Dual and multi slice CT – what about the doses?

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1 Purpose

Many axial and single slice spiral CT scanners have now been replaced by dual and multi slice scanners in Norwegian hospitals. Typical doses for CT-examinations based on axial scan techniques are well known. Some data are also available for single slice scanners but doses from dual and multi slice scanners have not been investigated to the same extent. Based on the advances in detector technology, dose reducing software algorithms (e.g. tube current modulation) and post processing tools on the CT work station (e.g. MPR techniques) one might anticipate lower patient doses. On the other hand multi slice technology may tempt to more extensive examinations. Furthermore, demands for better image quality in even thinner slices may offset the expected dose reduction or even result in a dose increase. The aim of this study was therefore to calculate doses from typical CT-examinations from dual and multi slice scanners and compare the doses with those received from older axial and single slice spiral scanners.

2 Methods and materials

Two CT dose surveys have already been carried out in Norway. The first one was carried out in 1995 and represent doses from single slice axial scanners [Ol97]. The second one was done in 2000 as part of a joint Nordic project. These results mainly reflect doses from single slice spiral scanners [Ol01]. In 2002 Norway was invited to join an international CT dose survey initiated by Leiden University Medical Center in the Netherlands. The aim of this international survey was to collect dose data from different CT examinations based on specific medical indications all over Europe. Norway chose to collect dose data only from dual and multi slice scanners. These new dose data were then compared with the dose data already available from axial and single slice spiral scanners in Norway. Only examinations reflecting medical indications comparable with the old dose data were included in this work (table 2). Number and type of scanners included in these three dose surveys are shown in table 1.

Table 1: Number and type of scanners included in the three CT dose surveys.

Period (year)	Number of scanners	Type of scanners (mainly)
1995	49	Single slice axial
2000	10	Single slice spiral
2002	9	Dual/multi slice spiral

The effective dose, lens dose, uterus dose, $CTDI_{vol}$ and DLP for a standard patient (70 kg) were calculated for all the examinations from 2002 by using the ImPACT CT Patient Dosimetry Calculator (http://www.impactscan.org/index.htm) together with the basic Monte Carlo data sets from the National Radiological Protection Board in UK [Jo91].

3 Results

Typical dose data for CT examinations of the head, chest, abdomen and LS from the three generations of CT scanners are shown in table 2. As can be seen from the range in doses (min-max), both the effective dose, $CTDI_{vol}$ and DLP varied a lot from hospital to hospital for all the types of examinations in all three time periods. When focusing on the dose survey from 2002 (dual and multi slice scanners) the largest dose variation was observed for chest examinations. Our results indicate a slightly increase in dose from head examinations going from axial and single slice to multi slice scanners. On the other hand, a dose reduction of almost 50% was observed in the mean value for examinations of the chest. No significant changes in the doses could be observed for examinations of the abdomen.

The dose to the eye lens depended on how the gantry was tilted. Typical lens doses were 50-70 mGy when covered by the primary beam and 4-7 mGy when outside the beam. Examinations of the chest resulted in insignificant doses to the uterus. The LS-columna examination gave rise to a uterus dose of around 10 mGy, mainly due to scattered radiation within the patient. Typically uterus doses from an abdomen examination were 20 mGy, but uterus doses approaching 100 mGy were observed for examination of the lower abdomen. No significant changes in either the lens doses or the uterus doses were observed during the three time periods representing the different CT scanner generations.

The doses from dual and multi slice scanners exceeds the European CT reference values given for head examinations (CTDIvol = 60 mGy, DLP = 1050 mGycm) but were below the reference values for chest (CTDIvol = 30 mGy, DLP = 650 mGycm) and abdomen (CTDIvol = 35 mGy, DLP = 780 mGycm) examinations [Eu99]. It has to be point out that the reference values were established before the introduction of the multi slice scanners, and an updating of the reference values are to be anticipated.

Table 2: Mean values of the effective dose (E), $CTDI_{vol}$ and DLP. Minimum and maximum values are given in brackets. N.A. = not included in the survey. The medical indication are specified by the letter a and b specified in the foot notes.

Examination	Period [year]	E (min-max) [mGy]	$CTDI_{vol}$ (min-max)[1] [mGy]	DLP (min-max) [mGycm]
HEAD	1995 [a]	1.6 (0.8-4.3)	N.A.	691 (351-1879)[2]
	1995 [b]	2.0 (0.5-4.0)	N.A.	871 (208-1736)[2]
	2000 [b]	1.6 (0.8-2.7)	60 (35-87)	633 (344-900)
	2002 [a]	2.2 (1.3-3.7)	79 (45-116)	991 (590-1626)
CHEST	1995 [a]	11.6 (2.8-41.1)	N.A.	683 (162-2419)[2]
	1995 [b]	11.5 (1.6-32.0)	N.A.	674 (97-1880)[2]
	2000 [b]	6.6 (1.8-14.7)	10 (5-22)	331 (92-803)
	2002 [a]	5.8 (1.8-11.3)	10 (4-17)	317 (102-647)
ABDOMEN	1995 [b]	12.8 (2.8-37.6)	N.A.	854 (188-2505)[2]
	2000 [b]	N.A.	N.A.	N.A.
	2002 [a]	11.4 (7.4-14.7)	12 (8-19)	643 (389-847)
LS	1995 [b]	4.5 (0.9-9.1)	N.A.	235 (46-478)[2]
	2000 [b]	4.3 (2.3-9.3)	34 (19-54)	265 (165-396)
	2002	N.A.	N.A.	N.A.

[a] Head: acute stroke, Chest: pulmonary metastases, Abdomen: rule out abscess
[b] Head: routine, Chest: routine, Abdomen: routine, LS: routine
[1] The $CTDI_{vol}$ are not corrected for tube current modulation if present on the scanner
[2] The DLP are calculated from the effective doses using the conversion factors given in European guidelines [Eu99].

4 Discussion and conclusion

Our study indicates that the introduction of dual and multi slice scanners may have increased the dose for head examinations and decreased the dose for thorax examinations. For abdomen examinations the doses seems to have remained unchanged. It has to be emphasized that the comparison of the dose data collected from the three time periods, reflecting the different CT scanner generations, is rough since the medical indications were not identical. More dose data have to be collected and analyzed before a final conclusion can be drawn about the dose trends. The huge variation in doses for the same medical indications indicates a potential for optimization of CT protocols in Norwegian hospitals. The best parameters to report for dose comparison would be $CTDI_{vol}$ and the total DLP. $CTDI_{vol}$ represents the average dose in the CT slice, and reflects the scanner technology (detector efficiency) and the selected scan parameters (kV, mAs, pitch, etc.). The total DLP reflects the scan length and number of series taken. In addition, the effective dose should also be calculated to give an indication about the risk associated with the actual CT-examination and as a input to collective effective dose calculations.

References

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