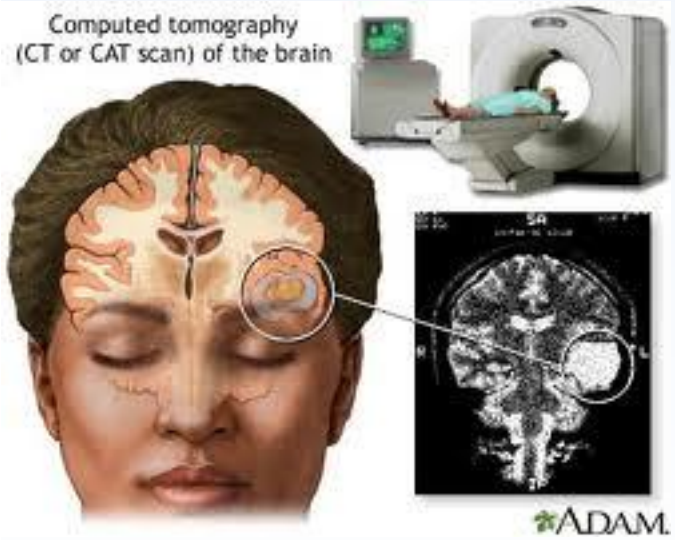
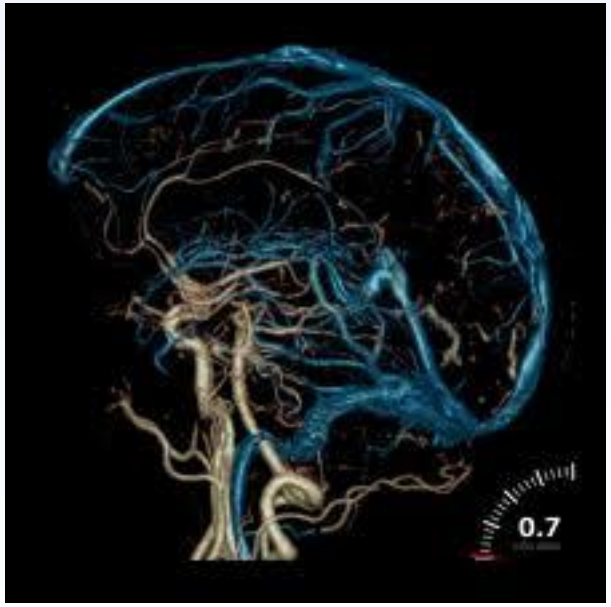
Patient dose management in CT and CBCT

Madan Rehani

ICRP Committee 3

Computed Tomography





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Study: CT scans can reduce lung cancer death

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NEWS

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

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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)

more news from this source

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

Be Aware!!

Radiological Protection does not imply reducing usage. It is aimed at reducing

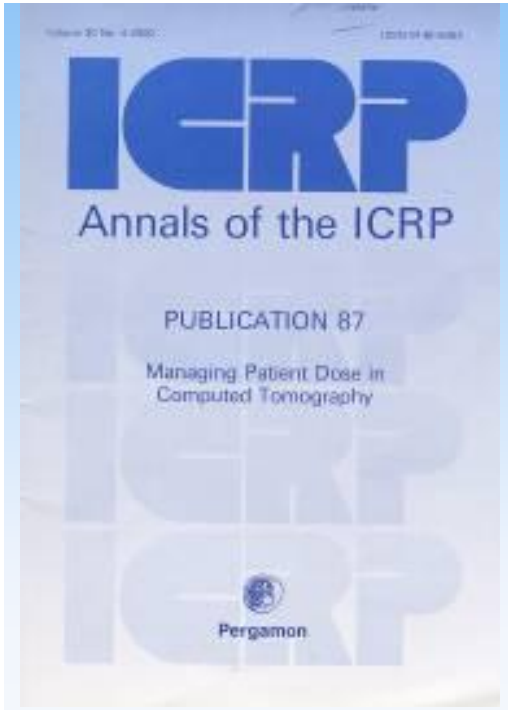
- **INAPPROPRITE usage and**
- **Unnecessary radiation dose**

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)

