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DOSIMETRIA IN PHANTOM OF NEWBORN HEAD FOR COMPUTERIZED TOMOGRAPHY SIGNS WITH VOLTAGES OF 80, 100 AND 120 KV

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ABSTRACT

Computed Tomography is the radiodiagnostic method that most contributes to the dose deposition in population. Therefore, the dose reductions used in these tests are very important, especially for pediatric patients who have a life expectancy greater than the rest of the population. This study purpose to compare the doses generated from newborns (NB) with different voltages in a 64-channel multichannel CT equipment of the GE brand. One head phantom in a cylindrical shape made in PMMA were used to newborn patient dimensions. 100 mA.s of charge of the X-ray tube were standardized, alternating the voltages between 80, 100, 120 kV in the axial acquisition. The absorbed dose measurements were performed with a pencil-type ionization chamber positioned within the five apertures in the phantom. The phantom was developed with the cephalic percentile of male NB of 14 and female of 28 days, respectively. The doses obtained in the head phantom of NB were compared with the voltages of 80, 100 and 120 kV. The volumetric dose index, C_{VOL}, generated in the 120 kV protocol was 25.10 mGy, for 100 kV of 19,06 mGy and not for 80 kV 15,81 mGy. The results allow to evaluate that for the generation of images with 120 kV, the dose was 37.0% higher when compared to the voltage of 80 kV. The study shows that the increase in tension in the tomography protocols also makes it possible to increase the dose for the NB patient.

Keywords: Dosimetry; CT, medical imaging, Newborns.

1. INTRODUCTION

Computed Tomography (CT) is diagnostic radiology method a known since 1972, and since then it had an exponential improvement in its technological performance and a remarkable growth in its clinical use. The use of helical scans associated with multidetectors arc allowed to reduce the acquisition time of the CT tests and to improve the image quality leading to a more reliable study [1].

The radiation used in CT tests can cause damages to human cells and can lead to tumor development. An international radiation protection standard was created in order to minimize the danger of the radiation for occupational and public exposure. The radiological protection standard applies to the principle of justification and optimization as well as the dose or risk limitation. The standard control is to achieve by local and individual monitoring, including a trustful instrumentation, measurements and their interpretation [2].

CT is the diagnostic radiology method which most contributes to dose deposition in population, and for this reason the reduction of doses used in these tests become very important, especially for pediatric patients [3].

Pediatric patients have a higher probabilistic risk of developing cancer compared to adults receiving the same dose. The longer life expectancy in children allows more time for any deleterious effect of radiation to manifest, and developing organs and tissues are more sensitive to the effects of radiation [4].

Several countries have already implemented into their legislation the need to check the doses received by patients who undergo radiological tests through defined measurements and related parameters. The Brazilian legislation defines limites only by MSAD (multiple scan average dose) in a typical adult patient as a parameter of quality control of the CT scans. The values are a maximum limit of 50 mGy to the head, 35 mGy to the lumbar spine and 25 mGy to the abdomen. [5].

To ensure levels as low as reasonably achievable on CT scans, dose optimization and justification of practice should be relevant to the patient, since the risk is increased at each CT scan to which the patient undergoes [6].

In general, there are some factors that have a direct influence on dose deposition, such as the characteristic of the X-ray beam spectrum, the X-ray tube current (mA), the X-ray tube rotation time, the Beam thickness, scanning length, object characteristics, pitch, distance from the X-ray tube to the isocenter, among others [7].

Villar, J. et al., "Postnatal growth standards for preterm infants: the Preterm Postnatal Follow-up Study of the Intergrowth-21st Project", The Lancet Global Health, vol.3 (11), pp.681-691 [8].

2. MATERIALS AND METHODS

The experiments were performed for the observation and comparison of the absorbed doses using a phantom of a Newborn. The scans were performed on a GE scanner, 64-channel Discovery model. A pencil-type ionization chamber was used for measuring doses when positioned inside the simulator objects.

2.1. Phantom

The newborn head phantom have a cylinder shape with 11 cm in diameter with a length of 15 cm and are made in PMMA. The newborn head phantom was built based on the measurements of head circumference of 34.54 cm, which corresponds to 42 weeks or 14 days of life for a male newborn and 44 weeks or 28 days of life for a female newborn [8]. The head phantom have five openings, one central and four peripherals lagged by 90 degrees. The peripheral openings have the center 10 mm from the edge of the phantom. Figure 1 show a the newborn head phantom and their dimensions.

