends on both the radiation output of the scanner and the patient habitus.⁸ Different studies have been performed for SSDE validation, optimization and simplification of the SSDE concept.^{1,4,10–13} Commercial and non-commercial software tools have been introduced to automatically perform diameter measurements and assess SSDEs.^{4,12,14} These software tools as well as manual diameter measurements require axial CT images or the scout images, which may not be always available, e.g. in the setting of cloud-based dose monitoring or retrospective data analysis.^{2,3} The AAPM recommended integration of automatic SSDEs reporting into the CT scanner software and into the digital imaging and communications in medicine radiation dose structured report, but this has not yet been executed by the manufacturers. To simplify the SSDE method and to calculate SSDEs without patients' images, different studies evaluated body weight as a surrogate parameter for SSDEs.^{4,15,16}

The initial AAPM report 204 introduced patient age (and not weight or BMI) as a surrogate parameter in paediatric patients.¹ Correlation between age and D_{eff} in this study was not significant in our adult collective. This has to be expected, as age in childhood may correlate with growth (and therefore D_{eff}) but it does not do so in adulthood.

Pourjabbar et al¹⁶ reported a correlation of $r = 0.89/r = 0.92$ between weight and anteroposterior/lateral transverse diameter. A significant correlation between patient's weight and SSDEs calculated from the diameter measurements on scout image was shown. Those results, however, cannot be compared with the results presented here, as only the lateral/anteroposterior diameter was measured and D_{eff} was not calculated. Furthermore, BMI was not part of the study and SSDEs were not calculated using surrogate parameters.¹⁶

Cook et al¹⁵ investigated the correlation between patient weight and D_{eff} in CT examinations of the chest and abdomen. They determined D_{eff} automatically on central CT images using a commercially available software tool (Radimetrics eXposure®; Bayer Healthcare, Toronto, ON, Canada). A linear relationship between patient weight and D_{eff} was reported, which is in accordance to our results. Detailed comparison of our results to those reported by Cook et al cannot be performed because BMI was not investigated in their study.

Khawaja et al⁴ reported a correlation between body weight and D_{eff} of $r = 0.87$ and did not find a statistical difference between SSDEs based on measurements and SSDEs based on weight in the paediatric population. This is similar to our results found in an adult population. Although Khawaja et al⁴ provided a comprehensive subgroup analysis in regard to body weight and age groups in their paediatric population, BMI as a surrogate parameter was not assessed. Our results indicate that different surrogate parameters are favourable for abdominal and chest CT studies, respectively. Because chest CT studies and abdominal

Table 4. Conversion factors to calculate size-specific dose estimates in chest CT using patient's weight as a surrogate parameter

Weight (kg)	Conversion factors
<44	1.50
45–47	1.48
48–51	1.45
52–54	1.42
55–58	1.39
59–61	1.36
62–65	1.33
66–68	1.30
69–72	1.28
73–77	1.24
78–81	1.21
82–85	1.18
86–90	1.15
91–94	1.12
95–99	1.09
100–104	1.06
105–109	1.03
110–114	1.00
115–120	0.96
121–130	0.92
131–140	0.86
141–150	0.81
151–160	0.77
161–170	0.72
>170	0.70

CT studies were not investigated separately by Khawaja et al,⁴ comparability with our study is limited.

Our study has certain limitations. Although median absolute relative difference of SSDE values in our population was only 4% per patient when using weight for chest CT and BMI

for abdominal CT, respectively, the difference between the reference standard and surrogated values was up to 25% in two cases. We used median and IQR and provided Bland–Altman plots to describe our method as exact as possible. We did not find a significant correlation between patient's weight, height or BMI and the variation of SSDEs. Owing to the restricted sample size of this study with a very limited number of outliers, we could not perform a more detailed analysis to further assess the reason for the deviation in single cases. Larger studies have to be conducted to verify our results and to determine in which patients BMI and weight might not be suitable as surrogate parameters for SSDEs.

All diameter measurements were performed manually as automatic measurement software was not available. This may lead to variability but reflects clinical routine. In a recent report, the AAPM proposed an alternative method of calculation of SSDEs based on the water equivalent diameter (D_w) which comprises patients' attenuation to correct $CTDI_{vol}$.¹⁰ We did not calculate D_w and therefore cannot give a statement about correlation of either weight or BMI and D_w . Further studies to assess the correlation between the parameters evaluated here and D_w are desirable. Nevertheless, according to the AAPM report 220, it is reasonable to use geometric data to calculate SSDEs when D_w is not available, and therefore D_{eff} is frequently used for the calculation of SSDEs in clinical routine as well as in various recent studies investigating radiation dose exposure from CT.^{10,17–19} The number of wide-detector CT scanners is increasing. $CTDI_{vol}$ is calculated based on a 10-cm pencil chamber and therefore SSDEs might not be applicable on these scanners.²⁰

In conclusion, a good correlation between body weight and effective diameter as well as BMI and effective diameter in adult chest and abdominal CT examinations was shown in the presented study. BMI demonstrated a significantly better correlation with D_{eff} for abdominal CT, whereas weight showed a significantly better correlation in chest CT. On average, SSDE value per patient calculated with one of the two surrogate parameters for abdominal and chest CT, respectively, differed <6% from those calculated with the reference standard. The lookup charts provided here can be used to assess SSDEs in adult CT of the torso in cases where patient images are not available.

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