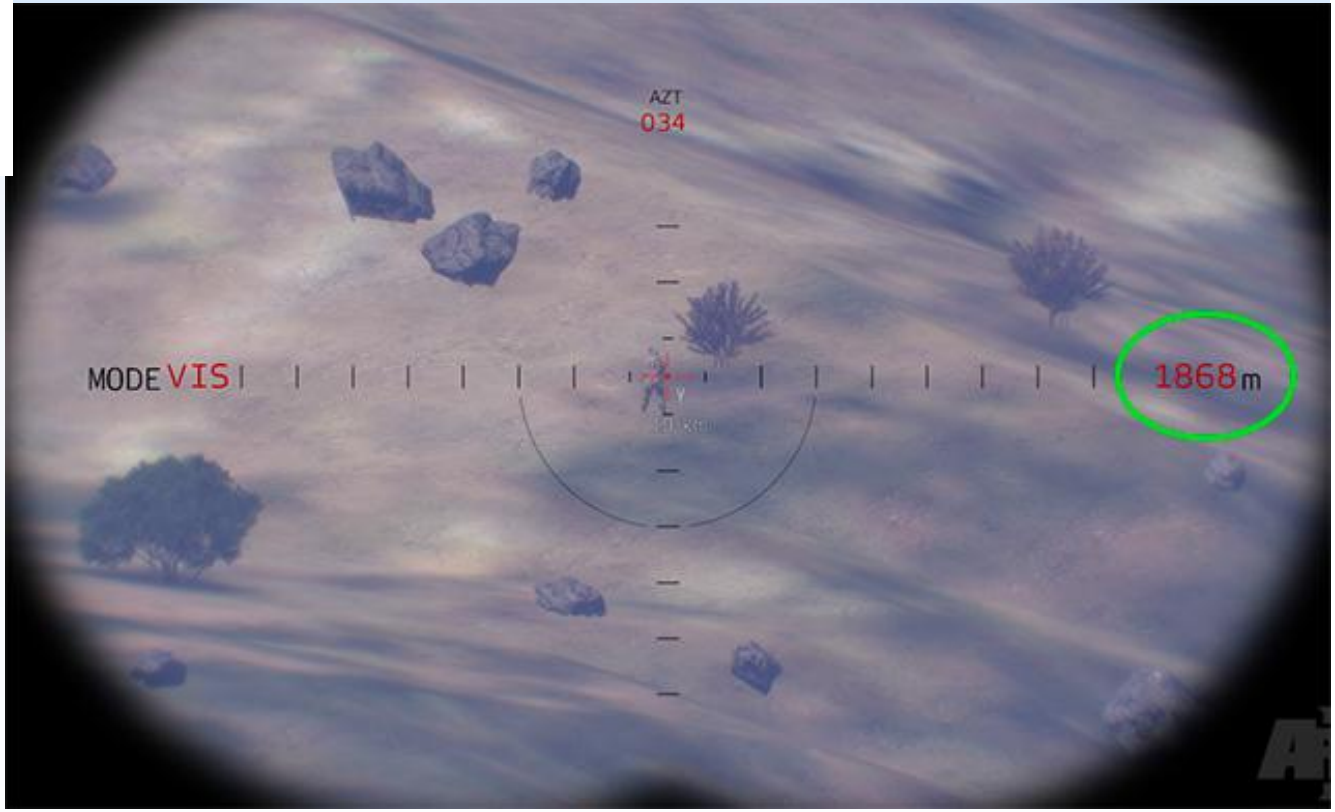
- **Editorial in Br Med J in March 2000**

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

Editorials **Rehani & Berry**

Radiation doses in computed tomography

The increasing doses of radiation need to be controlled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FORECASTING

CT is going to a major source of radiation exposure to population

Approach

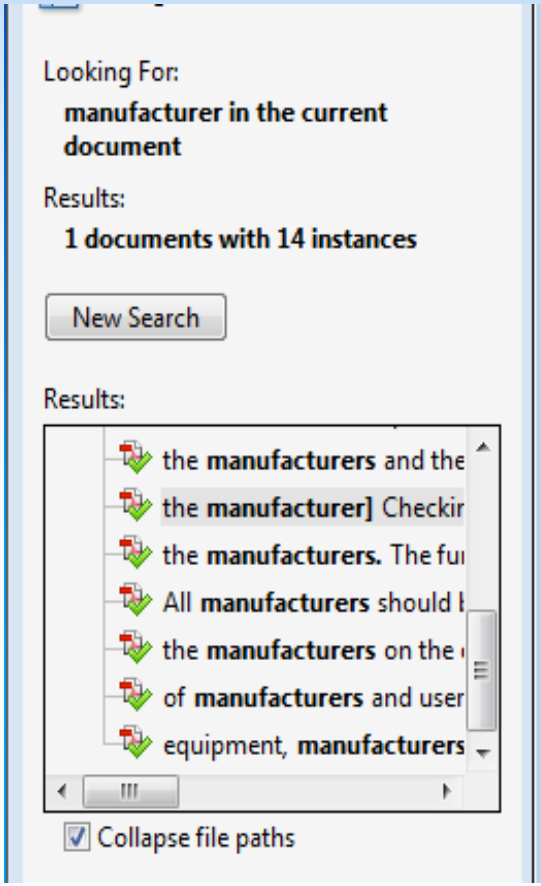
Safety is best achieved when it is built into the system rather than a matter of choice for users.

Approach

- **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 collison 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



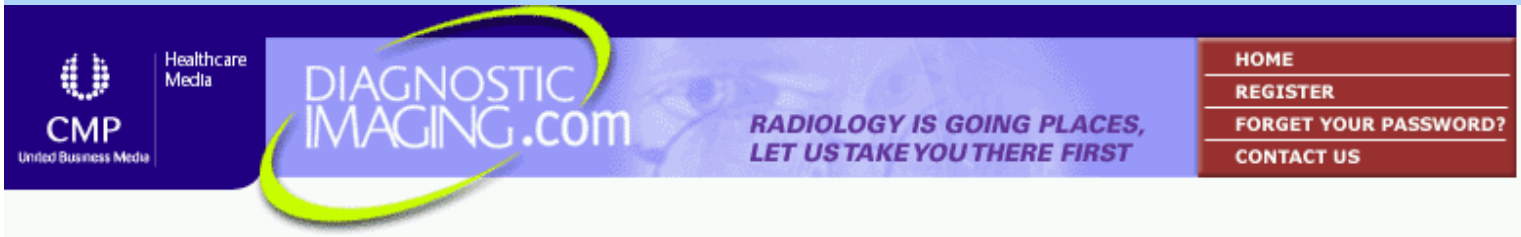
ICRP Publication 87

Table 5
Possibilities for patient dose reduction with CT

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

specific use of the new possibilities which multi-slice CT systems offer can also serve

Reactions- USA



Diagnostic Imaging Online
April 13, 2000

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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.

