ICRP & IAEA Actions on Radiation Protection in CT

Madan M. Rehani, PhD

Secretary, ICRP Committee 3

International Atomic Energy Agency, Vienna, Austria

ICRP SYMPOSIUM October 24-26 2011

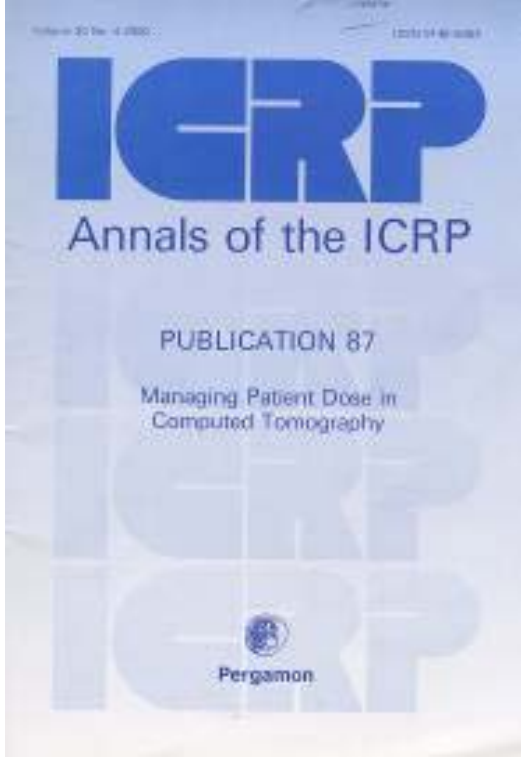
1997: Review of situation in ICRP

- **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**

- **1999- ICRP sets up a Task Group on Patient doses in CT**

Task Group

- 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

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.

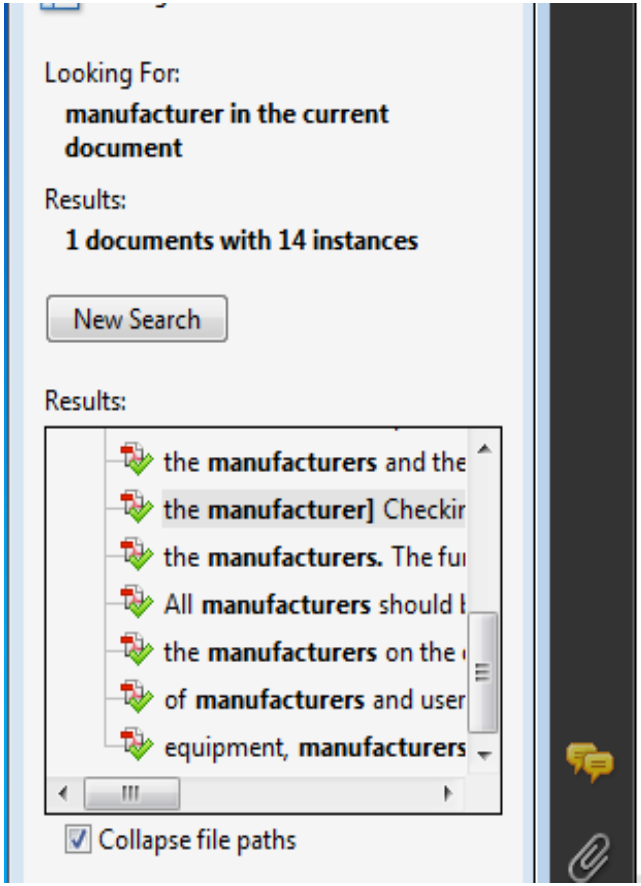
"The increasing doses of radiation need to be controlled worldwide," he said.

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 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

Manufacturer orientation in ICRP 87

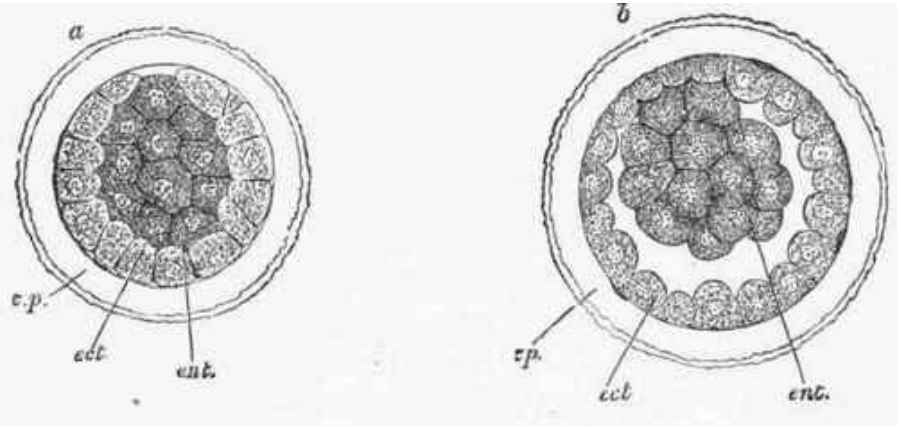


ICRP Publication 87

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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AJR issue with many articles & Editorial

