EDITOR'S CHOICE

Dose Is Not Always What It Seems: Where Very Misleading Values Can Result From Volume CT Dose Index and Dose Length Product

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Purpose: The volume CT dose index ($CTDI_{vol}$) and the dose-length product, commonly reported for examinations performed on clinical CT scanners, should not be used as surrogates for patient dose. This is because significant under or overestimates of these actual values can occur when there is a mismatch between the actual body size of the patient and the 16 cm or 32 cm diameter $CTDI_{vol}$ phantoms. This mismatch can be exacerbated in pediatric body examinations because of the fact that some manufacturers use the large diameter phantom while other manufacturers use the small diameter phantom as the $CTDI_{vol}$ reference phantom.

Method: A clinical example is described for a pediatric patient with a 4-fold difference in $CTDI_{vol}$ between a presurgical CT examination and a postsurgical CT examination, even though the actual dose absorbed by the patient was about the same. Using methods published by the American Association of Physicists in Medicine, we calculated the size-specific dose estimate (SSDE), and compared the estimated measurement of dose using the SSDE with the $CTDI_{vol}$.

Results: Using SSDE significantly reduced the discrepancy in radiation dose estimates of $CTDI_{vol}$ in the clinical study, and allowed dose estimate comparisons between scanners to be more meaningful.

Conclusions: Radiation dose estimates are more accurate when using the SSDE metric in lieu of the $CTDI_{vol}$ metric for reporting and comparing patient dose indices.

Key Words: Pediatric CT dose, $CTDI_{vol}$, size-specific dose estimate (SSDE)

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INTRODUCTION

The volume CT dose index, ($CTDI_{vol}$), is a metric reported by manufacturers of CT scanners that provides information regarding the radiation dose to a poly-methyl methacrylate cylindrical phantom. Two phantoms are used, having dimensions of 32 cm diameter for emulating the abdomen and 16 cm diameter for emulating the head of a patient. $CTDI_{vol}$ measurements are made using a 100 mm air ionization chamber placed along the 150 mm phantom length in the center and periphery, for specific CT scanner techniques (kV, mA, rotation time, beam collimation, pitch, field-of-view, and tube filtration) with correction for chamber calibration, partial volume irradiation, and conversion constants [1]. Although useful as a measure of scanner output, $CTDI_{vol}$ should not be used as an indication of patient dose because it does not take into account the size of the patient to which the dose was delivered, and therefore does not reflect patient absorbed dose [2].

Nevertheless, this value (along with dose-length product, [DLP]) is reported in the dose page of each patient CT study. With more patients interested in radiation dose delivered by CT and other medical imaging procedures, requests to get dose information are common, but unfortunately, the dose metrics that are readily available are often misunderstood. As a result, inappropriate and misleading conclusions can occur, as illustrated by a specific encounter at UC Davis Medical Center of a patient who had 2 CT scans, pre- and postsurgery, on different manufacturer's equipment.

