Dose in MDCT : What Is The Fuss About?

Kwan-Hoong Ng & BJJ Abdullah
Department of Radiology
University of Malaya

KH Ng

KH Ng

scope

- Is there a problem?
- Is it important?
- Is the same for all machines?
- What are manufacturers doing to reduce it?
- Are there ways the users can reduce it?

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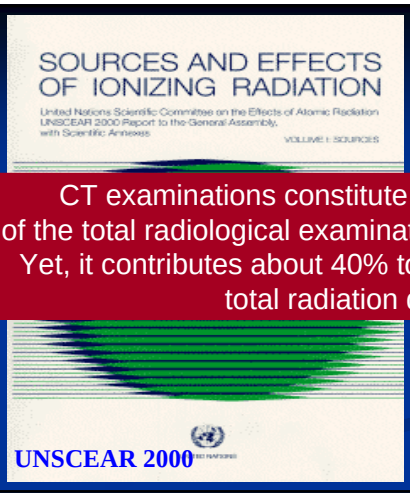

CT examinations constitute only 5% of the total radiological examinations
Yet, it contributes about 40% to the total radiation dose

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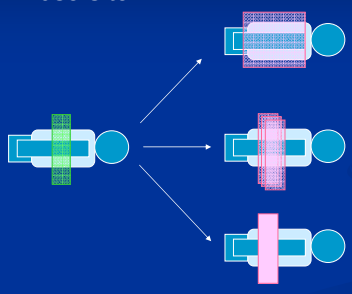
Technology: multislice scanners and dose

Greater flexibility afforded by MSCT can tempt users to



- scan larger volumes
- scan more phases in multi-phase studies
- increase mAs to keep noise down in thin slices

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Typical effective doses, equivalent periods of natural background radiation and lifetime fatal cancer risks from diagnostic medical exposures

Diagnostic procedure	Typical effective dose (mSv)	Equivalent period of natural background radiation*	Risk of fatal cancer per examination
Chest (PA)	0.02	3 days	1 in a million
Abdomen	0.7	4 months	1 in 30,000
CT Head	2	1 yr	1 in 10,000
CT Chest	8	3.6 yrs	
CT Abdomen	10	4.5 yrs	1 in 2000

* UK average = 2.2 mSv per year

Ref: NRPB http://www.nrpb.org.uk/Qmedical.htm#TABLE

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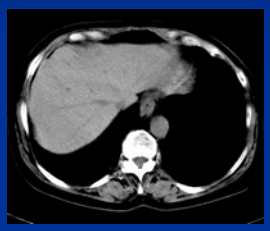
What is the risk factor?



An adult abdominal CT examination with an effective dose of 10 mSv has been estimated to increase the lifetime risk of fatal cancer by 1 in 2000

NRPB

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The Mother of All Fuss

USA TODAY Jan 22, 2001

CT scans in children linked to cancer

By Steve Sternberg, USA TODAY

Each year, about 1.6 million children in the USA get CT scans to the head and abdomen — and about 1,500 of those will die later in life of radiation-induced cancer, according to research out today.

What's more, CT or computed tomography scans given to kids are typically calibrated for adults, so children absorb two to six times the radiation needed to produce clear images , a second study shows. These doses are "way bigger than the sorts of doses that people at Three Mile Island were getting," David Brenner of Columbia University says. "Most people got a tenth or a hundredth of the dose of a CT."

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Chronology of the recent fuss

- Sternberg. CT scans in children linked to cancer later. USA Today 2001;01/22/01:A1.
- Brenner, Elliston, Hall, Berdon. Estimated risks of radiation-induced fatal cancer from pediatric CT. AJR 2001;176:289–96.
- **Rogers.** Editorial Radiation Exposure in CT: Why So High? *AJR Aug 2001; 177*: 277

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2001

FDA U.S. Food and Drug Administration

CENTER FOR DEVICES AND RADIOLOGICAL HEALTH

FDA Public Health Notification:

Reducing Radiation Risk from Computed Tomography for Pediatric and Small Adult Patients

(You are encouraged to copy and distribute this information)

November 2, 2001

To: Radiologists
Radiation Health Professionals
Risk Managers
Hospital Administrators

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2002

The British Journal of Radiology, 75 (2002), 1–4 © 2002 The British Institute of Radiology

Commentary

Radiation dose in CT: are we meeting the challenge?