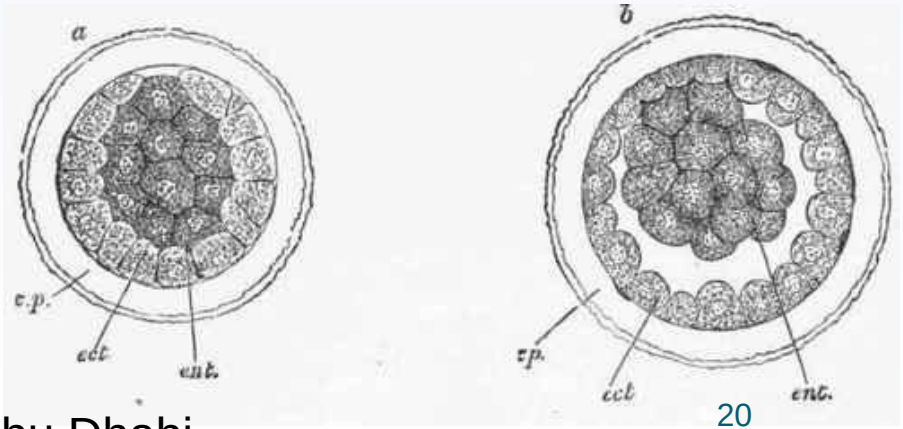
Writing last month in the British Medical Journal, Dr. Madan Rehani, chairperson of an international task force on safer dosage standards for CT scans, made the case for a closer look at CT radiation levels.

"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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FINAL SPORTS

Super Bowl

Let the hype begin

Clock is ticking toward Sunday. Full report, 1-4C
▸ 10 years ago, war was on our minds, 1C
▸ Coming Friday: Bonus Section

USA TODAY

NO. 1 IN THE USA

The Golden Globes

'Gladiator' wins best drama film

Julia Roberts, Tom Hanks honored for drama roles; *Almost Famous* named best comedy film ■ 1-2D
▸ The red carpet, 5D

By Robert Hanashiro, USA TODAY

Roberts: Smiles for *Erin Brockovich*.

Monday, January 22, 2001

Newsline

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Get the latest news, stocks, scores and more right now at USA TODAY's 24-hour online news site, all with a clean new interface. Plus, a stand-alone Tech section.

Asia stocks mixed overnight

Japan's Nikkei average is down 137 points, 1.0%, to 13,852 early today. Hong Kong's Hang Seng index is up 136 points, 0.9%, to 16,069.

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 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."

Both studies appear in February's *American Journal of Roentgenology*, the nation's leading radiology journal. The first, by Brenner and colleagues, is the first to estimate the risks of "radiation-induced fatal cancer" from pediatric CT scans. Until a decade ago, CT scans took too long to perform on children without giving them anesthesia to keep them still. Today's scanners spiral around the patient in seconds, providing cross sections, or "slices," of anatomy.

Doctors use CT scans on children to search for cancers and ailments such as appendicitis and kidney stones.

"There's a huge number of people who don't just receive one scan," says Fred Mettler of the University of New Mexico, noting that CT scans are used for diagnosis and to plan and evaluate treatment. "The breast dose from a CT scan of the chest is somewhere between 10 and 20 mammograms. You'd want to think long and hard about giving your young daughter 10 to 20 mammograms unless she really needs it."

Mettler recently published a study showing that 11% of the CT scans at his center are done on children younger than 15, and they get 70% of the total radiation dose given to patients. Children have more rapidly dividing cells than adults, which are more susceptible to radiation damage. Children also will live long enough for cancers to develop.

Researchers led by Lane Donnelly at Cincinnati's Children's Hospital found that children often get radiation doses six times higher than necessary. Cutting the adult dose in half would yield a clear image and cut the risk a like amount, Brenner says. "Radiologists genuinely believe the risks are small," he says. "I suspect they've never been confronted with numbers like this."

