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COMPARISON BETWEEN TWO METHODS FOR ESTIMATION OF EQUILIBRIUM DOSE IN MSCT PROCEDURERS

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Introduction: The use $CTDI_{100}$ as a dose indicator for mult-slice CT (MSCT) procedurers have caveats since this metric underestimate the dose contribution due the scattering beyond the scanning lengh. In 2010, a Report from AAPM Task Group (REPORT 111, 2010)[1] was published to propose a new paradigm on dosimetry of computer tomography, which includes a measurement of the dose using a large phantom to estimate the dose on an ideal infinity large phantom (*equilibrium dose*). As the scanning lengh (L) values increase, the *cumulative dose* (integrated dose over $-L/2$ to $+L/2$) grows asymptotically, converging to a maximum value.

The present work evaluated two approaches to estimate the equilibrium dose from the measured data: one presented in the PhD thesis from Gonzales (GONZALES, 2019)[2] and another presented on a new AAPM Report (REPORT 200, 2020)[3].

Material and method: The Gonzales work (GONZALES, 2019) presents dose measurements as a function of L ($D(L)$) using three tied $CTDI_{100}$ phantoms to extend the measurement axis and a thimble ion chamber. The estimation of equilibrium dose can be made from those data.

Acordind to the AAPM Report 111, an empirically characterized function that describes the asymptotical grows is an exponential (Equation 1),

$$D_L(z=0) = D_{eq} * \left(1 - \alpha \cdot e^{-\frac{4L}{Leq}}\right), \quad (1)$$

where D_{eq} (equilibrium dose), α (*scatter fraction*) and L_{eq} (*equilibrium length*) are parameters which are estimated by fitting the experimental data.

The method from Gonzales used the software Origin 2020 that fit the Equation 1 to the measured data adopting the Levemberg-Maquardt least-squares method.

The Report 200 of AAPM proposes a method that manipulates algebraically the Equation 1, transforming it in a linear function (Equation 2). The linear coefficients are used to estimate the parameters α and L_{eq}.

$$g(L, D^*) = \log_2\left(1 - \frac{D_L(z=0)}{D^*}\right) \approx \quad (2)$$

$$\approx \log_2 \alpha - \frac{\ln(2)}{4 * L_{eq}} * L = c_{linear} + c_{angular} * L,$$

where D^* is the estimative of the equilibrium dose, c_{linear} and $c_{angular}$ are coefficients of a linear regression. The best estimative of D^* makes the linear regression closer to the function $g(L, D^*)$. Data from a GE Discovery CT750HD (General Electric Company, Boston, USA) using different voltages, phantom diameters, measuring axis and pitches were evaluated.

Results: As an example, Figure 1 shows the result of both fitting methods and the experimental data considering 140 kV, pitch=0,969, head phantoms and measurement on the cental axis.

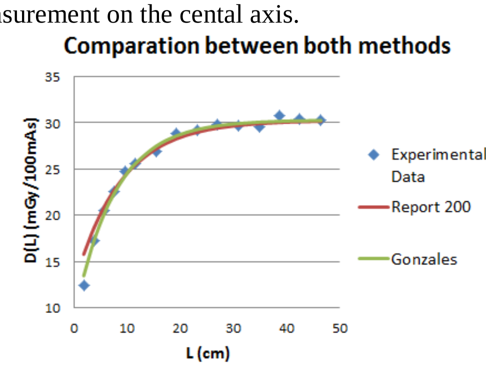

Figura 1. $D_{eq} = 30{,}3$, $Leq = 35{,}2$, $\alpha = 0{,}59$ from method of Report 200; $D_{eq} = 30{,}3$, $Leq = 30{,}5$, $\alpha = 0{,}71$ from method of Gonzales.

Conclusions: A general comparative evaluation demonstrate that both methods diverge, on average, 2,1% on D_{eq}, 32,7% on L_{eq} and 16,1% on α for all CT parameter combinations.

References:

1. AAPM Report No. 111, 2010
2. H. L. G. Gonzalez, 2019, PhD thesis – Universidade de São Paulo, São Paulo
3. AAPM Report No. 200, 2020