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Poster Discussion

Dose assessment in paediatric CBCT using measurements, MC simulations and image quality analysis

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Purpose/Objective:

Currently in radiotherapy, Image-Guided Radiation Therapy (IGRT) is a cornerstone for achieving submillimeter treatment precision. Cone Beam Computed Tomography (CBCT) is the type of IGRT most commonly used in radiotherapy departments. However, there are no guidelines for the different types of protocols and image parameters used, which leads to different absorbed doses in healthy tissues and this is especially important in paediatric patients. The aim of this study is to assess the doses from CBCT in paediatric patients.

Material/Methods:

Initially, measurements were performed in two linear accelerators, located in two different radiotherapy departments and equipped with the CBCT imaging system. A cylindrical Computed Tomography Dose Index (CTDI) phantom, a 100 mm pencil-type and a 0.6 cc Farmer ionisations chambers were used. The CTDI phantom made up of a 16 cm diameter head phantom and a 32 cm diameter body phantom. The head and neck, pelvic and thorax protocols were considered. At least 5 measurements were taken for each protocol (centre, top, bottom, left and right), according to the number of CTDI phantom inserts and for each ionisation chamber, in a total of 145 measurements. The dose differences between the two institutions were evaluated.

Subsequently, the TOR 18 FG phantom was used to assess the image quality. The signal to noise ratio (SNR) of the images acquired from this phantom with voltages from 40 kV to 150 kV in 10 kV steps at 25 mA e 50 ms exposure time in the clinical CBCT system was assessed.

Finally, through Monte Carlo (MC) simulations, several absorbed dose calculations in different organs were performed with PENELOPE code. The head and neck, pelvic and thorax protocols were performed with CBCT X-Ray source at different voltages, namely, 40 kV, 50 kV, 60 kV, 70 kV, 80 kV, 90 kV, 100 kV, 110 kV, 120 kV. The computational phantoms used for the simulations were the two ICRP paediatric female phantoms (10 and 15 years old).

Results:

The dose differences in the two institutions were due to differences in kV values, number of projections for each CBCT, mA values and exposure time. There were differences of 1.5 mGy per CBCT for head and neck protocols, 10.7

mGy for pelvic protocols and 1.5 mGy for the chest protocols with the 100 mm ionisation chamber. Additionally, for the 0.6 cc Farmer chamber, there were differences for each CBCT in the head and neck protocols of 2.2 mGy, 16.6 mGy for the pelvic protocols and 1.4 mGy for the chest protocols.

The best SNR is obtained at the voltage of 60 kV and slowly starts to decrease, until above 130 kV.

Table 1 shows the relative variation in the absorbed dose by each organ for a voltage of 60 kV and the kV values supplied by the manufacturer.

Table 1 - Relative variation of absorbed dose between the kV values supplied by the manufacturer versus 60 kV.

	Phantom 10F			**Phantom 15F**		
Organ	**Thorax**	**Head**	**Pelvis**	**Thorax**	**Head**	**Pelvis**
Bladder	- 70.66%	-	- 6.50%	- 65.39%	-	- 16.71%
Brain	- 52.36%	- 35.50%	- 59.60%	- 50.88%	- 36.25%	- 62.12%
Breast	20.15%	- 24.72%	- 69.20%	10.47%	- 28.77%	- 49.36%
Eyes	- 66.65%	18.65%	-	- 71.09%	18.64%	-
Heart wall	- 12.17%	- 59.64%	- 73.12%	- 14.92%	- 60.08%	- 75.06%
Kidney	- 55.76%	-	- 58.71%	- 61.64%	-	- 62.98%
Left colon	-	-	- 23.76%	-	-	3.10%
Liver	- 22.13%	-	- 64.84%	- 27.90%	-	- 64.39%
Lung	- 9.73%	- 57.08%	- 73.97%	- 8.45%	- 55.23%	- 77.06%
Oesophagus	- 24.59%	- 60.31%	-	- 32.72%	- 64.02%	-
Ovaries	- 68.40%	-	- 17.51%	- 37.97%	- 68.29%	- 20.91%
Pancreas	- 49.14%	-	- 57.52%	- 56.30%	-	- 60.14%
Right colon	-	-	- 12.51%	-	-	-0.17%
Small intestine content	-	-	- 10.12%	-	-	- 11.34%
Small intestine wall	-	-	- 11.58%	-	-	- 13.48%
Spleen	- 42.82%	-	- 66.14%	- 49.00%	-	- 69.18%

Stomach content	- 39.65%	-	- 59.76%	- 47.04%	-	- 61.01%
Stomach wall	- 37.70%	-	- 60.34%	- 41.87%	-	- 58.89%
Thyroid	- 5.26%	- 59.61%	-	- 28.27%	- 62.71%	-
Uterus	- 93.36%	-	- 25.38%	- 80.19%	-	- 33.09%

The maximum difference is seen in the uterus, with a dose reduction of around 90% compared to the manufacturer's values.

Conclusion:

Today there are several guidelines for IGRT that vary from country to country. However, for CBCT there are still no specific guidelines for each pathology, taking into account the physiognomic characteristics of each patient. This becomes especially important in children, as they have a very small body size, making the organs closer together and they are much more susceptible to the effects of ionising radiation.

Our results show that for 60 kV, there is a reduction in the absorbed dose with CBCT of 28.93% for the thorax protocol, 39.02% for the head and neck protocol and 42.14% for the pelvic protocol. Findings from studies such as those conducted on pediatric CBCT provide valuable input to direct further research and develop optimized protocols.

Keywords: CBCT, pediatric, dose optimisation

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Poster Discussion

Development of a Mobile Application to Support Paediatric Patients Undergoing Radiotherapy

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Purpose/Objective:

Radiotherapy is one of the treatment options for pediatric cancer patients [1]. While the treatment is not painful and lasts only a few minutes, young children aged between 5 and 7 often experience high levels of distress and may require anesthesia to cope with it. Nevertheless, the use of anesthesia could potentially be avoided if patients are adequately prepared for their treatment [2]. To address this issue, we developed an interactive, user-friendly mobile application that could be used by caregivers to introduce the child to the hospital environment and treatment process.