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

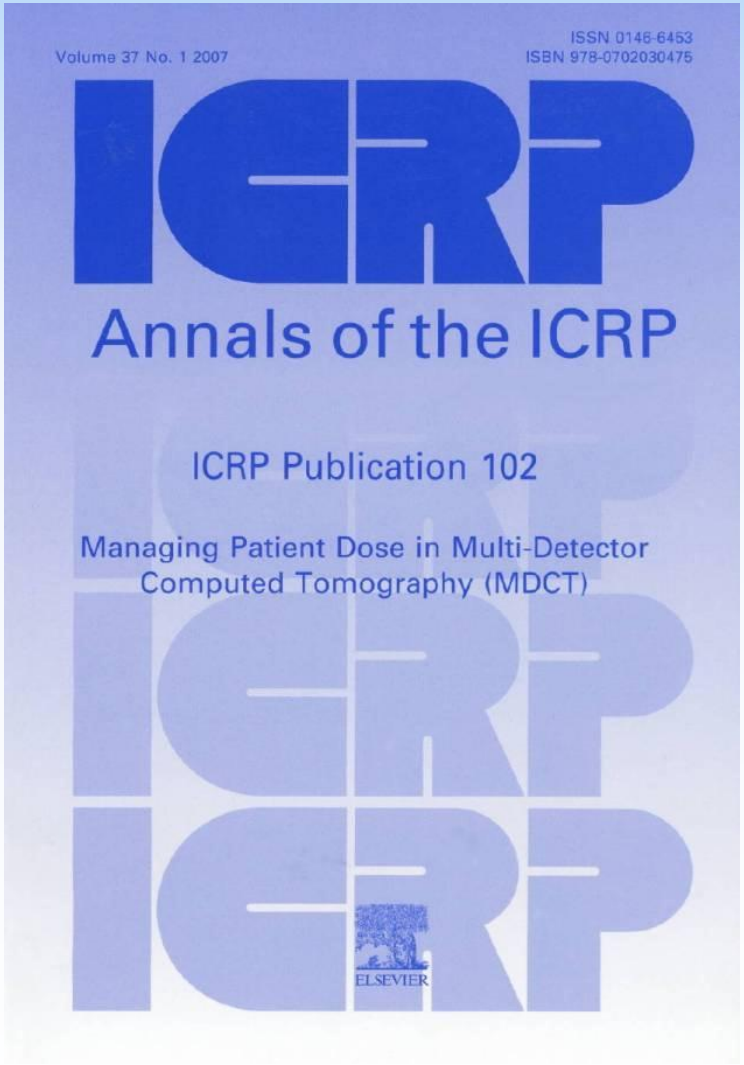
After ICRP 87

- **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

ICRP Publication 102, 2007



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

CT perfusion with DSA

Imanishi et al. Eur Radiol. 2005 Jan;15(1):41-6

1972-2007=35 years

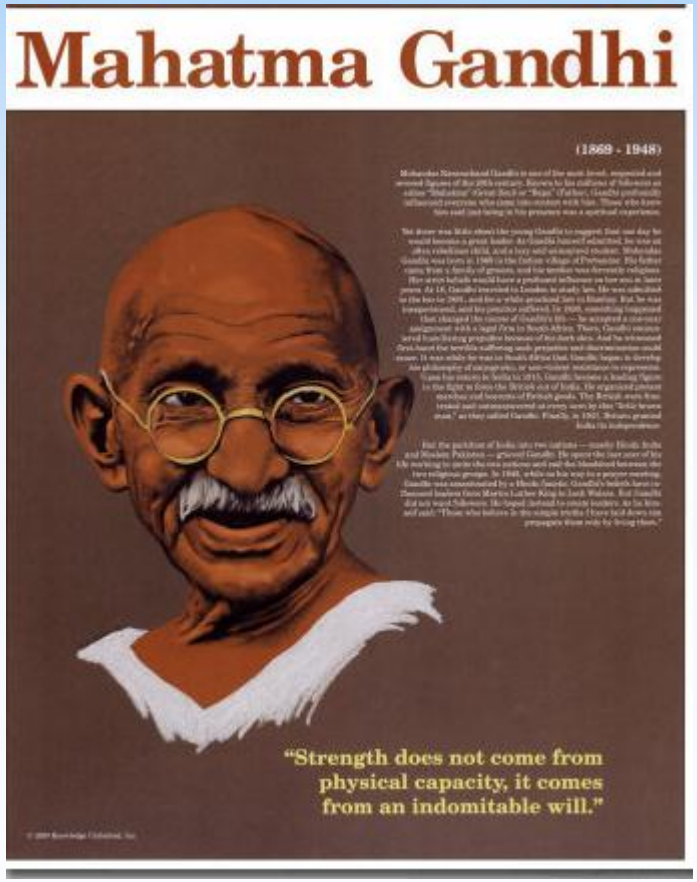
CT Machines were most well behaved ones for 35 years

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”**



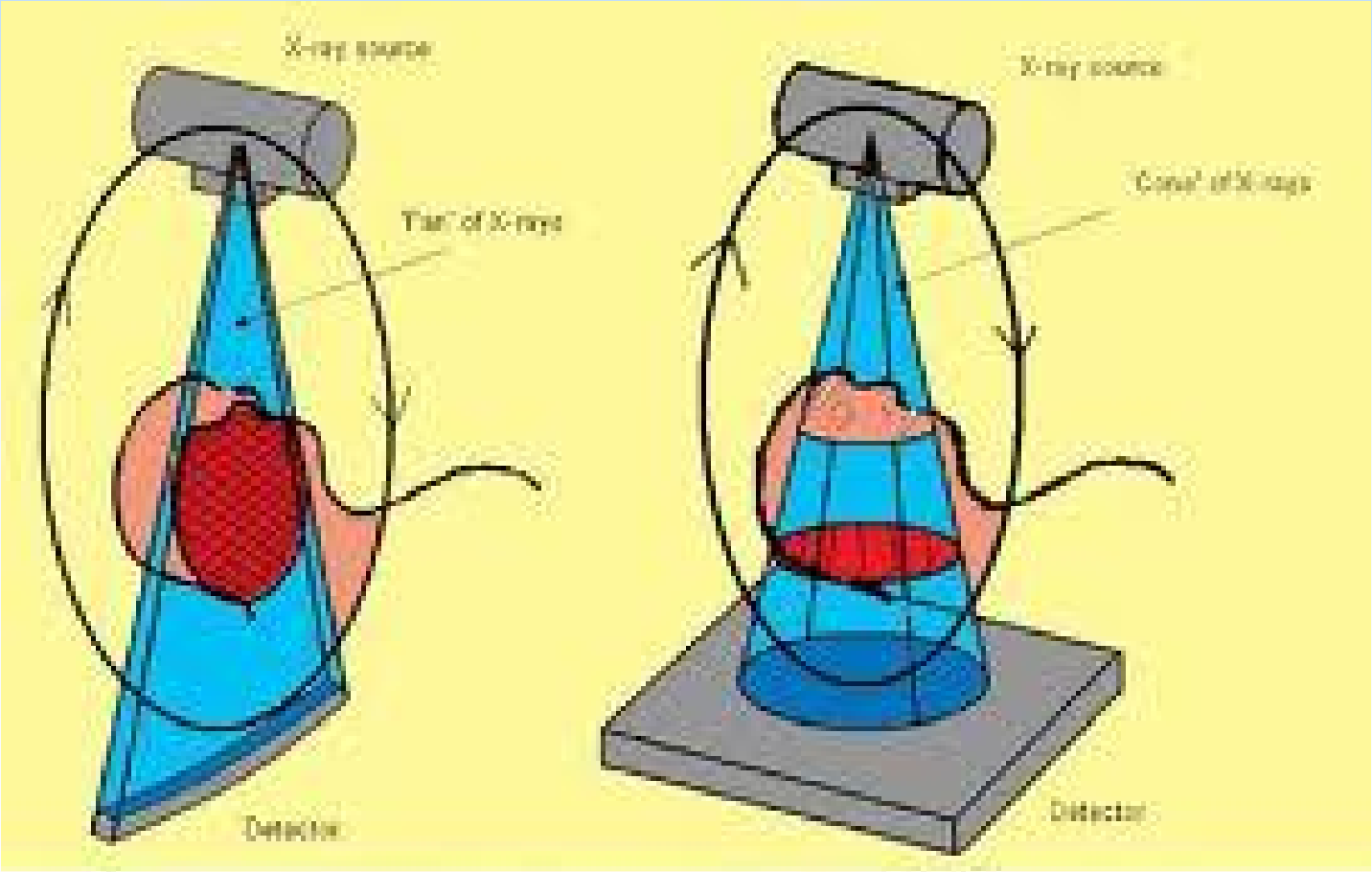
TG 88: RP in Cone Beam CT

- **Chair: Madan Rehani**
- **Full members:**
  - **Rajiv Gupta, USA**
  - **Soenke Bartling, Germany**