[1]S J GOLDING, MA, FRCR and [2]P C SHRIMPTON, MA, PhD

[1]Department of Radiology, University of Oxford and [2]National Radiological Protection Board, Chilton, Didcot, Oxon OX11 0RQ, UK

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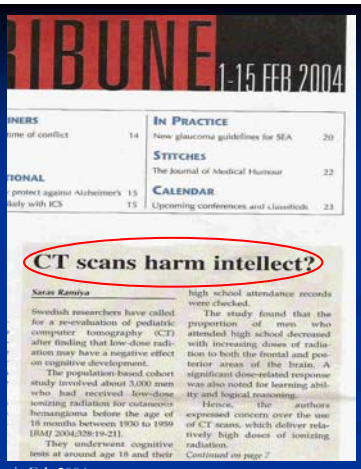

TRIBUNE 1-15 FEB 2004

IN PRACTICE
New glaucoma guidelines for SEA 20

STITCHES
The Journal of Medical Humour 22

CALENDAR
Upcoming conferences and Classifieds 23

CT scans harm intellect?

Saras Ramiya

Swedish researchers have called for a re-evaluation of pediatric computer tomography (CT) after finding that low-dose radiation may have a negative effect on cognitive development.

The population-based cohort study involved about 3,000 men who had received low-dose ionizing radiation for cutaneous hemangioma before the age of 16 months between 1930 to 1959 (*BMJ* 2004;328:19-21).

They underwent cognitive tests at around age 18 and their high school attendance records were checked.

The study found that the proportion of men who attended high school decreased with increasing doses of radiation to both the frontal and posterior areas of the brain. A significant dose-related response was also noted for learning ability and logical reasoning.

Hence, the authors expressed concern over the use of CT scans, which deliver relatively high doses of ionizing radiation.

Continued on page 7

Medical Tribune Malaysia Feb 2004

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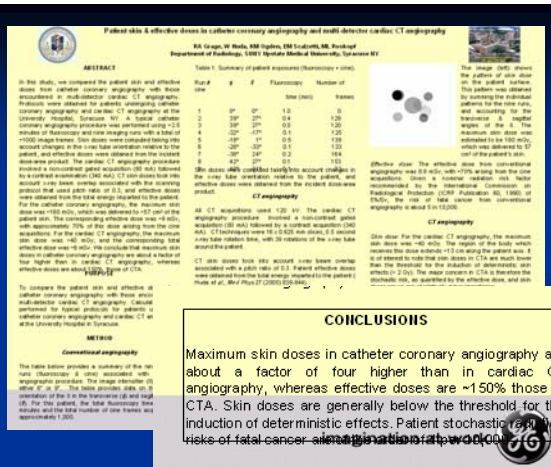

CONCLUSIONS

Maximum skin doses in catheter coronary angiography are about a factor of four higher than in cardiac CT angiography, whereas effective doses are ~150% those of CTA. Skin doses are generally below the threshold for the induction of deterministic effects. Patient stochastic radiation risks of fatal cancer although ...

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Is the same for all machines?

- Understanding patient radiation exposure, or dose, in conventional radiography and single-slice CT (SSCT) is relatively straightforward,
- Not the same for MDCT.
- Knowledge of scanning technique
  - mAs
  - kVp
  - slice thickness
  - pitch
- Differences in system design

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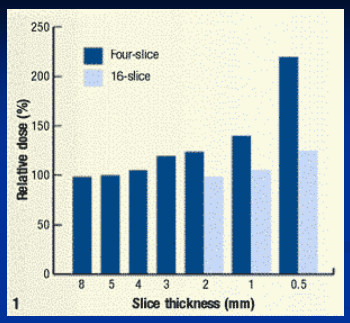

(Toshiba Aquilion four- and 16-slice scanners.)

Dose increases, due to penumbra, with very thin slices on four-slice CT systems.

Penumbra dose penalty for thin slices disappears with 16-slice systems.

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Is the same for all machines?

