Patient dose management in CT and CBCT

Madan Rehani
ICRP Committee 3
Computed Tomography
Study: CT scans can reduce lung cancer death

Low dose CT screening for lung cancer could save 12,000 US lives a year, researchers claim

*BMJ* 2013; 346 doi: http://dx.doi.org/10.1136/bmj.f1302 (Published 26 February 2013)

Cite this as: *BMJ* 2013;346:f1302
Coronary CT angiography saves lives and money: 20,000-plus cases prove it

October 01, 2007   |   CT, Cardiac Imaging, Practice Management

ACR

Quality is Our Image

Pediatric CT Scans Save Lives When Used Appropriately

Released: 6/6/2012 10:00 AM EDT
Embargo expired: 6/6/2012 6:30 PM EDT
Source Newsroom: American College of Radiology (ACR)

Parents Should Not Forego Necessary Imaging Scans for Their Children
VERY Many more ….. The benefits of medical imaging are undeniable in Saving life & in Improving quality of life.
When good things become reason for your health

Hey! Watch out
Radiological Protection does not imply reducing usage. It is aimed at reducing

- INAPPROPRIATE usage and
- Unnecessary radiation dose
1998: Review of situation in ICRP

- There were no cases of skin injuries from CT
- There was no momentum on cancer risk estimates from CT scans
- Manufacturers not really concerned about patient doses, as hardly customers asked for it
- Most emphasis on faster and faster CT scanners
Task Group (1998)

- M.M. Rehani (Chairman)
- Members:
  - G. Bongartz (Switzerland); S.J. Golding (UK); L. Gordon (Sweden); W. Kalender (Germany); T. Murakami (Japan); P. Shrimpton (UK)
- Corresponding members:
  - R. Albrecht (USA) and K. Wei (China)
ICRP Publication 87 (2001)

  
  *BMJ* 2000;320:593-594 (4 March)

**Editorials** Rehani & Berry

**Radiation doses in computed tomography**

*The increasing doses of radiation need to be controlled*
CT is going to a major source of radiation exposure to population
Approach

Safety is best achieved when it is built into the system rather than a matter of choice for users.
The best example is a collision avoidance systems which started with automobile industry but has now been implemented in medical imaging equipment also.

If the gantry of the imaging machine just touches a person, the gantry just stops moving.

When collision has to be avoided through education, training, instructions, the results cannot be the same.

Both detection and avoidance should be automatic.
Moving industry and of course users
Manufacturer orientation in ICRP 87

ICRP Publication 87

Table 5
Possibilities for patient dose reduction with CT

<table>
<thead>
<tr>
<th>Measures for the user</th>
<th>Measures for the manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checking the indication and limiting the scanned volume</td>
<td>Increasing the pre-filtration of the radiation spectrum</td>
</tr>
<tr>
<td>Adapting the scanning parameters to the patient cross-section</td>
<td>Attenuation-dependent tube current modulation</td>
</tr>
<tr>
<td>Pronounced reduction of mAs values for children</td>
<td>Low-dose scanning protocols for children and special indications</td>
</tr>
<tr>
<td>Use of spiral CT with pitch factors &gt; 1 and calculation of overlapping images instead of acquiring overlapping single scans</td>
<td>Automatic exposure control for conventional CT and spiral CT</td>
</tr>
<tr>
<td>Adequate selection of image reconstruction parameters</td>
<td>Noise-reducing image reconstruction procedures</td>
</tr>
<tr>
<td>Use of z-filtering with multi-slice CT systems</td>
<td>Further development of algorithms for z-filtering and adaptive filtering</td>
</tr>
</tbody>
</table>

specific use of the new possibilities which multi-slice CT systems offer can also serve to limit the dose. The new approaches to interpolation and z-filtering which allow...
CT radiation dose questions draw international attention

Radiation dosage from CT scans could become a matter of debate if international calls for reduced radiation levels move forward.

Writing last month in the British Medical Journal, Dr. Madan Rehani, chairperson of an international task force on safer dosage standards for CT scans, made the case for a closer look at CT radiation levels.

"The increasing doses of radiation need to be controlled worldwide," he said.

The task force was established by the International Commission on Radiological Protection (ICRP). The organization meets in Zurich this month to discuss safer dosage recommendations.

While the ICRP believes that there is cause for concern about high radiation dosage in CT scans, some physicians claim that there is no basis for alarm.

"The FDA approves a technology only after due research. Radiation is used discerningly in our country. America is one of the most conscious medical communities when it comes to radiation safety, and radiation is used wisely by physicians only after weighing cost and benefit, keeping in mind safety of the patients," said Dr. Jonathan Goldin, an assistant professor of radiology at the University of California, Los Angeles, who studies radiation dosages and effects. (ICRP)
CT scans in children linked to cancer later

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 from 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,” says David Brenner of Columbia University.