Corresponding members

  - **Greg Sharp, USA**
  - **Theocharis Berris, Greece**
  - **John Boone, USA**

Cone Beam CT



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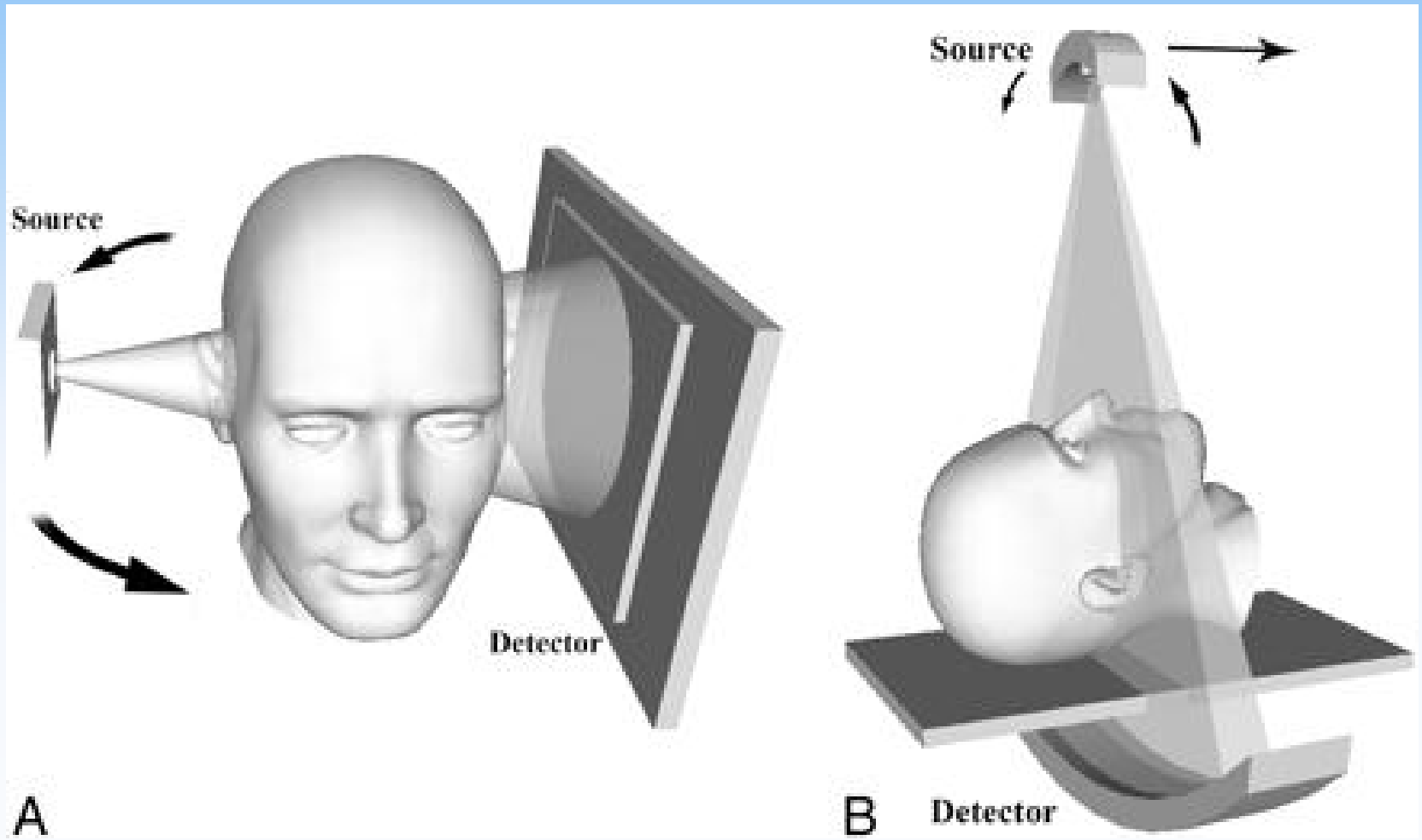
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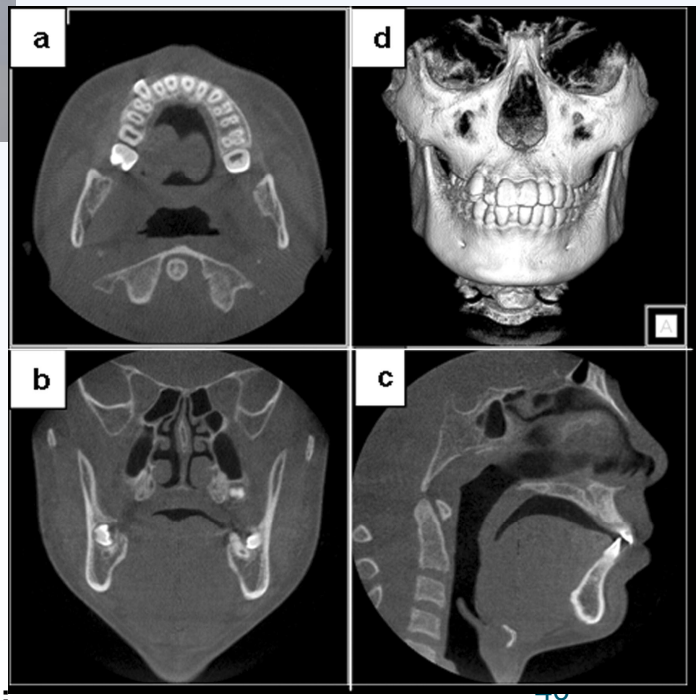