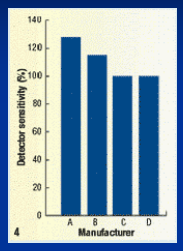

FIGURE 4. Detector efficiency assessed by light output.

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Is the same for all machines?

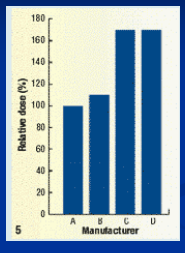

FIGURE 5. Dose required to detect a small lesion may vary by 73% due to differences in low-contrast detectability among scanners.

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Is the same for all machines?

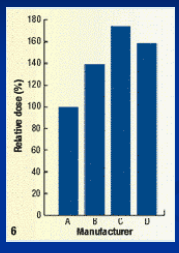

FIGURE 6. Average dose for 14 common examinations among four manufacturers.

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Is the same for all machines?

- MDCT scans are best viewed as
  - volume data sets
  - with real-time multi-planar reformations
- Operator should choose
  - the minimal slice thickness
  - before the penumbra dose penalty becomes significant.
- On 4-slice MDCT
  - the dose profile is similar from 8 to 2-mm slice thickness
  - it increases nearly 50% over 8-mm slice thickness at 1-mm slice thickness
  - and slightly more than 100% at 0.5-mm slice thickness.
- Routine images are therefore performed at 2 mm, which provides the optimum balance of minimal slice thickness for 3D data sets and minimal dose.

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Is the same for all machines?

- Thinner slices may be employed to enhance multiplanar image analysis for specialized applications.
  - 1-mm images are routinely used for imaging the spine and large joints, while 0.5-mm images are commonly used for the orbits, sinuses, temporal bones, and small joints.
- Thinner slices, with their accompanying dose penalty, are also useful to minimize artifact arising from highly attenuating orthopedic hardware.
- Does not apply for a 16-row MDCT
- This elimination of the thin-slice dose penalty will likely become a driving force for the acquisition of 16-slice technology.

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Is the same for all machines?

- Signal to noise of an image depends on the
  - displayed slice thickness
  - not the acquired slice thickness.
- Acquiring the thinnest slice possible is vital to maintaining the in-plane resolution of sagittal, coronal, or other multiplanar reformations
- In-plane resolution determines the reformatted image's diagnostic value.
- Integrity of a postoperative spinal fusion, for example, can be reliably assessed by reformations from 1-mm acquired slices but not from thicker 2- or 3-mm acquired slices.

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Is the same for all machines?

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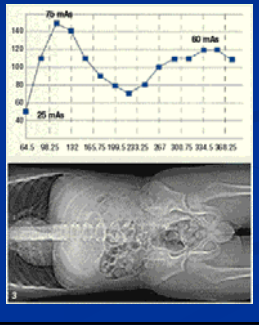
What are the manufacturers doing to reduce dose?

- Automated dose modulation.



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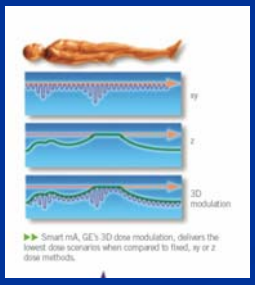

▶▶ Smart mA, GE's 3D dose modulation, delivers the lowest dose scenarios when compared to fixed, xy or z dose methods.

▶▶ Smart mA, 3D dose modulation accounts for the body in all three dimensions – personalizing each scan.

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What are the manufacturers doing to reduce dose?

- ECG dose modulation.

▶▶ ECG dose modulation helps to achieve up to 50% dose reduction on most cardiac studies.

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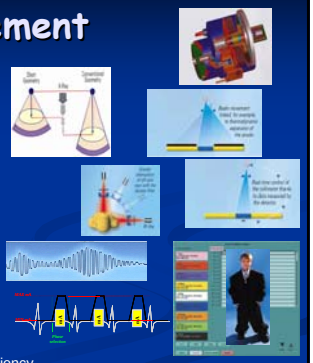
Overall Commitment to Dose Management

- higher detection efficiency
- Higher detector with 100% active area
- Electron Collector
- Optimized cardiac filters
- 3D Dose Modulation
- Smart-Track Dynamic Collimation
- Color Coding For Kids
- SmartBeam –X-ray beam filtration
- NO Post Patient Collimation
- Hi-Res Chest Protocol
- Prospective Display CTDivol, DLP, Efficiency



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The fuss continues…

- Wall.
  What needs to be done about reducing patient doses from CT? The North American approach.
  BJR, 2003 76: 763–765
- Lee, Haims, Brink, Forman
  Diagnostic CT Scans: Assessment of Patient, Physician, and Radiologist Awareness of Radiation Dose and Possible Risks
  Radiology 2004 231: 393-398.

