

BACKGROUND

Water equivalent diameter (WED) is the preferred patient size surrogate needed to calculate the normalized dose calculation (NDC) to determine the size-specific dose estimates (SSDE). The WED can be calculated from computed tomography (CT) axial scans providing the gold standard. A calibration method has been developed that relates the CT localizer pixel values (LPV) to the water-equivalent area calculated from the CT localizer. Utilizing CT localizers will provide an estimate of SSDE prior to the scan that may be used in DRR workflows and will reduce data overhead. We investigate the calibration method on patient data on two scanners with different vendors with different techniques.

METHODS

For calibration, CT localizer and CT axial images of the computed tomography dose index (CTDI) and ACR phantoms were acquired using routine techniques on both scanners: GE Revolution (120 kV and lateral localizers) and SIEMENS Intevo (80 kV and lateral localizers). The water-equivalent area (WEA) and LPV were related. Then CT axial and CT localizer images of patients were acquired using the same technique and the WED was calculated using the calibration method.

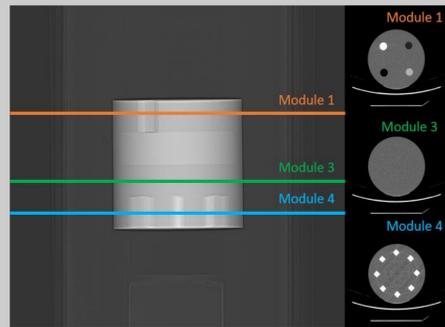


Figure 1. Example of the 3 modules from the ACR phantom used with vastly different attenuation properties for this calibration method.

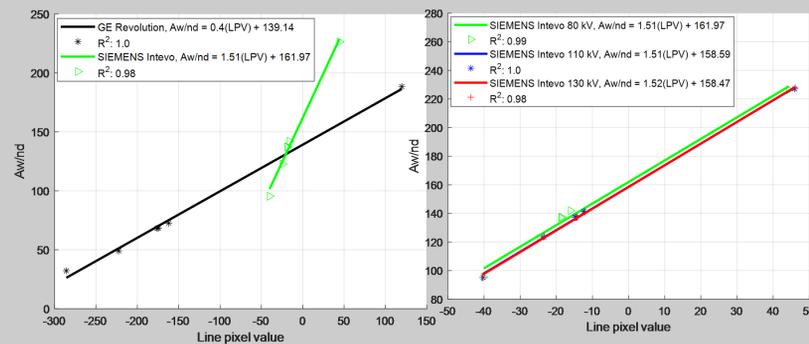


Figure 2 a) calibration curves for GE Revolution (120 kV), and SIEMENS Intevo (80 kV) showing the linear conversion of line pixel value (LPV) to water-equivalent area normalized to image width (A_w/nd) with $R^2 > 0.98$ for all cases, and b) calibration curves for SIEMENS Intevo at 80, 110 and 130 kVp showing similar slopes and y-intercepts with $R^2 > 0.98$ for all cases.

System	Data set	kV	Image quality reference	Typical scan Range	Kernel Recon CT Axial	Kernel Recon CT Localizer
GE Revolution	CT Abdomen	120	Noise index: 7-25	Shoulders to pelvis	STD	STD
SIEMENS Intevo	CT full body	80	Quality reference effective mAs	Top of head to bottom legs	B08s	T80f

Table 1. Experimental data collection of human patient routine cases performed on the GE Revolution and SIEMENS Intevo for the CT scans for pediatric patients. The Noise Index (NI) refers to the vendor-specific automatic exposure control (AEC) setting.

RESULTS

The NDC calculation for GE Revolution ($R^2=0.93$) and SIEMENS Intevo ($R^2=0.98$) show good correlation with most data points falling within the 95% confidence interval including the line of unity and AAPM TG Report 220 results. The maximum, mean and minimum absolute percentage differences of NDC for GE Revolution were 21.2, 3.0, and 0.2% and for SIEMENS Intevo were 4.0, 1.6, and 0.4%, respectively. The 21.2% was due to a single outlier whereas most cases were around the average of 3.0%.

System	Maximum percentage difference WED (%)	Mean percentage difference WED (%)	Minimum percentage difference WED (%)
GE Revolution	33.6	3.4	0.03
SIEMENS Intevo	3.4	1.5	0.3

Table 2. The absolute maximum, mean, and minimum percentage differences for WED for all three scanners.

System	Maximum percentage difference NDC (%)	Mean percentage difference NDC (%)	Minimum percentage difference NDC (%)
GE Revolution	21.2	3.0	0.2
SIEMENS Intevo	4.0	1.6	0.4

Table 3. The absolute maximum, mean, and minimum percentage differences for NDC for all three scanners.

RESULTS

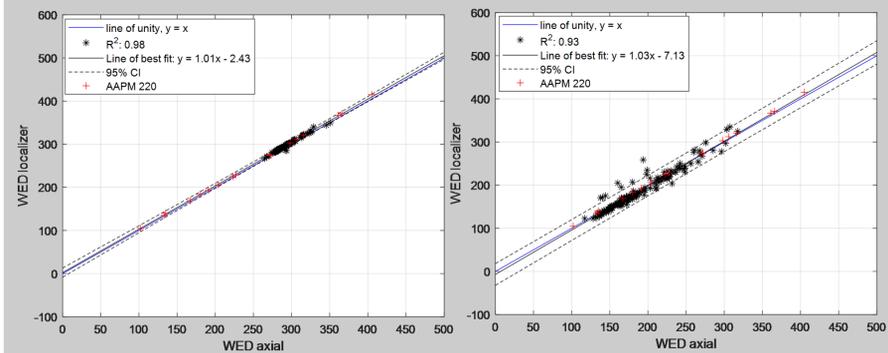


Figure 4. The water-equivalent diameter (WED) calculated from the CT localizer as function of CT axial NDC for c) GE Revolution, d) SIEMENS Intevo. The line of best fit and 95% confidence interval (CI) are plotted for all graphs, including the results from AAPM 220.