Low doses

Office based

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Rehani. ICRP Abu Dhabi 2013


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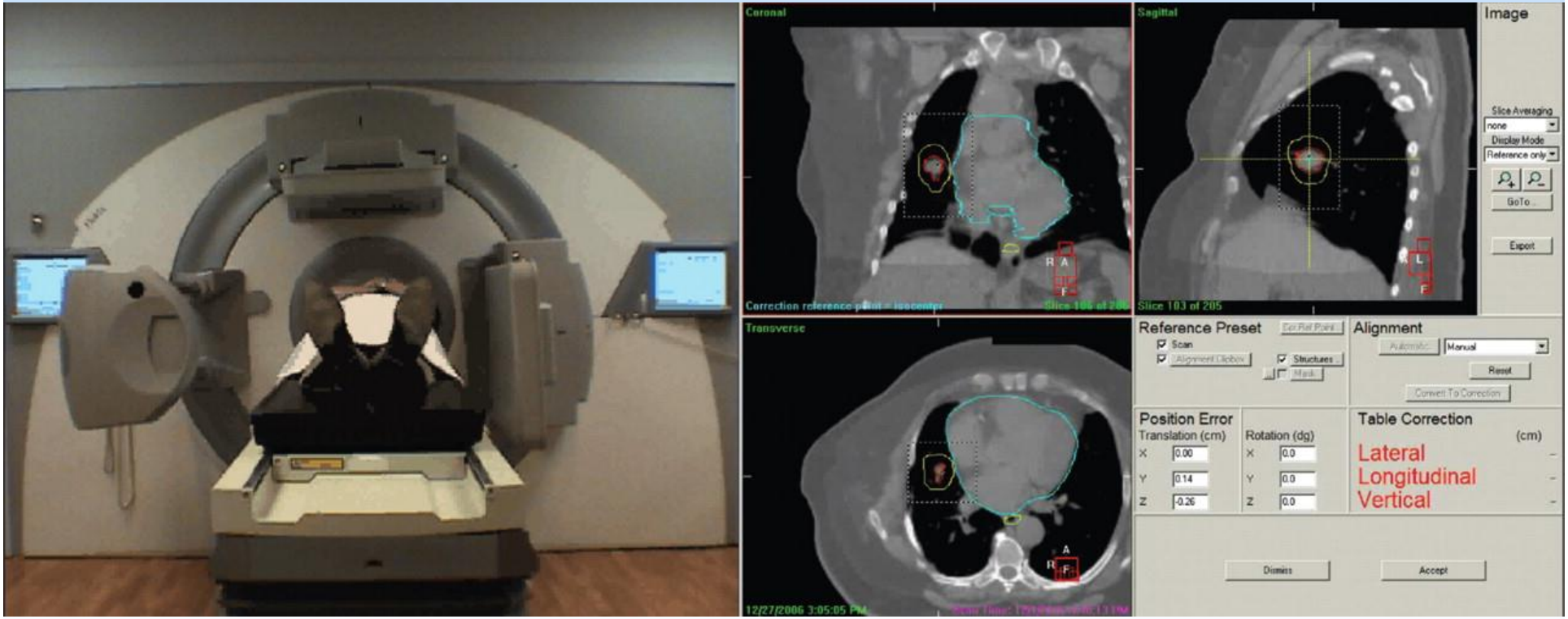
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Rotation (dg)
Table Correction
(cm)
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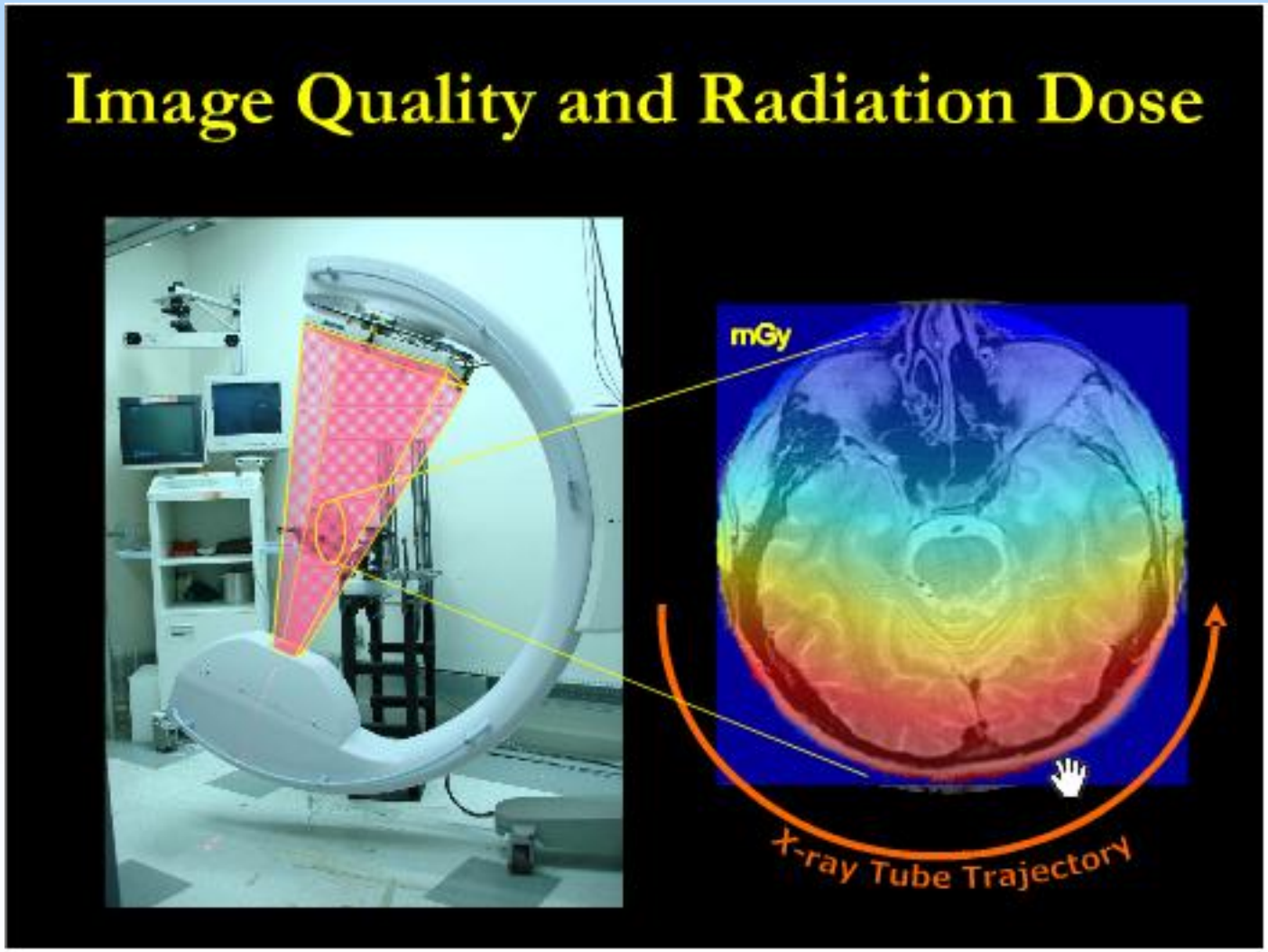
Longitudinal
Vertical
Dismiss
Accept