Brenner, Lee Rogers, Paterson, Donolly, Nickoloff, Haaga
Era on ATTENTION to radiation in CT
Manufacturers vying with each other on Radiation Dose
- Forecasting
- Warning
- Actions needed by
  - Industry
  - Users
After ICRP 87

- Spiral CT 1999-2000
- 2000-2003: Doses in MDCT are higher
- Newer applications
- Potential for
  - Steep increase in usage
  - Multiple CT examination
2005: ICRP

- Established another TG on Patient dose Management in MDCT
- Chair: Madan Rehani
  - Others members:
    - M.K. Kalra, USA
    - C.H. McCollough, USA
    - H.D. Nagel, Germany
- Corresponding members
  - L. Collins, NSW, Australia
  - W. Kalender, Erlangen, Germany
Single most important point in new document
Be aware!!
About image quality that you are using
Guidance on HOW to optimize
2005: CT perfusion, DSA

1972-2007=35 years
CT Machines were most well behaved ones for 35 years
Right or WRONG, accidents drive safety
We need to have mechanism within ICRP to deal with such situation
Till skin injuries were reported, there was talk about CT dose reduction, but no hype or fear
Whatever you do will be insignificant, but it is very important that you do it.”
TG 88: RP in Cone Beam CT

- Chair: Madan Rehani
- Full members:
  - Rajiv Gupta, USA
  - Soenke Bartling, Germany
- Corresponding members
  - Greg Sharp, USA
  - Theocharis Berris, Greece
  - John Boone, USA

Rehani. ICRP Abu Dhabi 2013
Cone Beam CT
Low doses
Office based
CBCT in radiation therapy

- The primary role is pre-treatment verification of patient position and target volume localization for treatment.
- For radiotherapy, the overall dose to a patient due to CBCT imaging with CBCT is around 40 mGy per fraction.
- With over 35 fractions, it would result in a total imaging dose of 1.4 Gy which is not ignorable.
Image Quality and Radiation Dose
<table>
<thead>
<tr>
<th>Imaging</th>
<th>Tissues</th>
<th>Dpse (mGy)</th>
<th>Effective dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head CBCT</td>
<td>Brain, lens, salivary glands,</td>
<td>2-37</td>
<td>1-2</td>
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<tr>
<td>Neuro-interventions</td>
<td></td>
<td>40-75</td>
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<tr>
<td>Fenestrated branched endovascular aneurysm repair (FEVAR)</td>
<td>Skin dose</td>
<td>0.5 Gy</td>
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<td>Atrial ablation</td>
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<td>8</td>
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<td>Hepatic arterial embolisation therapy</td>
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<td>12</td>
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</table>
Users are tempted to see CBCT as a “light” CT or consider it as a “low-dose CT”.

Beware!!!!!
As or now,

- Tissue reactions from cone beam CT (CBCT) have not been reported among patients and workers,

- Control of accidental exposure in CT was implemented only after cases of accidental exposure were reported in USA in 2007-2008. Lesson to learn.
Expectations from Industry

- Providing alerts when dose is higher than specified
- Stopping exposure at levels that should not be crossed.
Recommendations

- Regular and continuous monitoring of radiation output throughout the examination,
- Comparing with reference or desired levels,
- Providing feedback to system and automatically adjusting it
Managing dose versus Risk

- In past emphasis: Dose management
- Risk management
- Skin injuries: most intensive IR procedures are in >50s, fewer in 40s: where stochastic risks are of lower consequence
Nishita Kothary et al. Imaging Guidance with C-arm CT: Prospective Evaluation of Its Impact on Patient Radiation Exposure during Transhepatic Arterial Chemoembolization

- Routine use of C-arm CT can increase stochastic risk (DAP) but decrease deterministic risk (CD) from DSA.
- However, the increase in DAP is operator-dependent, thus, with experience, it can be reduced to under 10%.
- C-arm CT provides information not provided by DSA in 33% of patients, while decreasing the use of iodinated contrast medium.
Currently available CBCT scanners are not able to provide values in standardised dose indices for machine or patient.
Most interventional and intra-procedural C-arm CBCT systems can scan an angular range spanning 180 to 240 degrees + the cone angle of the x-ray beam. The radiation sensitive organs such as thyroid, eyes, female breast and gonads should be on the “detector side” of the arc, whenever possible.
Points for Industry

- Avoiding collimation to exceed detector size,
- Providing guidance of needle through laser in intervention and
- Minimization of wastage of dose by mechanical components
Equipment used for both fluoroscopy and CBCT presents new challenges in dosimetry and there is a need to develop methods that aggregate exposures to individual patients during entire procedures.
Training

- The level of training in radiological protection should be commensurate with the level of expected radiation exposure (ICRP, 2009).
Training

- All personnel intending to use CBCT for diagnostic purpose should be trained in the same manner as for diagnostic CT and for interventional CBCT same as interventional MDCT
Continuous Monitoring of CT Dose Indexes at Dubai Hospital

**OBJECTIVE.** Experience of continuous monitoring and control of patient doses in CT in Dubai Hospital over a period of approximately 4 years (January 2008 through August 2011) is presented.

**MATERIALS AND METHODS.** Dose measurements—in particular, weighted and volumetric CT dose index, dose-length product (DLP), and estimated effective dose—were regularly monitored using head (16 cm diameter) and body (32 cm diameter) CT phantoms. Patient radiation dose indexes were manually recorded during 2008 for common CT examinations: head, chest, and abdomen and pelvis scans. In 2009–2011, these CT dose data were recorded within the radiology information system and the PACS. Dose reduction actions were taken while maintaining a match or lower quality. The effects of these factors were monitored.
Fig. 8—Curve shows adult head CT dose-length product levels as example of monthly patient dose monitoring results.
First ever study of this kind

Rehani. ICRP Abu Dhabi 2013
Countries from Arabic region

- Iran
- Kuwait
- Lebanon
- Saudi Arabia
- Syria
- Qatar
- UAE
Patient Doses in Radiographic Examinations in Asia, Africa, Latin America and Eastern Europe

<table>
<thead>
<tr>
<th>Country 1</th>
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Thank You

• TG Members
• ICRP Colleagues
• Public consultation
• Project participants

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