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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

■ News ■ Money ■ Sports ■ Life

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USA TODAY .com

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

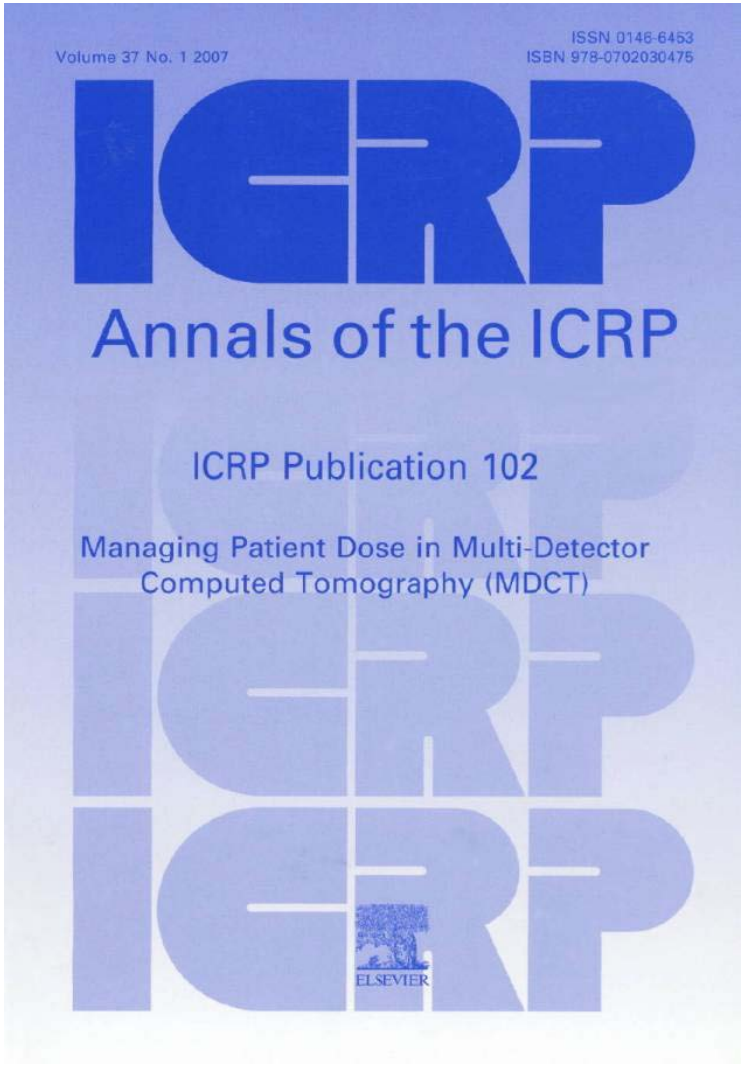
After ICRP 87

- 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

This can also happen

CT perfusion with DSA

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

4 Major culprits in increasing dose

- **Shorter scanning times (time is intuitive, that it may result in lesser radiation dose- very little if any, published data available on this),**
- **Image quality higher than necessary (knowledge),**
- **Unjustified examinations,**
- **Not using the features that the machine provides**