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



Imaging	Tissues	Dpse (mGy)	Effective dose (mSv)
Head CBCT	Brain, lens, salivary glands,	2-37	1-2
Neuro-interventions		40-75	
Fenestrated branched endovascular aneurysm repair (FEVAR)	Skin dose	0.5 Gy	
Atrial ablation			8
Hepatic arterial embolisation therapy			12

Rehani. ICRP Abu Dhabi 2013

Warning

- **Users are tempted to see CBCT as a “light” CT or consider it as a “low-dose CT”.**
- **Beware!!!!!**

Current situation

- **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**

JVIR Nov 2011

- 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**.

Actions on Dosimetry

- **Currently available CBCT scanners are not able to provide values in standardised dose indices for machine or patient.**

Using new features

- **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**
- **Mminimization of wastage of dose by mechanical components**

CBCT: Points

- **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**

AJR October 2013

Continuous Monitoring of CT Dose Indexes at Dubai Hospital

Jamila S. AlSuwaidi[1,2]
Laila G. AlBalooshi[2]
Hashim M. AlAwadhi[3]
Ali Rahanjam[3]
Mohamad A. ElHallag[3]
Jassem S. Ibrahim[3]
Madan M. Rehani[4]

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

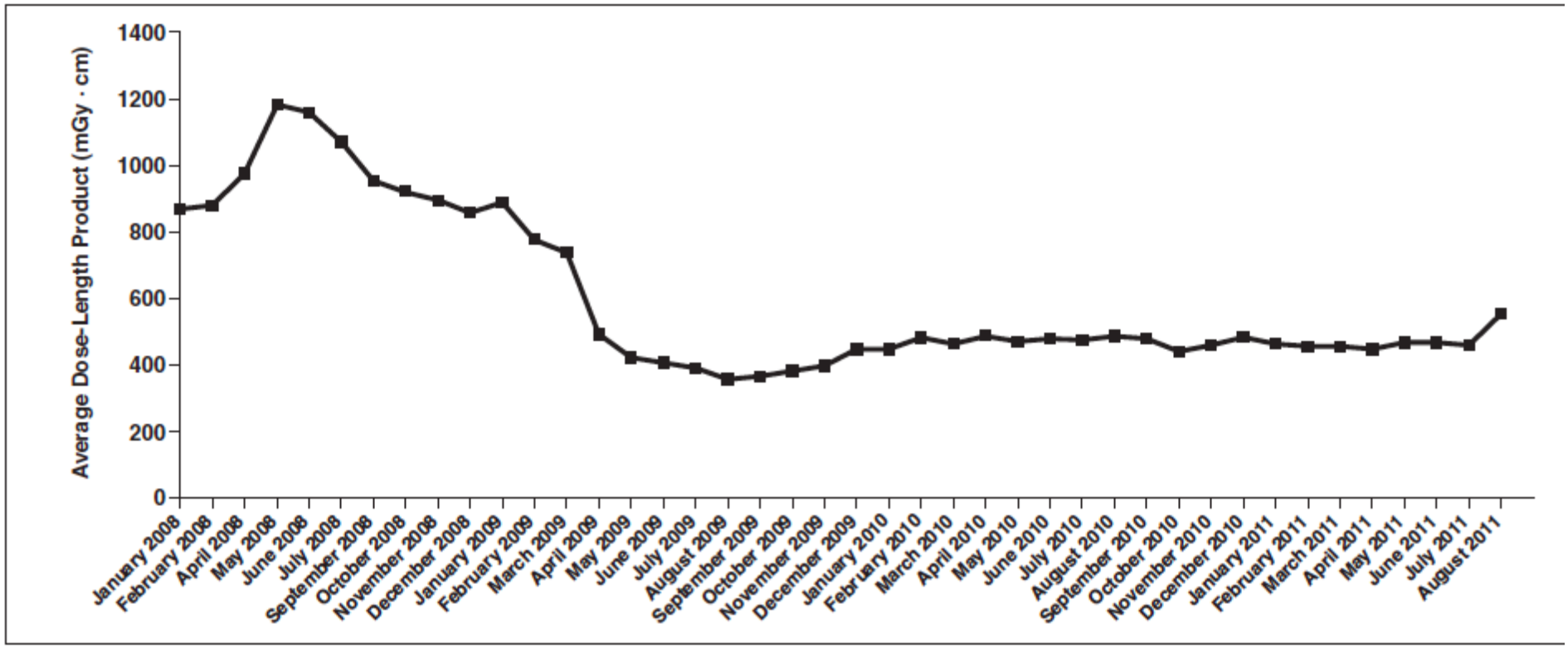