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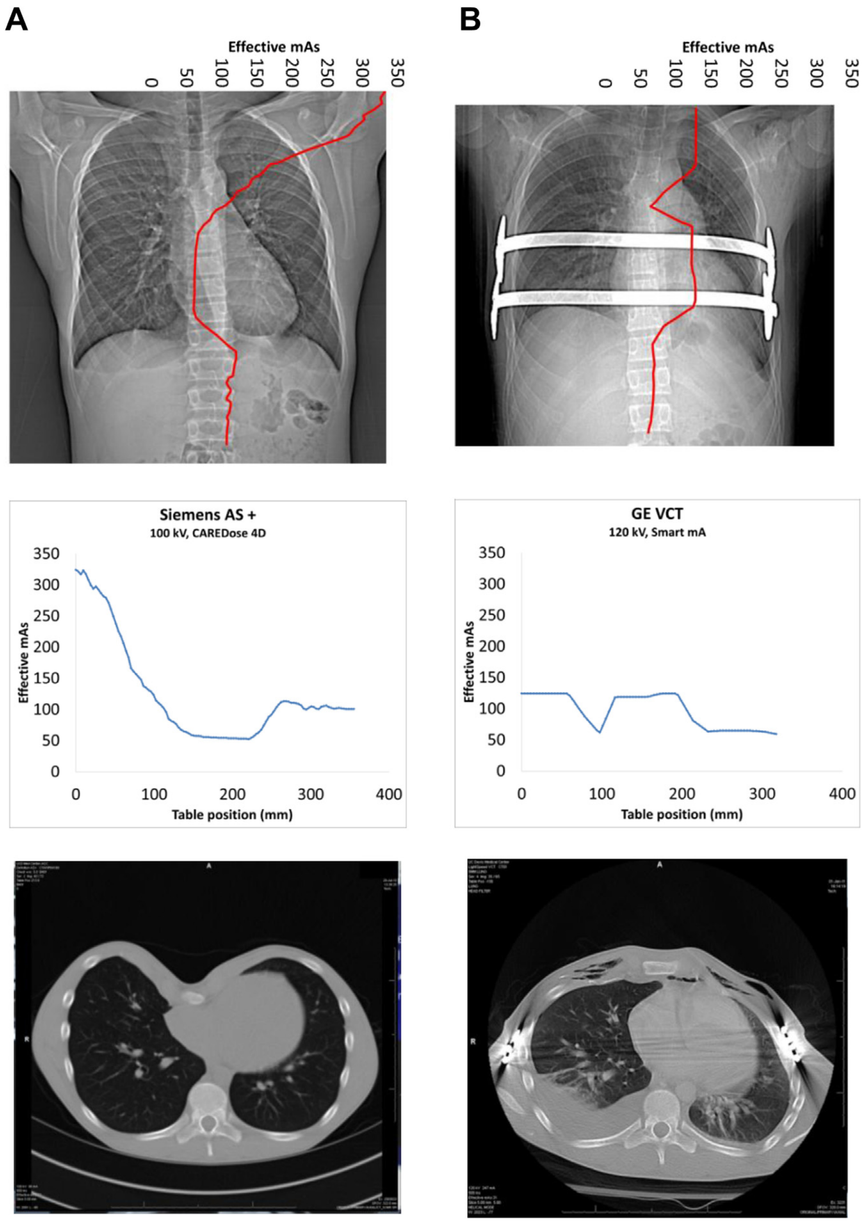

Fig 1. (A) Presurgery scan, Siemens Definition AS+, 100kV, CareDose4D. Top: CT localizer radiograph with mA modulation and effective mAs scale superimposed. Middle: tube current modulation with table position "0" at top of localizer. Bottom: Reconstructed axial scan. **(B)** Postsurgery scan, GE VCT, 120 kV, Smart mA. Top: CT localizer radiograph with mA modulation and effective mAs scale superimposed. Middle: tube current modulation with table position "0" at top of localizer. Effective mAs is calculated by dividing mAs/slice by pitch. Bottom: Reconstructed axial scan. kV = kilovolt; mA = milliampere.

BACKGROUND

A CT scan was performed on a 14-year-old patient of 1.78 m height and 60.6 kg weight, using a Siemens Definition 128 AS+ scanner (Siemens AG, Forchheim, Germany) at the UC Davis Medical Center outpatient clinic. The purpose of the scan was for surgical planning for repair of an involuted chest (pectus excavatum) deformity. The protocol used the Siemens tube current modulation technique, CareDose 4D at 100 kV, with a 0.5 s rotation time. The CT localizer radiograph, tube current effective mAs as a function of table position, and axial scan of the pulmonary region are shown in Figure 1A. During surgery, metal Nuss Bars were placed across the patient's chest to correct his pectus excavatum deformity. After surgery, a second CT scan was performed for the clinical suspicion of pneumonia on the inpatient General Electric VCT scanner (GE Healthcare, Waukesha, Wisconsin), using the GE tube current modulation protocol, Smart mA, at 120 kV and 0.5 s rotation time. The CT localizer radiograph, tube current effective mAs as a function