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Rogers 2001:

"So the time has come for radiologists to make the effort to lower radiation exposure doses in CT for our patients . . . Why is radiation exposure in CT so high? Probably because we radiologists have not insisted that patient exposure doses be lowered. It is *time for us to do so*."

AJR Aug 2001; 177: 277

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Is dose reduction possible?

- "Radiographic techniques for unenhanced chest CT examinations can be reduced from 280 to 120 mAs without compromising image quality"
  Ravenel et al ***AJR*** *2001;177:* 279-284.
- "Chest CT image quality appears to be acceptable for evaluating normal anatomic structures even with a 50% reduction in radiation dose."
  Prasad et al. *AJR* 2002; 179:461-465

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Is dose reduction possible?

- "Abdominal CT scan quality appears to be acceptable even with a 50% reduction in radiation dose except in patients with large anthropometric measurements. A reduction in CT radiation dose is possible if the tube current is optimized for the patient's weight and abdominal dimensions."
  Kalra et al *AJR* 2002; 179:1101-1106

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American Journal of Roentgenology published weight-based guidelines for pediatric patients

kg	Chest (MA)	Abdomen (MA)
4.5-8.9	40	60
9-17.9	50	70
18-26.9	60	80
27-35.9	70	100
36-45	80	120
>70	140	170

AJR, 2000, 175:4, 985-992

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Are there ways the users can reduce it?


PUBLIC RELEASE DATE: 3-MAY-2004

'Considerable reductions' in radiation exposure possible with 16-MDCT scanner on body applications

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Are there ways the users can reduce it?

- The following steps constitute the most effective ways to minimize dose with MDCT for imaging children:
  - Choose the thinnest slice before the penumbra dose penalty becomes significant.
  - Decrease the mAs to one appropriate for the patient's size.
  - Use a higher pitch.
  - Use automated dose modulation.
  - Reduce kVp to 80 to 100.
  - Minimize over-scanning.

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Are there ways the users can reduce it?

- Image quality is mainly an issue with a highly attenuating volume of tissue.
- most effective ways to optimize image quality in these situations:
  - Use the thinnest slice possible, which will help minimize partial volume artifact, particularly with multiplanar reformations.
  - Increase mAs.
  - Use a lower pitch.
  - Adjust automated dose modulation for high-quality imaging rather than low-dose imaging.
  - Increase kVp.
  - Use a soft-tissue rather than a bone reconstruction algorithm to minimize streaking.

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Opportunities available now

- Eliminate unnecessary exams
  - •Other diagnostic tests may be available
- Ensure exams are targeted to necessary organs

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Opportunities available now

- Optimise scan protocols
  - Is a pre-contrast scan necessary?
  - Are multiple phases all necessary?
  - kV / collimation / pitch / mAs
- Tailored exposure parameters for the individual
- Use gantry tilt
- Shielding of sensitive organs
- Comparison with reference doses

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Our local experience

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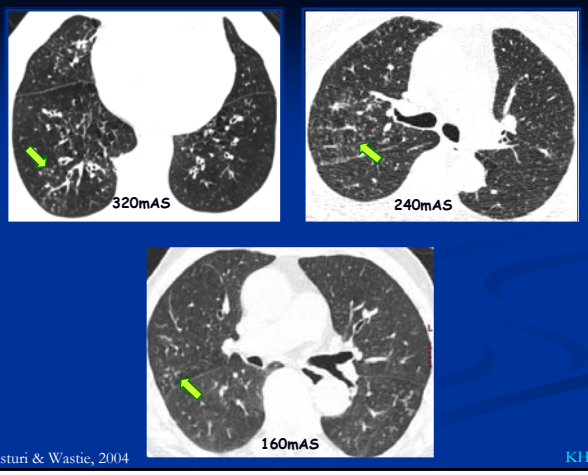