Time for CHANGE

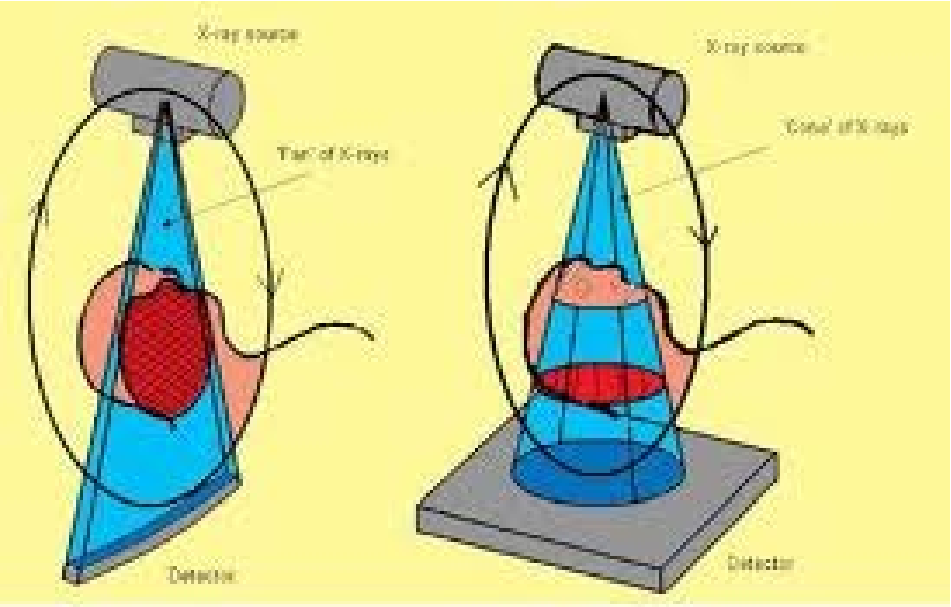
Played role

- **Presaging problem**
- **Developing guidance (Emphasizing on application of ICRP principle principles)**

Current situation:

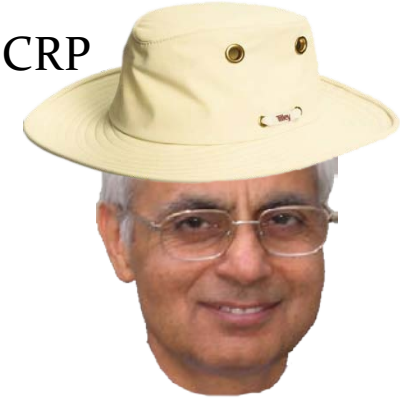
- **Manufacturer-radiation dose TOP on the agenda**
- **Momentum among users on optimization**
- **Growing momentum on justification**

Cone Beam CT



© J Can Dent Assoc 2006; 72(1): 75-80

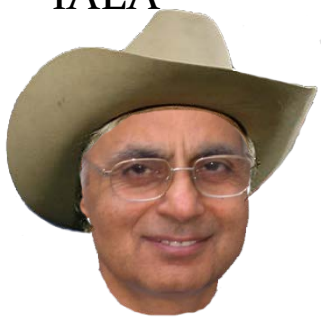
ICRP



ICRP

www.icrp.org

IAEA



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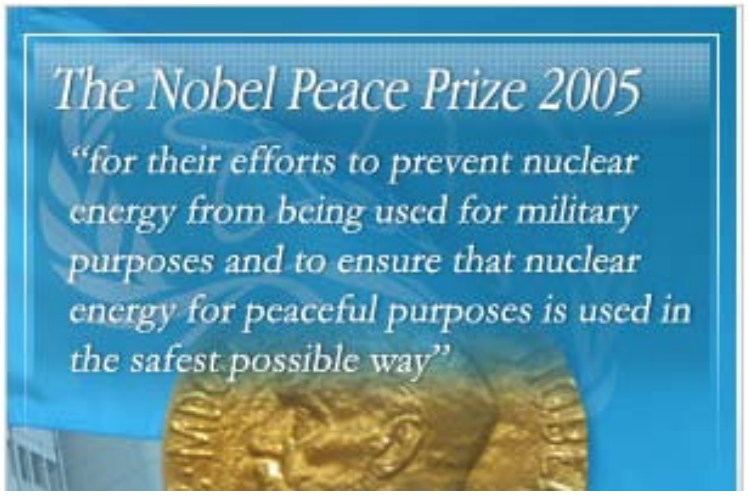

The Nobel Peace Prize 2005
"for their efforts to prevent nuclear energy from being used for military purposes and to ensure that nuclear energy for peaceful purposes is used in the safest possible way"

Common Impression

- ~~Super regulator~~
- Use ~~only~~ Top Down approach (developing regulation, enforecement…)

Bottom-up approach

40 Less resourced countries

Countries (scanners) 146 CT facilities at 126 hospitals

Armenia (1), **Belarus (1),** **Bosnia & Herz (3)** **Brazil (5),** **Bulgaria (12), China (3),** **Costa Rica (1),** **Croatia (3),** **Czech Republic (6),** **Estonia (2),** **Indonesia (1),**	**Iran (10),** **Israel (7),** **Kuwait (5),** **Lebanon (6),** **Lithuania (3),** **Malaysia (5),** **Malta (1),** **Mexico (2),** **Montenegro (1),** **Moldova (5),** **Myanmar (1),**	**Oman (1),** **Pakistan (5),** **Paraguay (3), Peru (1),** **Poland (1),** **Qatar (1),** **Serbia (3),** **Singapore (1),** **Slovakia (4),** **Slovenia (1),** **Sri Lanka (2)**	**Sudan (3),** **Syria (8),** **Tanzania (3),** **Thailand (2),** **The Former Yugoslavia Republic (FYR) of Macedonia (5),** **United Arab Emirates UAE (15).**