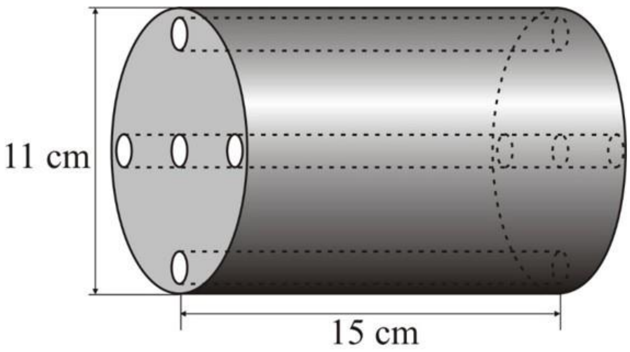

Figure 1. Head phantom of NB

The head phantom has five openings of 12.67 mm, with four peripherals lagging at 90 ° that have their center spaced about 10 mm from the edge of the simulating object, and the central aperture. To perform the tests the simulator was positioned in the isocenter of the tomograph, Fig. 2, with the pencil camera positioned inside the aperture 12.

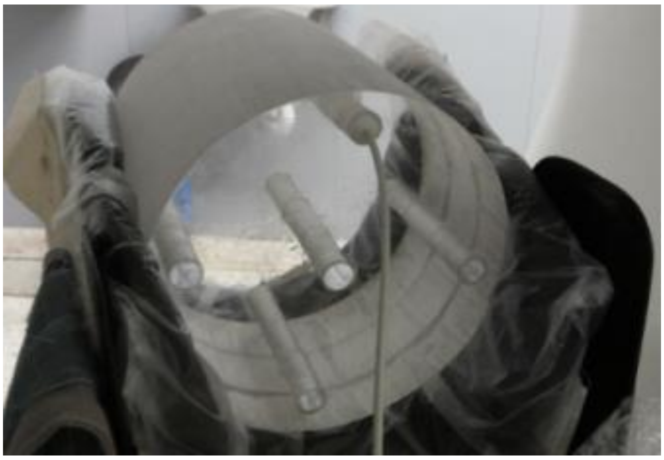

Figura 2, newborn head phantom placed in the gantry isocenter.

The openings of the phantom are filled with PMMA rods that need to be removed one by one for the pencil chamber placement in order to measure the absorbed dose in the five positions. The phantom were placed in the gantry isocenter and the peripheral openings were identified as the hours of an analog clock: 3, 6, 9, 12. Figure 3 shows the axial section of the phantom of the newborn's head with the pencil chamber positioned in the aperture12.

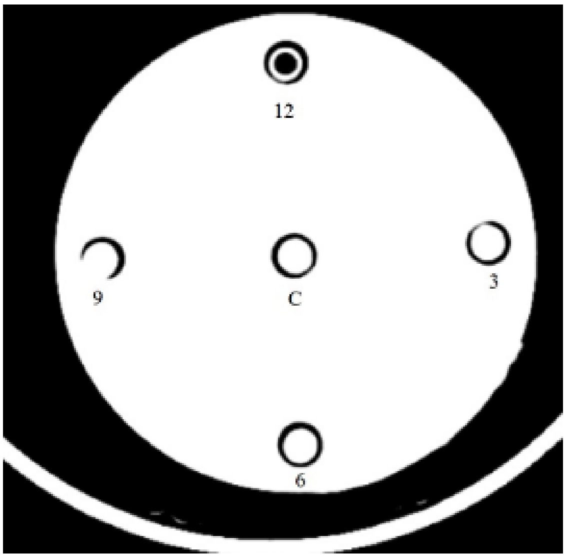

Figura 3, axial section of the simulator object with the identifications of the apertures with the pencil chamber positioned in the aperture 12.

2. 2. Measurements

The central slice was successively irradiated in axial mode, and the measurements were done five times in each position using a pencil ionization chamber. The gantry was in the angle position of 0 degrees and the phantom in the isocenter on a static table during the central slice irradiation. When the pencil chamber was placed into an opening the others were filled with PMMA rods. The pencil chamber was placed alternating with each opening of the newborn phantom. The voltage of the X-ray tube alternated between 80, 100 and 120 kV with of charge fixed at 100 mA.s, central slice thickness of 10 cm, pipe rotation time of 0.5 s. The parameters used in central slice irradiation are presented in Tab. 1.

