Is more radiation exposure to patients better for diagnostic interpretation in CT scanning?

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STUK

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TYKS

AIM

To study association between radiation exposure and necessary quality for diagnostic reading of computed tomography (CT) scans.

Computed tomography unit imaging parameters.
*Years in use at the department of Radiology, Turku University hospital

	LightSpeed 16 (2003-2012)*	**Plus 4** (1996-2006)*
Max power (kW)	53	55
Anode heat storage capacity (MHU)	6.3	5.3
Helical pitches	4 different, 0.5625, 0.9375, 1.375 and 1.75	freely selectable, 0.5-3
Voltage (kV)	80, 100, 120, 140	80, 120, 140
Current (mA) Number of series	10-440 3	50-420 2
Slice width (mm)	0.63, 1.25, 2.5, 3.75, 5, 7.5, 10	1, 2, 3, 5, 8, 10
Collimation (mm)	0.63-20	1-10
Tube	Performix Ultra (tungsten)	Dura 502 (TZM, W, Re, Graphite)

Methods

The scans were performed using LightSpeed 16 (General Electric) equipped with automatic exposure control (AEC) system and Plus 4 (Siemens Somatom).

The scanned region was trunk/whole body with or without contrast. NRPB-SR250 software* was used to determine effective doses and organ doses.

The scans with the widest range and highest exposure doses were re-assessed by an independent radiologists without knowledge of estimated organ doses and effective doses.

*Salminen et al. Radiat Prot Dosimetry. 2012 Dec;152(4):328-33.
http://www.hpa.org.uk/Publications/Radiation/NPRBArchive/NRPBSoftware/

Male patients < 40 years

Characteristic	N , range or %
Number of patients	65
Median age, range Seminoma/Non-Seminoma	28 (16.5 – 39.4) 26/39 (40% - 60%)
Waist circumference measured from CT scans, median (range)	89.6 (66.6-126.3)
Number of Whole Body CTEs Number of Whole Body CTEs/patient Mean (SD) Number of whole body CTE with contrast -LightSpeed16 -Plus 4 NRPB-SR250 available for CT dose estimates	279 4.8 (2.7) 104 (75.9%) 112 (78.9 %) http://www.hpa.org.uk/Publications/Radiation/NPRBArchive/NRPBSoftware/ Public Health England

Patients

279 whole body CT scans were done to 65 male patients < 40 years, in 2000 to 2011 at Turku University Hospital Dept of Radiology.

On the average they had 4.8 scans per person.

The scanned area usually covered the whole body from lower neck to the symphyse/mid-thigh; in a few cases it started from the outer auditory canal to cover all the neck.

Patients were characterized by waist circumpherence, which was ≥ 100 cm for large patients.

Dose reconstruction

- Every patient was given an identification symbol to link patient to images and dose data.
- For image data tabulation information was gathered: data from the radiology unit where imaging was performed, type of scanner, name of the examination, imaged area, current, rotation time, slice thickness, table feed during one rotation, length of imaged area, number of images, number of rotations and $CTDI_{air}$.
- Every examination was given its own identification indicator.
- The dose data table contained data for each patient: imaged area, equivalent and effective doses and the use of shielding or contrast medium.

Dose calculation

The organ doses and effective doses were calculated using NRPB-250-software, which has been designed to estimate the radiation exposure of CT imaging.

The software version was 1.4 and the effective dose was calculated using tissue - weighting factors from ICRP 60 .

Eleven target organs were selected from the 27 organs in the software

For each patient, besides the effective dose values, the calculated doses were summed for each organ and entered in the dose data table.

