CT technology: Is the job well done for radiation dose to patient?

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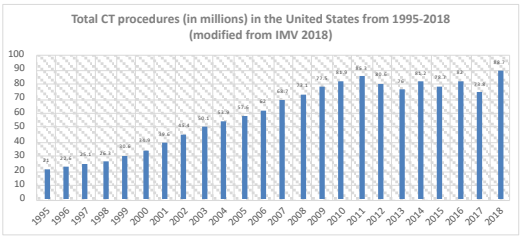
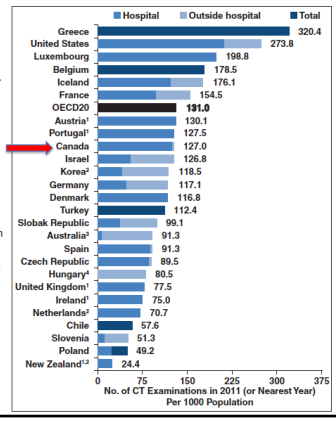
Is there another medical imaging technique that has attracted public media attention as much as CT has?



Globally around 270 million CT exams annually
Around 30, 000 CT exams during my talk

CT-Associated Radiation Risks

Fig. 1.—Number of CT scans per 1000 population in different countries (data for 2011 or nearest). Data for Israel may be found elsewhere (dx.doi.org/10.1787/888932315602). OECD20 = combined data from 20 countries in the Organisation for Economic Cooperation and Development (OECD). [1]Examinations performed outside hospitals were not included. [2]Examinations that were privately funded were not included. [3]Examinations of public patients were not included. [4]Examinations in hospitals were not included. Based on data from the Organisation for Economic Cooperation and Development (OECD) [8].



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October 7, 2019

Waste in the US Health Care System
Estimated Costs and Potential for Savings

William H. Shrank, MD, MSHS[1]; Teresa L. Rogstad, MPH[1]; Natasha Parekh, MD, MS[2]

» Author Affiliations | Article Information

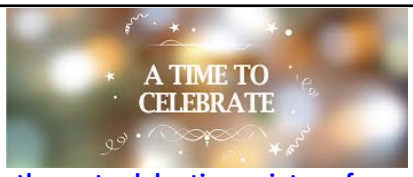
JAMA. Published online October 7, 2019. doi:10.1001/jama.2019.13978

Question

CT is currently a low radiation dose imaging modality and we should not worry too much about the dose as benefits are so high and risks so low

A. True

B. False



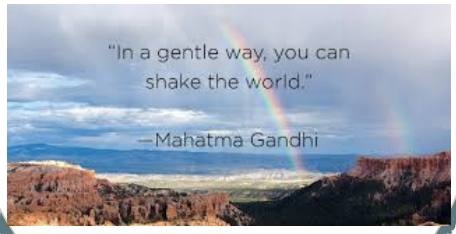
Are we there at celebration points as far as technological developments in CT are concerned (far radiation dose in CT)?

A. Yes, whatever was possible has largely been accomplished
B. No, there is still lot that can be done in technology improvement

Question

Risk assessment strategies should only be based on safety per use not on complete cycle of use of the technology

A. True
B. False



A look at the past

Trends in average effective doses for medical examinations (UNSCEAR 2008)

Average effective dose per examination (mSv)
Examination Health care level I

	1970–1979	*1980–1990*	*1991–1996*
Chest radiography	0.25	0.14	0.14
Abdomen X-ray	1.9	1.1	0.53
Mammography	1.8	1.0	0.51
CT scan *	1.3	4.4	8.8

*Type of equipment varied from single to multi slice

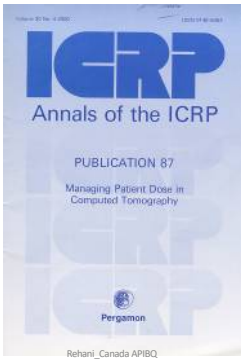
1998: Review of situation in ICRP

- **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**

ICRP 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 (2000)



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

Question: Safety should be

A. **built into the system**
B. **be a matter of choice as users can be trained effectively**

Approach

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

Approach

- **The example of a collision avoidance systems which started with automobile industry.**
- **When collison has to be avoided through education, training, instructions, the results cannot be the same.**
- **Both detection and avoidance should be automatic.**

ICRP 87 (2000)

- Forecasting
- Warning
- Actions needed by
  - Industry
  - Users

Editorial in Br Med J in March 2000

Journal List › BMJ › v.320(7235); Mar 4, 2000 › PMC1117635

BMJ. Mar 4, 2000; 320(7235): 593–594.