First such multi-national study

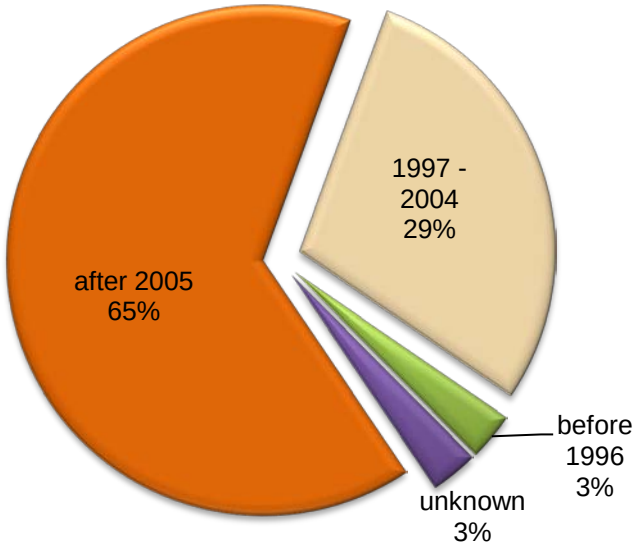
IAEA study covering 40 countries

1. **Technology**

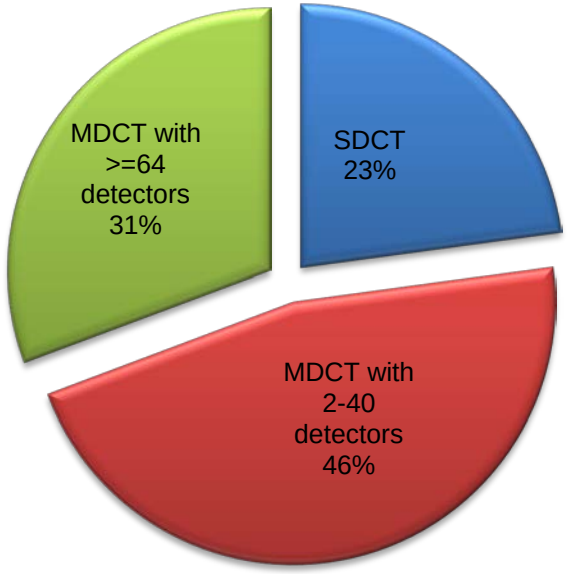
IAEA Survey in 40 less resourced countries