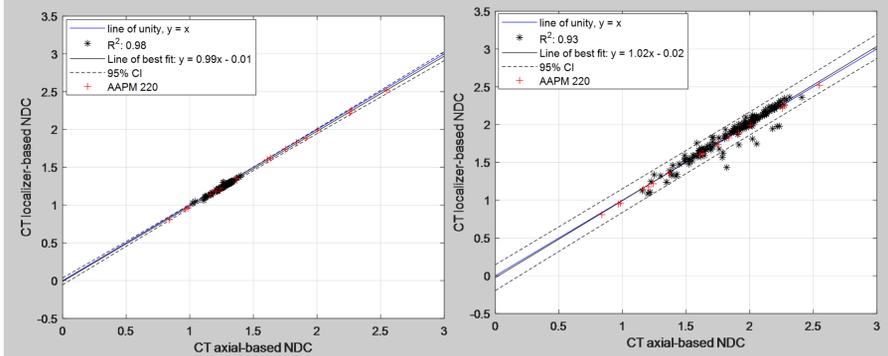


Figure 5. The normalized dose coefficient (NDC) calculated from the CT localizer as function of CT axial NDC for c) GE Revolution, d) SIEMENS Intevo. The line of best fit and 95% confidence interval (CI) are plotted for all graphs, including the results from AAPM 220.

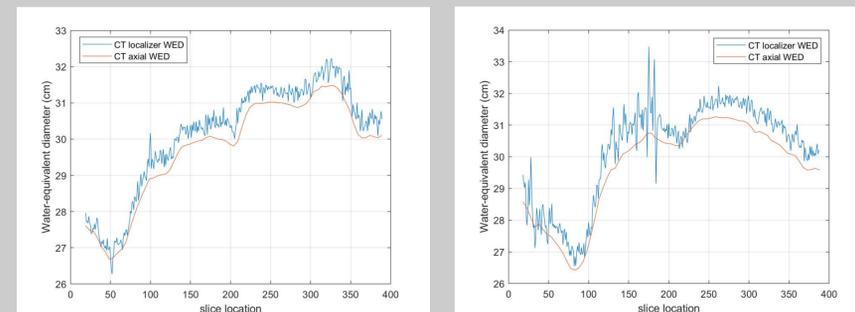


Figure 6 shows two examples of the WED as a function of slice location for CT axial with a slice thickness of 5mm and CT localizer scans on a SIEMENS Intevo of a patient scanned from head-to-toe.

CONCLUSIONS

This study validates that the calibration method gives a good estimate of WED from CT localizers. The normalized dose coefficient can be determined within 20% as recommended by the AAPM TG Report 220.

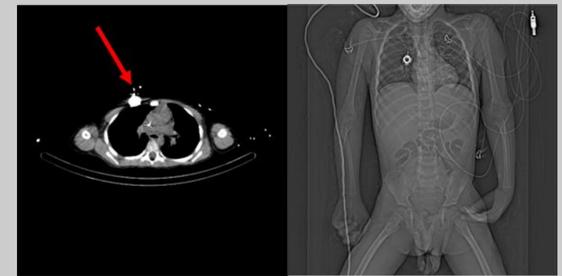


Figure 7 shows an example of the the CT axial slice with a surgical device that has a relatively higher attenuation that will increase the Hounsfield units.

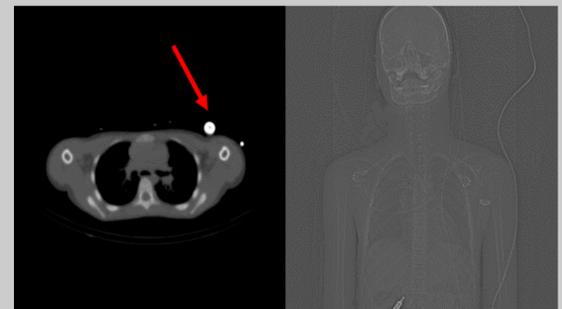


Figure 8 shows an example of the the CT axial slice with a surgical device that has a relatively higher attenuation that will increase the Hounsfield units.

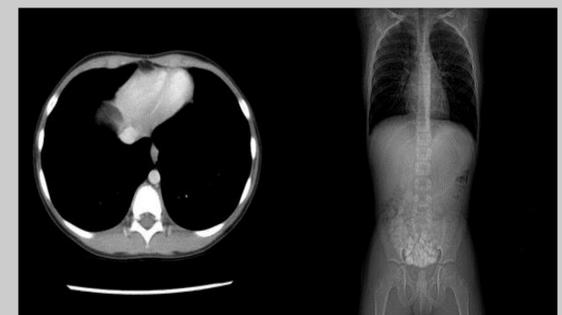


Figure 9 shows an example of a patient with a high ratio of lung region to soft tissue and less subcutaneous fat that will result in a relatively lower attenuation and will decrease the Hounsfield units.