Evaluation, Comparison and optimization of the effects of manual versus software automated protocols on radiation dose and image quality in paediatric chest computed tomography

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OBJECTIVES

The aim of this study was to retrospectively compare the effects of switching from automated to manual acquisition parameters on image quality and radiation dose in a small paediatric cohort of patients and in several simulated paediatric chest CT scans utilizing a phantom.

In order to obtain the lowest possible dose-length-product (DLP) value while maintaining an adequate image quality, the scans were performed by manually reducing the dose below the lowest dose value proposed by automated software prior to the exam.

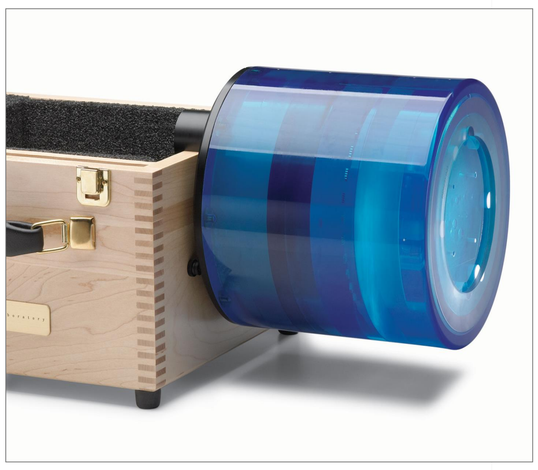

Figure 1. Catphan CT Phantom

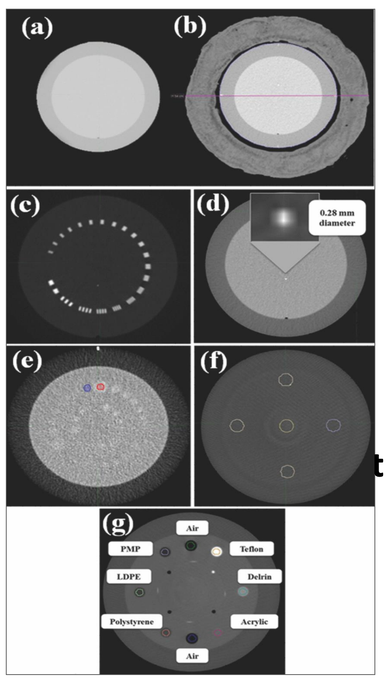

Figure 2. Sections of Catphan

MATERIALS AND METHODS

- The Catphan CT phantom underwen simulated pediatric chest CT scans using both automated and manual parameters optimization approaches performed by a radiologist.
- Phantom was scanned within different protocols varying kV, mAs, pitch, IR.
- The subjective and objective image qualities were assessed by both radiologists and software.
- Computed tomography dose index (CTDI) and dose length product (DLP) values were collected and analyzed.
- Equivalent dose to organ at risk (OAR) was assessed with a Monte Carlo system tool of Radimetrics using a digital phantom simulating a six year old pediatric patient.

N.	Description of CT exam	Care Dose	Care kV	kV	mAs	CTDI (mGy)	DLP (mGy cm)	Scan Time (s)	Rotation Time (s)	Pitch	Collimation	Slice (mm)	Lenght (cm)	Radiologist visual evaluation score test
1	THORAX IV Siemens automatic acquisition	Yes	Yes	120	42	2.37	38.2	0.71	0.28	3	128x0.6	2	18.7	23
2	Manual with the lowest mAs value	No	No	80	4	0.07	1.7	0.65	0.28	3	128x0.7	2	18.7	15
3	Manual with the highest mAs value	No	No	80	122	1.92	49.7	0.65	0.28	3	128x0.8	2	18.7	26
4	Manual reference acquisition by the radiologist	No	No	80	50	0.79	20.4	0.65	0.28	3	128x0.9	2	18.7	25
5	Manual reference acquisition by the radiologist increasing kV and decreasing mAs values	No	No	100	30	0.99	25.7	0.65	0.28	3	128x0.10	2	18.7	31
6	Manual reference acquisition by the radiologist varying pitch value	No	No	80	80	0.76	19	0.65	0.28	1.55	128x0.11	2	18.7	26
7	Routine automatic chest with lowered pitch value	No	No	100	90	3.07	68.3	0.65	0.28	0.9	32x1.2	2	18.7	20
8	Routine automatic chest with lowered pitch value varying collimation	No	No	100	90	3.07	68.3	0.65	0.28	3	128x0.13	2	18.7	28

Figure 3. Technical details of CT acquisition protocols

RESULTS

Dose to OAR, CTDIvol and DLP were substantially lower (90%,58% and 32% respectively) adopting a manual approach, maintaining a good subjective image quality as demonstrated by a human visual scoring (VSA) test evaluation on images.

Through CT acquisitions, linearity and resolution were constant while image noise (mean 6.4, standard deviation 10.1) and uniformity (mean 6.4, standard deviation 10.1,) varied between scans, as observed by 3 experienced radiologists by VSA.