Radiation doses in computed tomography

The increasing doses of radiation need to be controlled

Madan M Rehani, additional professor of medical physics
Manorma Berry, professor of radiodiagnosis

Reactions- USA

Diagnostic Imaging Online
April 13, 2000

Tell a colleague about this page!

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.

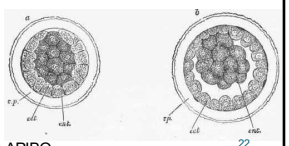
Writing last month in the British Medical Journal, Dr. Madan Rehani, chairperson of an international task force on safer dosage standards for CT scans, made the case for a closer look at CT radiation levels.

"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.

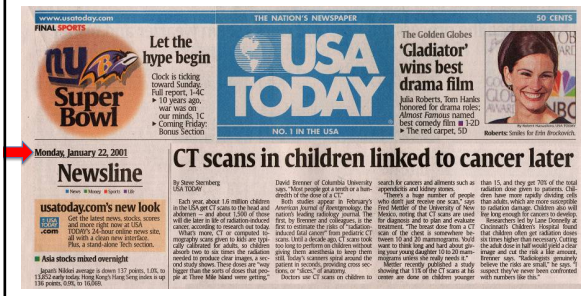
While the ICRP believes that there is cause for concern about high radiation dosage in CT scans, some physicians claim that there is no basis for these.

"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



Other actions that gave thrust

AJR issue with many articles & Editorial



Brenner, Lee Rogers, Paterson, Donolly, Nickoloff, Haaga

Era on ATTENTION to dose in CT

Manufacturers vying with each other on Radiation Dose

Role of Steve Sternberg in making patients & staff safer

Enjoying being with the wave or create wave

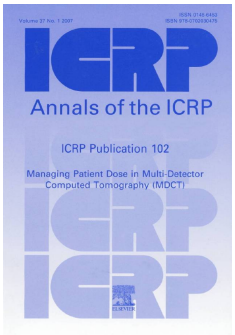
After ICRP 87

- Spiral CT 1999-2000
- 2000-2003: Doses in MDCT are higher
- Newer applications
- Potential for
  - Steep increase in usage
  - Multiple CT examination
- Watched literature on patient doses

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

1972-2007=35 years

CT Machines were most well behaved ones for 35 years

Over-exposure: 2010 Regulatory actions

CA Legislative Activities

Sen. Padilla introduced SB 1237 in Feb 2010
- Radiation Control: Health Facilities and Clinics

Schwarzenegger signed SB 1237 on September 29, 2010

Bonnie Lowenthal introduced AB 510 to amend SB 1237

CT dose reporting is required on July 1, 2012

Alexander Padilla

Bonnie Lowenthal

Arnold Schwarzenegger

Message for Professionals

Either you regulate yourself or be ready to be regulated

Lack of Strategy and Vision

Till skin injuries were reported, there was talk about **CT dose reduction,**
but **no hype or fear**

Computed Tomography Dose Check

- **XR-25**
- **NEMA: Specifies an equipment feature for CT scanners to produce dose-related notification and alert messages to inform operators prior to scanning if the estimated dose would exceed the preset levels.**

Another Era started
Patients/parents
Public

Question

What do you think works for a major technological change?

It is difficult to find another example of a modality in medical imaging, which has attracted as much media attention as Computed Tomography (CT)

AJR 2015; 204:W234–W235

Residents inRadiology

What Makes and Keeps Radiation Risks Associated With CT a Hot Topic?

Madan M. Rehani[1]

Although CT has been around since 1972, there was little momentum in radiation dose reduction until almost 2001. The sporadic appearance of articles in indexed journals during the 1980s and 1990s indicated interest in some academic centers [1, 2]. The International Commission on Radiologic Protection foresaw the emerging applications of CT and predicted that radiation dose resulting from CT would become an important issue [3]. The major change, however, came through media attention to articles published in *AJR* in 2001 pointing out some professionals continuing to propagate estimations and others opposing these figures as lacking a sound scientific basis. Unfortunately, rather than both groups being willing to publish joint position statements, there have been strong efforts to use professional organizations of medical physics to propagate the idea that risk estimations are not reliable [7]. Sadly, these position statements have not involved well-established radiation effects experts, such as radiation biologists and radiation epidemiologists. Achieving consensus involves huge amounts of resources and time, as the experience of