Table 1: Parameters used in scanning protocos

Tests	Number of channels	Pipe rotation (s)	Current (mA)	Charge (mA.s)	Tubo tension (kV)	Pitch
1	64	0,5	200	100	120	0,984
2	64	0,5	200	100	100	0,984
3	64	0,5	200	100	80	0,984

3. RESULTS

All results obtained in the readings were multiplied by the Ar-PMMA conversion factor (values 1.068 to 120kV, 1.064 to 100kV and 1.054 to 80kV) and by 0.93 which is the calibration coefficient of the ionization chamber. The mean values of $C_{K,100}$ with the standard deviation (SD) obtained with the pencil câmera are described in Table 2, and graph of Figure 4.

Table 2: Mean values of $C_{k,100}$ measurements, newborn phantom.

Newborn head phantom						
Position	**Tubo tension, 120 kV**		**Tubo tension, 100 kV**		**Tubo tension, 80 kV**	
	$C_{k,100}$ (mGy)	SD	**$C_{k,100}$ (mGy)**	SD	**$C_{k,100}$ (mGy)**	SD
3	20,62	0,16	14,80	0,14	8,29	0,05
6	20,69	0,08	13,30	0,02	7,26	0,04
9	22,47	0,10	14,72	0,06	8,19	0,08
12	25,59	0,29	16,90	0,12	9,66	0,13
Central	23,24	0,10	15,16	0,05	8,18	0,02

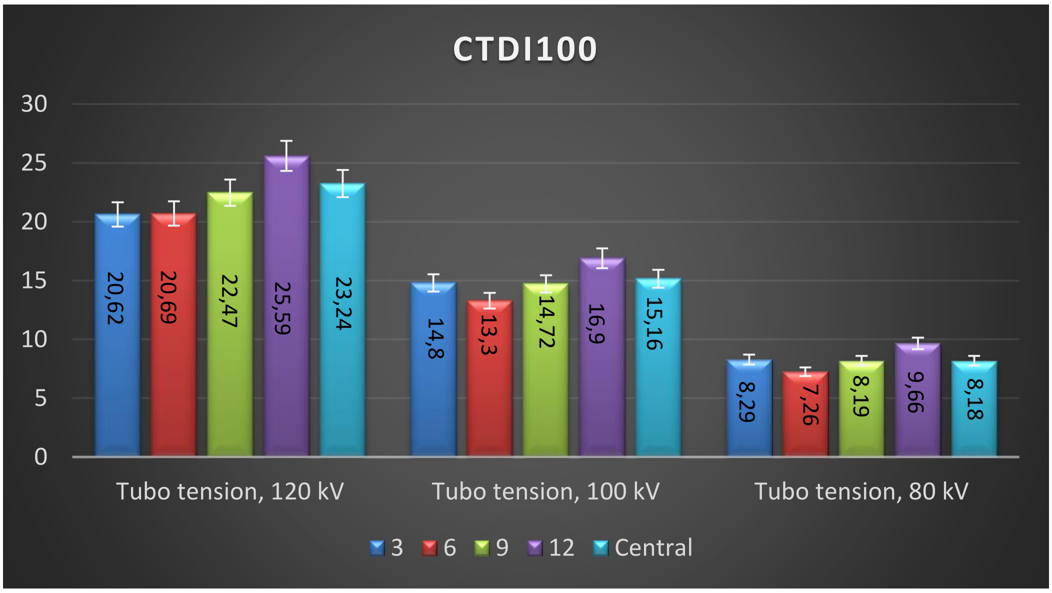

Figure 4, Mean values of $C_{k,100}$ measurements for NB phantom

The weighted CTDI values, C_w, serve to indicate the mean dose of a single tomographic slice. From the mean values of $C_{K,100}$ obtained in the measurements of the peripheral and central openings of the simulating object, it was possible to calculate the weighted dose index C_w, obtained through Equation 1. The values are recorded in Table 3 and plotted in the graph Of Figure 4.

$$C_W = (C_{K100,\,C} + 2\,C_{K,P})\,/3 \qquad (1)$$

Table 3: Values of C_w

Tubo tension (kV)	Dose em mGy	SD
120	24,7	0,01
100	18,75	0,01
80	15,55	0,02

The volumetric dose index, CVOL, corresponds to the dose index for the scanning of the simulating object, defined by Equation 2. From the values of Cw defined in Table 3, the values of CVOL were calculated and are recorded in Tab. 4 and the graph of figure 4.