Acquisition	1	2	3	4	5	6	7	8
Organ	THORAX IV Siemens automatic acquisition	Manual with the lowest mAs value	Manual with the highest mAs value	Manual reference acquisition by the radiologist	Manual reference acquisition by the radiologist increasing kV and decreasing mAs values	Manual reference acquisition by the radiologist varying pitch value	Routine chest with lowered pitch value	Routine chest with lowered pitch value varying collimation
Thymus	27.9	0.1	3.9	1.6	2.1	1.6	3.7	3.6
Thyroid	5.1	0.1	0.9	0.3	0.5	0.3	0.4	0.4
Breast	33.9	0.1	4.2	1.7	2.1	1.7	6.3	6.1
Lung	33.8	0.1	4.2	1.7	2.2	1.7	5.8	5.6
Hearth	32.6	0.1	3.8	1.6	2.1	1.5	6.0	5.9

Figure 4. Dose to organs for different CT protocols

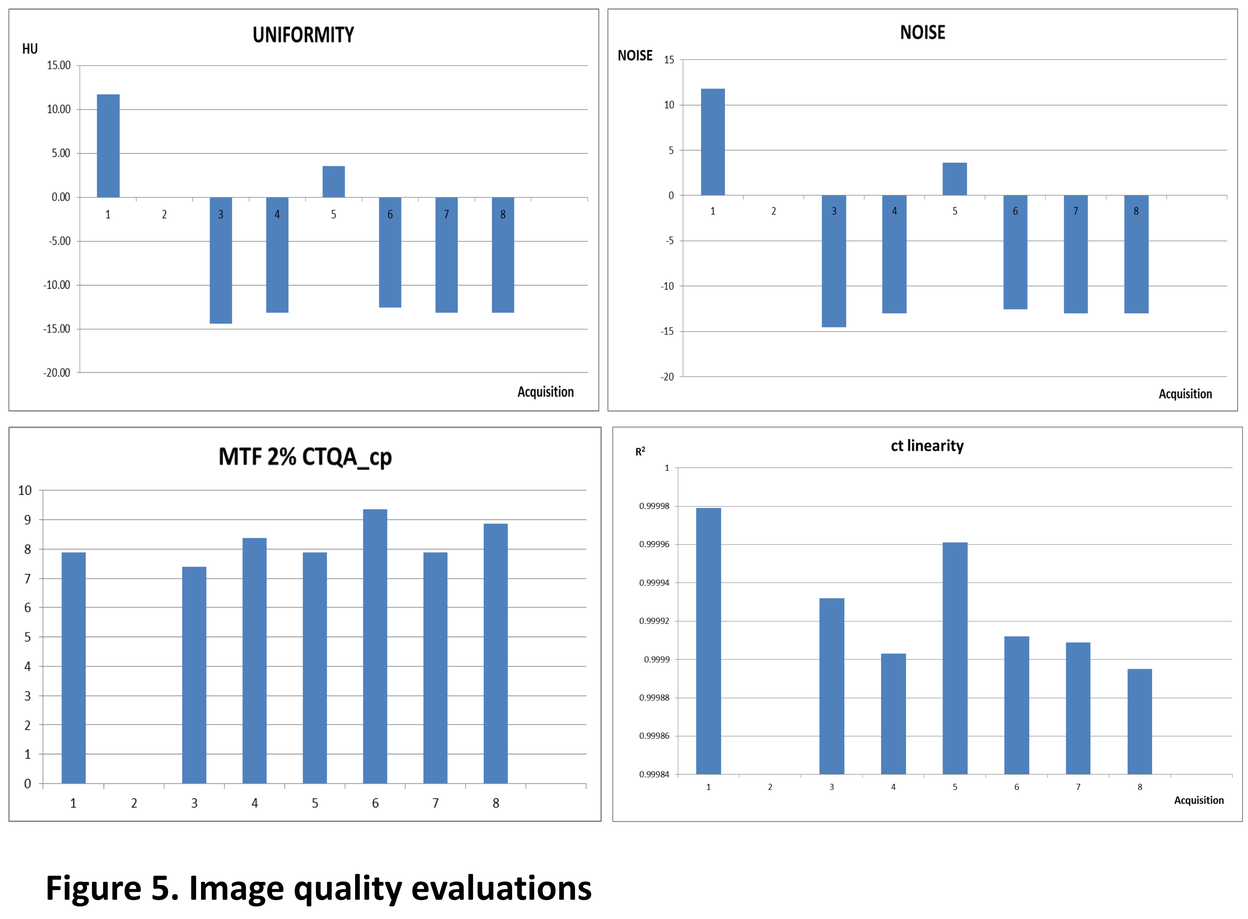

Figure 5. Image quality evaluations

CONCLUSIONS

In both real and simulated paediatric chest CT studies manual acquisition settings generated the best results in terms of optimal dose-image quality ratio compared to automated parameters.

References

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Image quality assessment tools for optimization of CT images; Radiography · Volume 16, Issue 2, May 2010, Pages 147-153; DOI: 10.1016/j.radi.2009.10.002