2001-2005

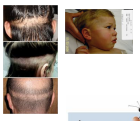
International Action Plan (IAEA)
Cancer risk from CT scan
First skin injury from CT and DSA combined

2011-2015

BONN CALL FOR ACTION
10 Actions to Improve Radiation Protection in Medicine in the Next Decade

Choosing Wisely

2006-2010



World Health Organization
Global Initiative

image gently

IMAGE WISELY

2016-

Several regional and national campaigns

ESR EUROSAFE IMAGING

LATIN SAFE PEDIATRIA

AFROSAFE RAD Championing Radiation Safety

Arab Safe Promoting Radiation Safety

Canada Safe Imaging | Imagerie Sécuritaire Canada

Japan Safe

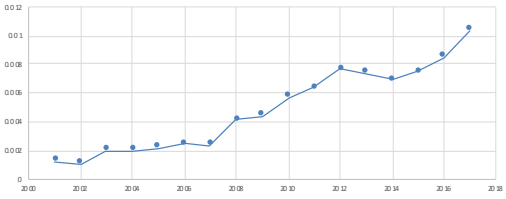
Incomplete list

A check on PubMed for the number of papers on CT dose optimization in 2018 shows three to five papers every week

Was it so in early 2000?

Normalized to "radiology" publications

"radiation dose" AND "computed tomography"



Is sub-mSv CT for all body parts going to be a reality?

A. **Yes, I am definite**
B. **I think we have almost achieved whatever was possible**

General feeling on CT doses

- Equipment are much safer
- Patient doses have gone down substantially for a defined level of information
- There are continuous efforts and momentum has been astounding
- CT cannot be considered as a high dose imaging modality

Most organizations

Negative information gets highlighted in public domain

This is a significant positive movement in professional domain

Hey!!!!

Hold on

May be we have not looked at something

Data Under Publication

Data from 344 hospitals
>500 CT scanners
20 Countries

3.3 million patients and
>5 million CT exams

≈ Half Million patients are likely getting added every year globally with CED ≥ 100 mSv only from recurrent CT exams. Organ doses.

NO Sir/Madam, I am serious

Typical arguments

1. Patients may be over 50 years of age with a significantly lower probability of radiation effects
2. Patients may have malignant or other serious disease with short life expectancy
3. CT scans may be clinically justified and needed to save the patient's life.

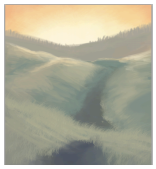
Hey!!!!

Further, hold your breath!

We have (a very small fraction of) patients who received 100 mSv **in a single day** from CT guided procedure?

Important points

- **Utility of CT is not questioned**
- **We are NOT saying that CT was used in these patients without justification or optimization**
- **We are not getting into the territory of effects, but as medical physicists talking about Dose**
- **Perhaps this may be the first time when imaging appropriateness in such patients was seriously studied**
- **Can anyone think of a time in last century when there was a similar situation? More details in a couple of month (4 publications submitted).**

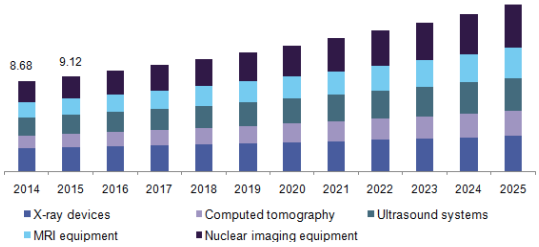


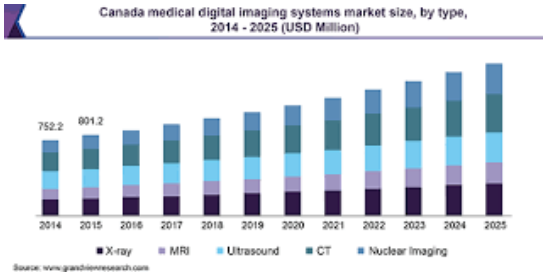
Even though CT is one of the safest imaging modalities, and its contribution to patient benefit is unquestionable, it seems that we have a real point for patients who need recurrent imaging

Something on Horizon!!

Remember: This is what we felt

Sorry.
No chance to sit back and relax, but need to act further





Do you agree that there is need for contributions by

- Medical Physicists
- Industry
- Users

A.Yes
B.No

P Roch, D Célier, C Dessaud, C Etard, MM Rehani.
Eur Radiol Sept 16, 2019

The Good, The Bad & The Ugly of DRLs
11 years experience with national DRLs analyzed

Fluoroscopic Guided Interventions

- **Reference doses were available only for a limited number of procedures**
- **We have provided 5 percentiles (10th, 25th, 50th, 75th, 95th) for 101 procedures**
- **X Li, JA Hirsch, MM Rehani, K Yang, B Liu. AJR (accepted)**
- **Will take care of some bad aspects of DRLs**

What drives innovation?