CT equipment

Year of installation

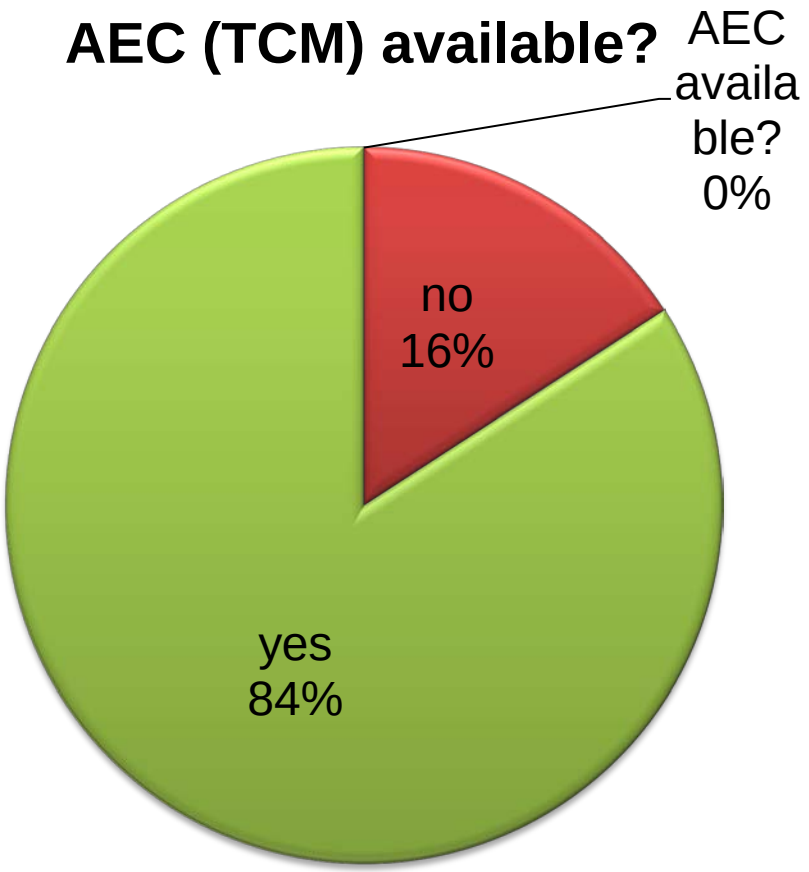


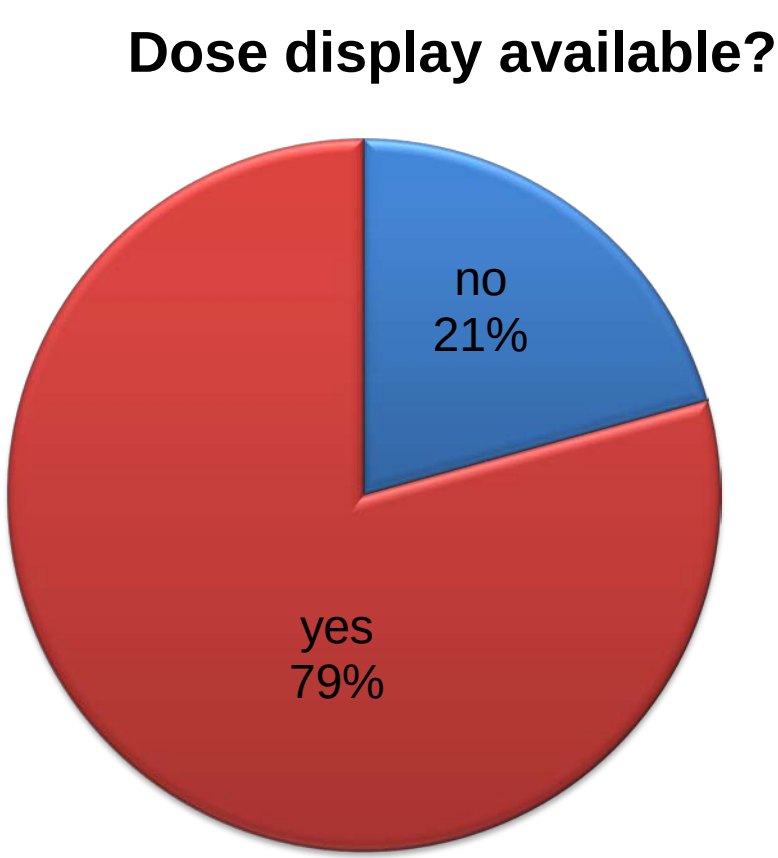
Number of detector rows



IAEA Survey in 40 less resourced countries

- CT equipment

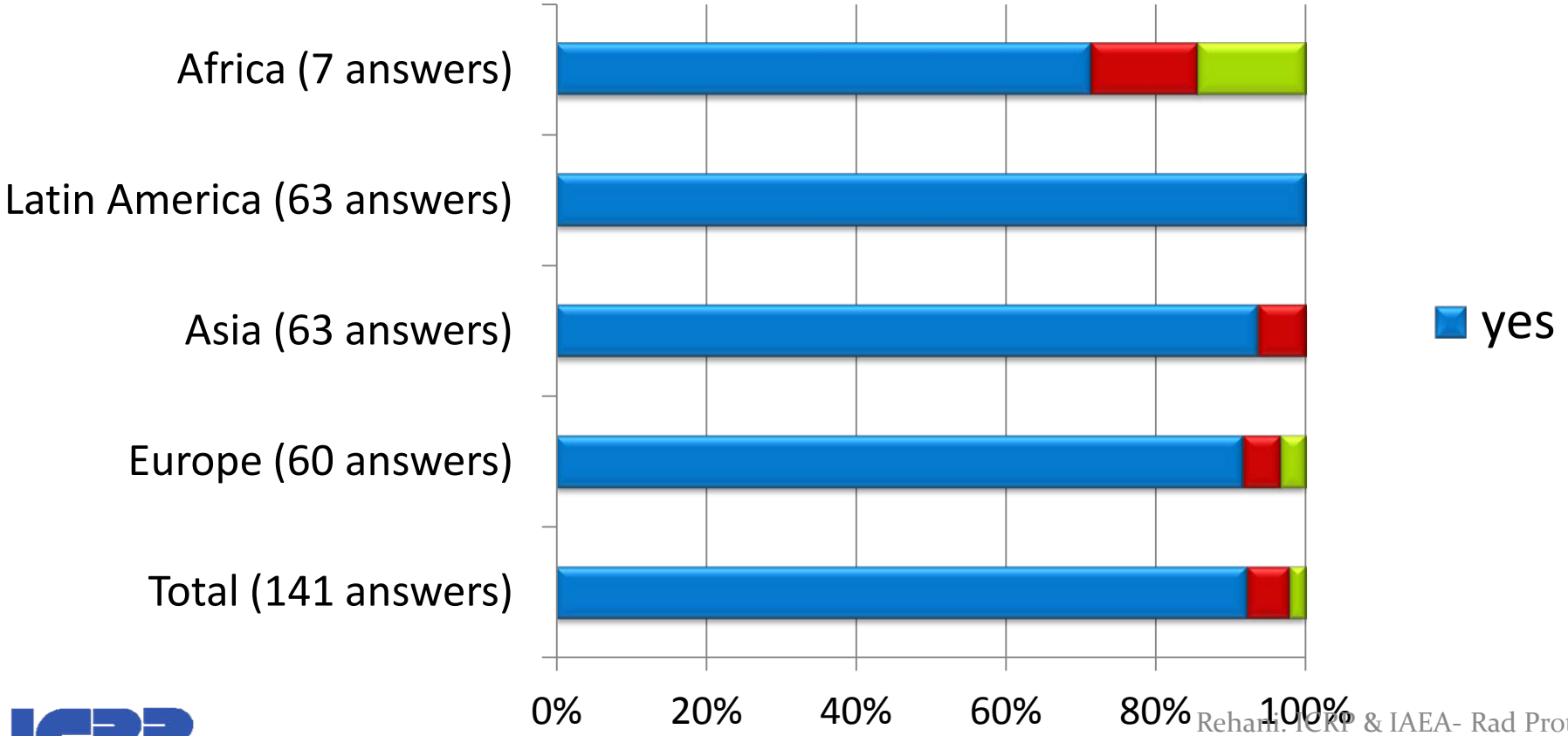