$$C_{VOL} = C_W/\text{pitch} \quad (2)$$

Table 4. - Values of C_{vol}

Tubo tension (kV)	Dose em mGy	SD
120	25,1	0,01
100	19,06	0,01
80	15,81	0,02

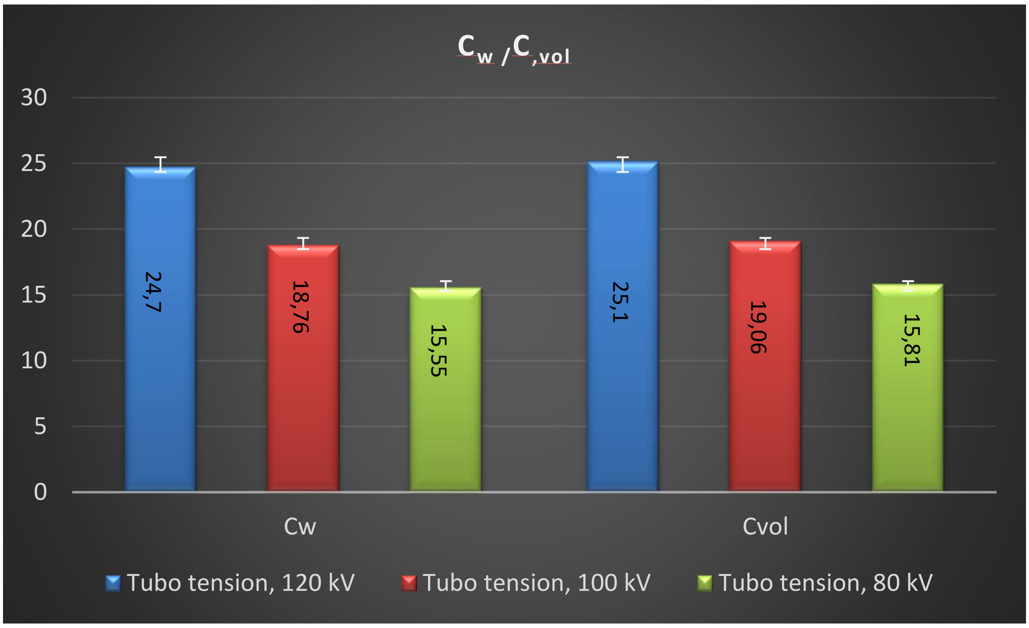

Fig. 4. Valores de índice de dose ponderado (C_w) e índice de dose volumétrico (C_{vol})

3. DISCUSSIONS

From the values of $C_{k,100}$ found in Table 2, in the tests with the three voltages, it can be verified that the measurements at aperture 6 are actually those that differ from the other peripheral regions because they present the least result due to the filtration of the radiation by Part of the tomograph table. Aperture 12 received a larger dose because of the less influence of the filtered beam on the table. The largest value records are found in apertures 12, 3 and Central. In relation to the mean of the peripheral dose compared to the central dose of the NB simulating object, the central one is larger, since the size of the simulating object influences the measurement of the central dose. The smaller the irradiated objects, the smaller the dose difference in the central position in relation to the peripheral dose.

The newborn phantom received higher doses with higher voltages as well because of the constant load (mA.s). The measured mean values of C_{vol} were 25.1 mGy for 120 kV voltage, 19.06 mGy for 100 kV voltage and 15.81 mGy for 80 kV voltage. With the results of C_{vol}, it was found that the 120 kV protocol provided an increase of 37.0% higher than that of 80 kV.

5. CONCLUSiON:

The newborn phantom received higher doses in the protocols with tensions of 120 and 100 kV when compared with the one of 80 kV. The reduction in voltage from 120 to 80 kV, while maintaining the other parameters of the protocol, allowed the reduction of 37.0% of the dose measured with the ionization chamber. However, it can not be said that optimized image quality has all the necessary requirements for effective medical diagnosis. For this, it is necessary to evaluate the presence of noise levels present in the image in order to ensure an appropriate medical diagnosis. It is recommended in future studies to compare the dose profile using thermoluminescent dosimeters such as lithium fluoride stick and radiochromic films.

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