Fig. 8—Curve shows adult head CT dose-length product levels as example of monthly patient dose monitoring results.

AJR FOCUS ON:

IAEA Survey of Pediatric CT Practice in 40 Countries in Asia, Europe, Latin America, and Africa: Part I, Frequency and Appropriateness

Jenia Vassileva[1]
Madan M. Rehani[2]
See end of article for complete author list

OBJECTIVE. The purpose of this study was to assess the frequency of pediatric CT in 40 less-resourced countries and to determine the level of appropriateness in CT use.

MATERIALS AND METHODS. Data on the increase in the number of CT examinations during 2007 and 2009 and appropriate use of CT examinations were collected, using standard forms, from 146 CT facilities at 126 hospitals.

Eur Radiol
DOI 10.1007/s00330-012-2639-3

COMPUTED TOMOGRAPHY

IAEA survey of paediatric computed tomography practice in 40 countries in Asia, Europe, Latin America and Africa: procedures and protocols

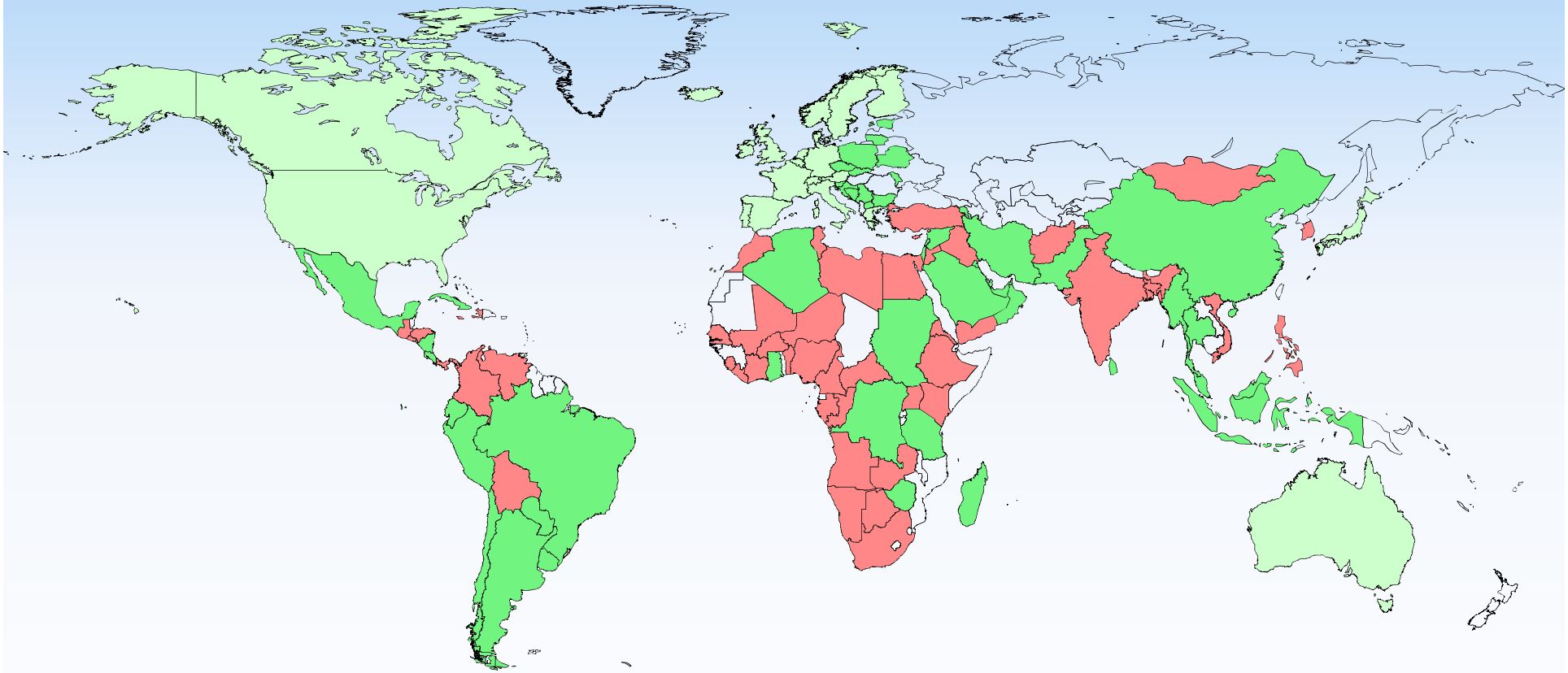
Jenia Vassileva · Madan M. Rehani · Kimberly Applegate · Nada A. Ahmed · Humoud Al-Dhuhli · Huda M. Al-Naemi

First ever study of this kind

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



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Chile	Estonia	Lithuania	Nicaragua	Serbia	Thailand	

Thank You

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

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