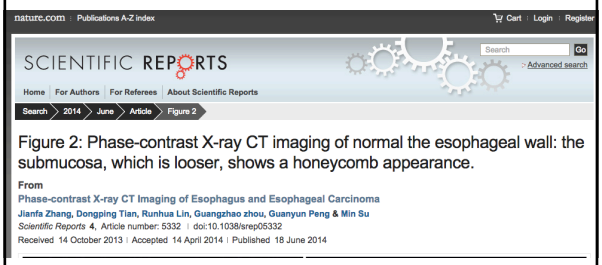
- **Urge to have a name, fame**
- **Urge to contribute to the cause**
- **Competitive spirit**
- **Prepared mind with chance**

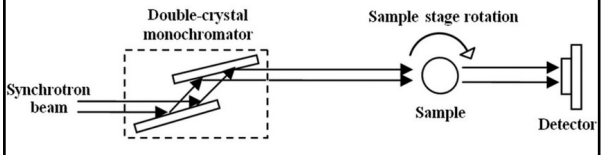
Experience sharing

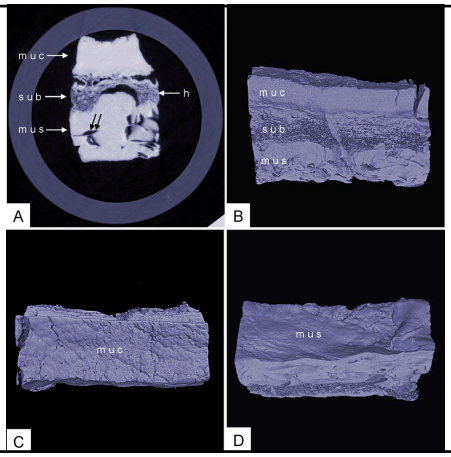
- **on Technological implementation by the industry**

Phase Contrast

- Use information concerning changes in the phase of an X-ray beam that passes through an object in order to create its images
- In PCI, the beam's phase shift caused by the sample is not measured directly, but is transformed into variations in intensity, which then can be recorded by the detector







RESEARCH

Dec 5, 2013

RSNA: focusing on phase-contrast CT

Phase-contrast CT, a process that relies on refraction and interference effects, potentially offers far higher contrast in weakly-absorbing tissues than conventional absorption-based X-ray imaging. At the RSNA annual meeting, held this week in Chicago, IL, researchers presented new preclinical research in a scientific session on non-conventional CT imaging.

Anal Bioanal Chem (2011) 401:803–808
DOI 10.1007/s00216-011-4913-7

ORIGINAL PAPER

Synchrotron radiation phase-contrast X-ray CT imaging of acupuncture points

Dongming Zhang · Xiaohui Yan · Xinyi Zhang · Chenglin Liu · Ruishan Dang · Tiqiao Xiao · Peiping Zhu

Received: 28 February 2011 / Accepted: 14 March 2011 / Published online: 9 April 2011

Abstract Three-dimensional (3D) topographic structures of acupuncture points were investigated by using synchrotron

Introduction

Acupuncture has been applied all over the world for se

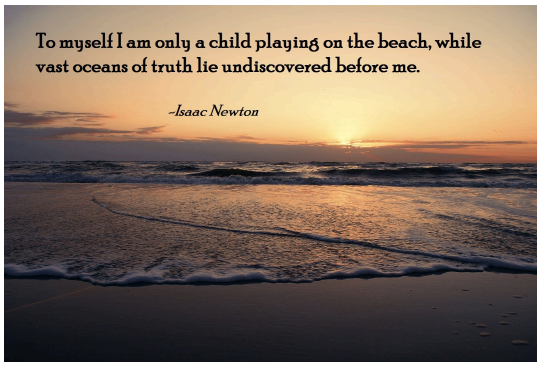
Future- How much hope

Vision: Sub-mSv CT scan

- Operator actions: Few tens of %, ≠ 100%
- Justification: 100%
- Technological innovations: few hundreds % (halving of dose or more)

In Summary, we need startups in Medical Imaging

Where utility is the dominating factor



Thank You

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