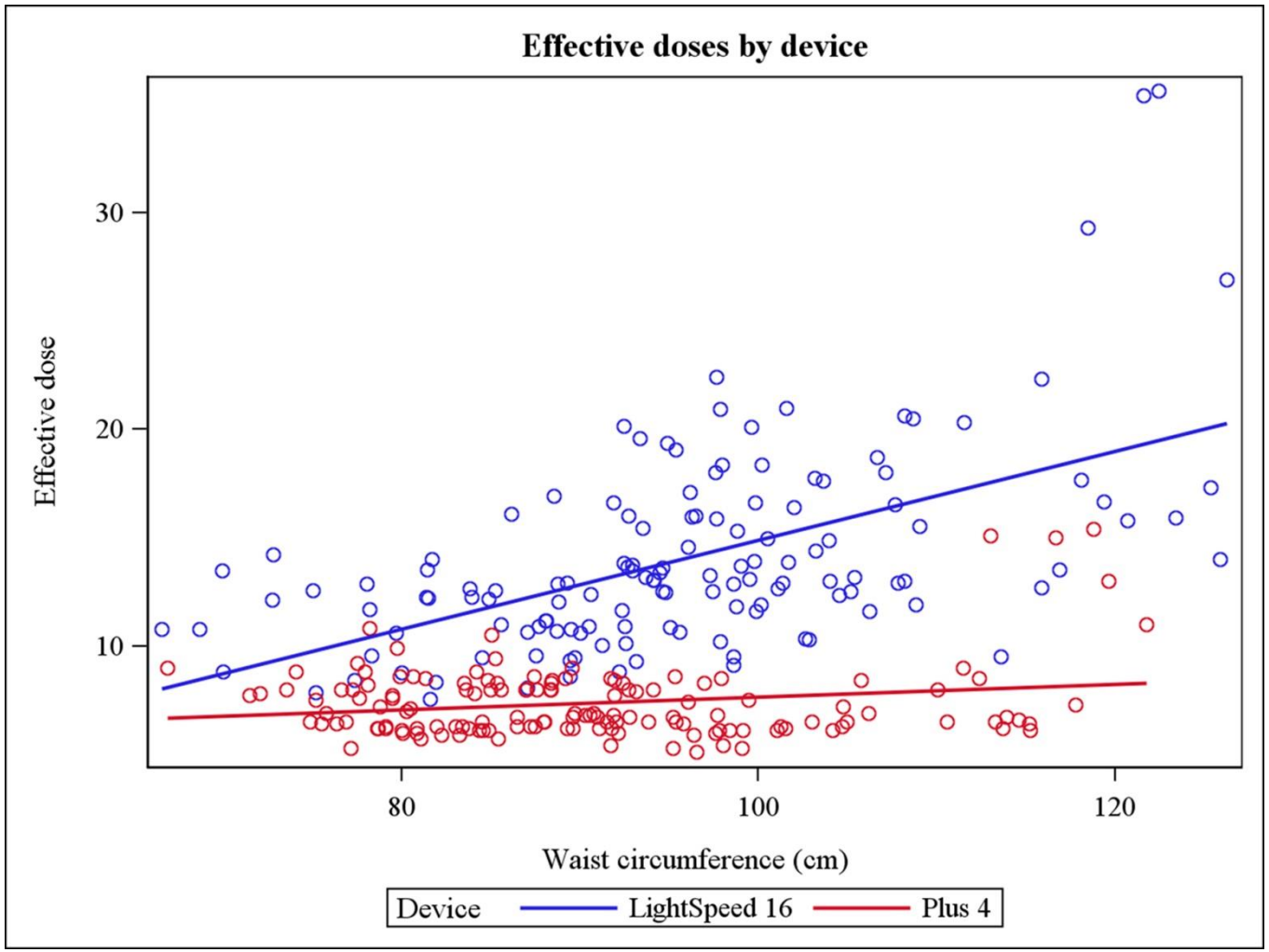

Figure. Effective dose versus waist circumference (WC) by scanner type in whole body examinations.

Re-reading for diagnostic information

- Re-reading of scans was done with an experienced radiologist (MV) who was unaware of the exposure data.
- The criteria for comparison between scans were based particularly on the image quality of liver, lymph nodes, lower lungs and bony structures. Special critical consideration was given to liver parenchyma where distinction between normal and abnormal is most depending on scanning noise.
- Scans with LightSpeed 16 did not have statistically significantly better quality of image compared to Plus 4 ($p = 0.437$).
- More scans with unnecessary high exposure for diagnostic evaluation were observed among patients scanned with LightSpeed 16 (30 vs. 15, $p=0.037$ Mantel Haensel).
- According to the reader, scans with good/satisfactory were completely of acceptable quality.

Diagnostic re-assessment based on quality of imaging for scans performed for patients with waist circumpherence >100 cm.

	LightSpeed 16	Plus 4
Number of scans	43	25
Quality of assessment		
Very good	30	15
Good/Satisfactory	13	10

Mean effective dose [mSv] by device and waist circumference group with and without iv contrast.

	LightSpeed 16				Plus 4			
	< 100cm		>= 100cm		< 100cm		>= 100cm	
i.v.contrast	mean	SD	mean	SD	mean	SD	mean	SD
Given	13.6	3.2	17.5	6.1	7.4	1.2	8.5	3.3
No contrast	10.7	2.0	12.8	1.9	6.2	0.5	7.7	2.5

Results

Significantly higher radiation exposure was observed for larger patients with LightSpeed16 compared to Plus 4, the dose increased with increase in waist circumference of the patients ($p<0.0001$) and was even higher when contrast was applied.

The quality of imaging for diagnostic purpose was reflected in increased radiation exposure.

Scans with LightSpeed16 did not have statistically significantly better quality of image compared to Plus 4 ($p = 0.437$).

The highest effective and organ doses were associated with scans exceeding the needs for proper diagnostic reading.

Conclusion

High exposure rates were observed in large patients scanned with AEC equipped device with no added value for diagnostic reading.

- In this materials the AEC system increased the effective dose particularly in oversized patients.
- High exposure was not always necessary for diagnostic reading qualities.
- The results indicate a need for careful consideration of the set-up of basic parameters for CTE to avoid unnecessary high exposure for all scanned patients, the exposure being further increased when contrast use is required. Quality reference mAs required by the AEC system to adjust mA must be defined by the user.

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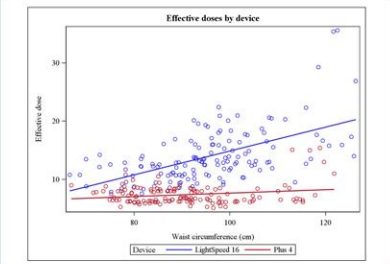

Figure. Effective dose versus waist circumference (WC) by scanner type in whole body examinations.

Results

Significantly higher radiation exposure was observed for larger patients with LightSpeed16 compared to Plus 4 (Figure), the dose increased with increase in waist circumference of the patients ($p<0.0001$) and was even higher when contrast was applied (Table 1). The quality of imaging for diagnostic purpose was reflected in increased radiation exposure. Re-reading of scans was done with an experienced radiologist (MV) who was unaware of the exposure data. Scans with LightSpeed16 did not have statistically significantly better quality of image compared to Plus 4 ($p = 0.437$, Table 2).

The highest effective and organ doses were associated with scans exceeding the needs for proper diagnostic reading (Table 2).

Table 1. Mean effective dose [mSv] by device and waist circumference group with and without iv contrast.

	LightSpeed 16				Plus 4			
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