IAEA Survey in 40 countries

- **141 radiologographers/ technologists answered**

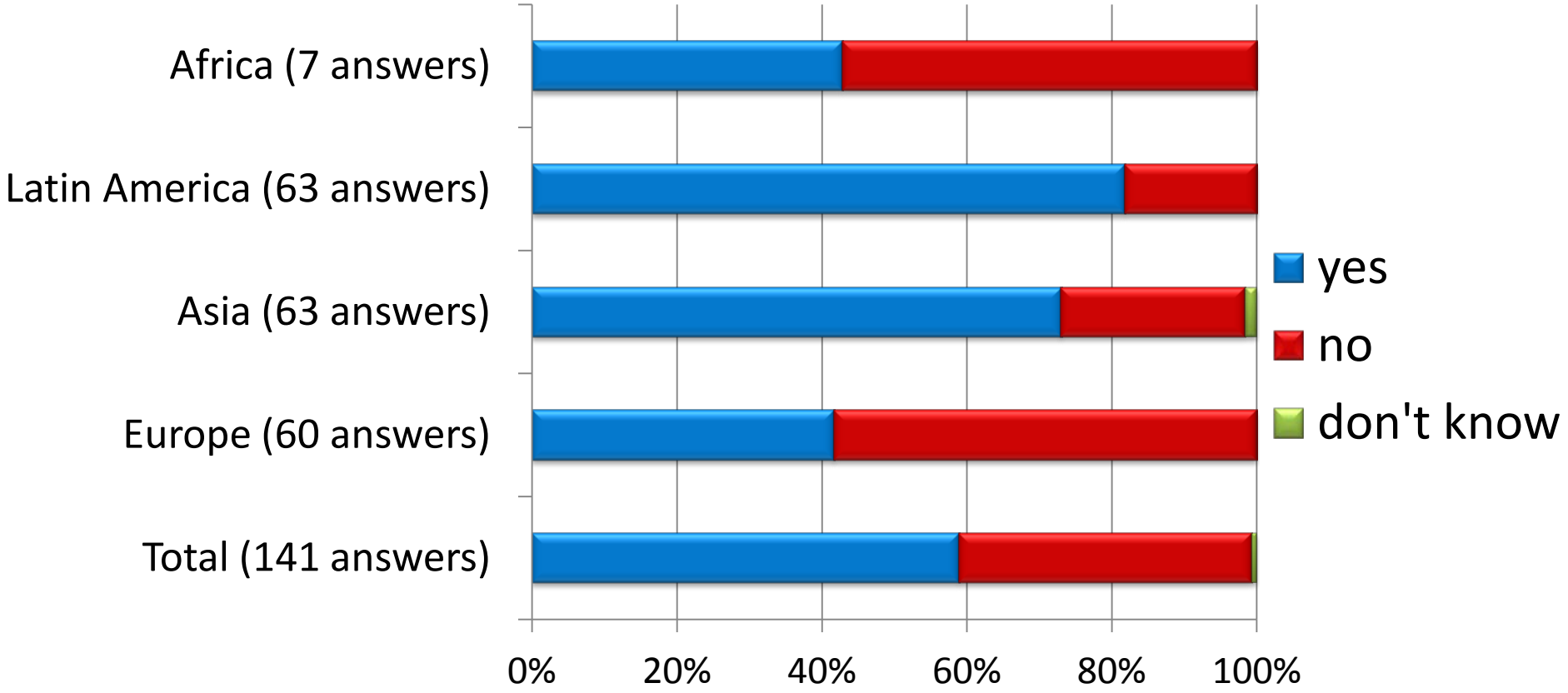
  Dedicated scanning protocols for pediatric examinations available? Yes, in overall 94%