Kasturi & Wastie, 2004

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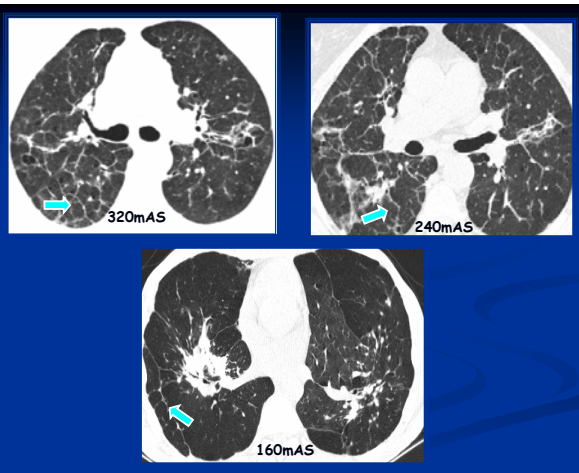

Kasturi & Wastie, 2004

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Effective dose for various techniques in HRCT chest GE Light speed 16

(calculations based on Win-Dose using ICRP 60)

	kV	mA	SLICE THICKNESS	EFFECTIVE DOSE (*mSV*)
Standard HRCT	120	320	1.25 mm – 1.0 mm gap	2.29
Volumetric HRCT	120	240	0.625 – no gap	4.57
	120	160	0.625 – no gap	3.05

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Conclusion

No significant difference in image score between scans at 300 mAs and 160 mAs.

i.e. we can scan at lower mA without sacrificing diagnostic information.

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WHAT WE SHOULD DO…

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Education

- Although CT is the primary source of medical radiation exposure, knowledgeable use of MDCT will minimize patient radiation exposure
- proper use of MDCT should result in a substantially lower dose than with SSCT
- The early reports of higher doses with MDCT than with SSCT systems reflected improper use of MDCT technology in its early implementation.

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Education

- Improve the understanding of CT doses and risks by both radiology professionals and patients.
- Prepare booklet that physicians could use when counseling patients, which put the radiation risks from CT into perspective with other everyday risks.
- Avoid scaring patients away from justified CT examinations by placing too much emphasis on the risks and not enough on the benefits.

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Equipment

- Develop patient-size based technique charts for all existing scanners, to provide standard clinical protocols with target CT dose index ($CTDI_{vol}$) values for common examinations on new scanners
- Introduce true, real-time AEC as soon as possible (already installed in some CT scanners)

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Policy/regulations

- Adopt/ endorse the ACR accreditation programme for CT sites.

(This is for USA, but health authorities in other countries could implement similar policy)

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Clinical matters

- Emphasize the importance of continuing professional education for both radiographers and radiologists.
- Regularly schedule in-service training programmes ith CT dose-reduction techniques, particularly for smaller patients, and with the amazing capabilities of the latest multislice CT scanners, were considered essential.

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Other fusses

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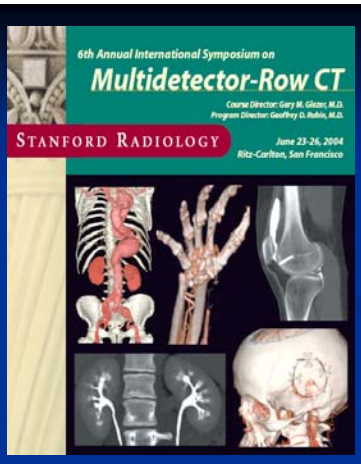

The debate over CT screening is unlikely to be resolved by any conclusive studies in the near future.

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Does early diagnosis necessarily lead to better outcomes?

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Radiology

Volume 232, Issue 3, September 2004

Special Report!

Estimated Radiation Risks Potentially Associated with Full-Body CT Screening

David J. Brenner and Carl D. Elliston

"A full body computed tomography screening (CT scan) once a year for 30 years
The chances of getting cancer go up from 1 in 1200 to 1 in 50"

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