IAEA Survey in 40 countries

- **141 radiolographers/ technologists answered**

Indication based protocols? Available in about 58%



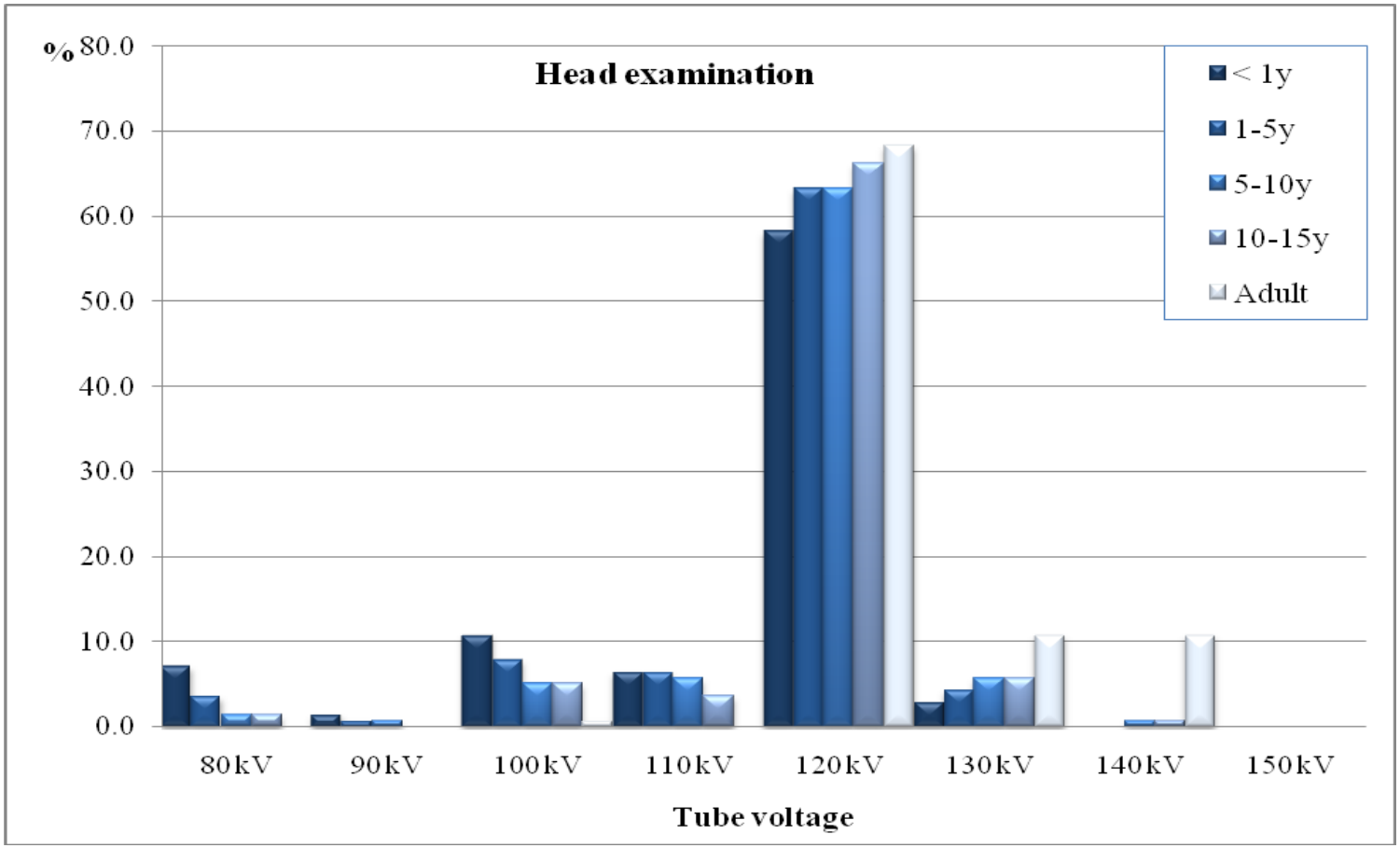
IAEA study covering 40 countries

1. Technology
2. **Pediatric CT practice**
   a. Technique

IAEA Survey in 40 countries

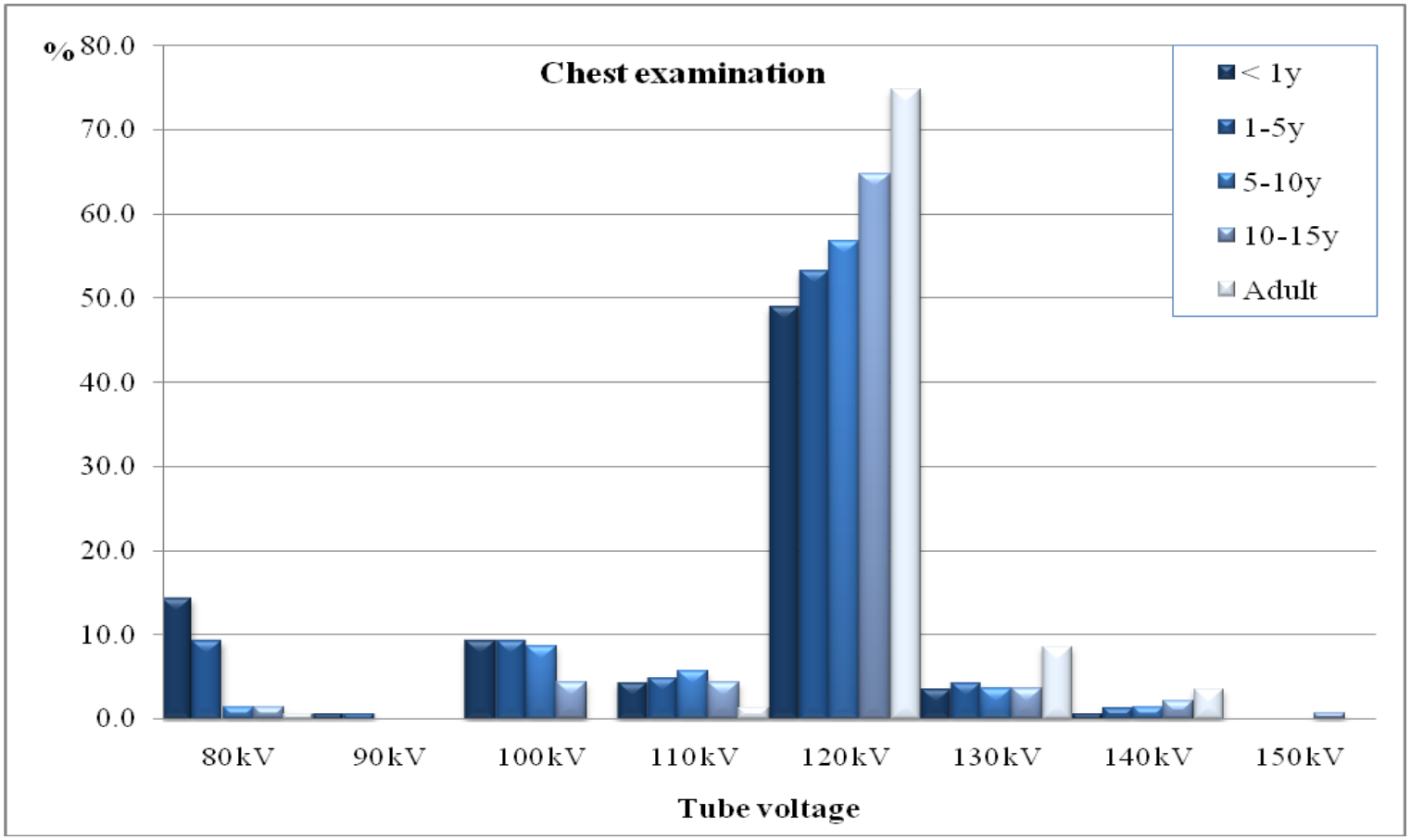
Most commonly used kVp=120

Head CT



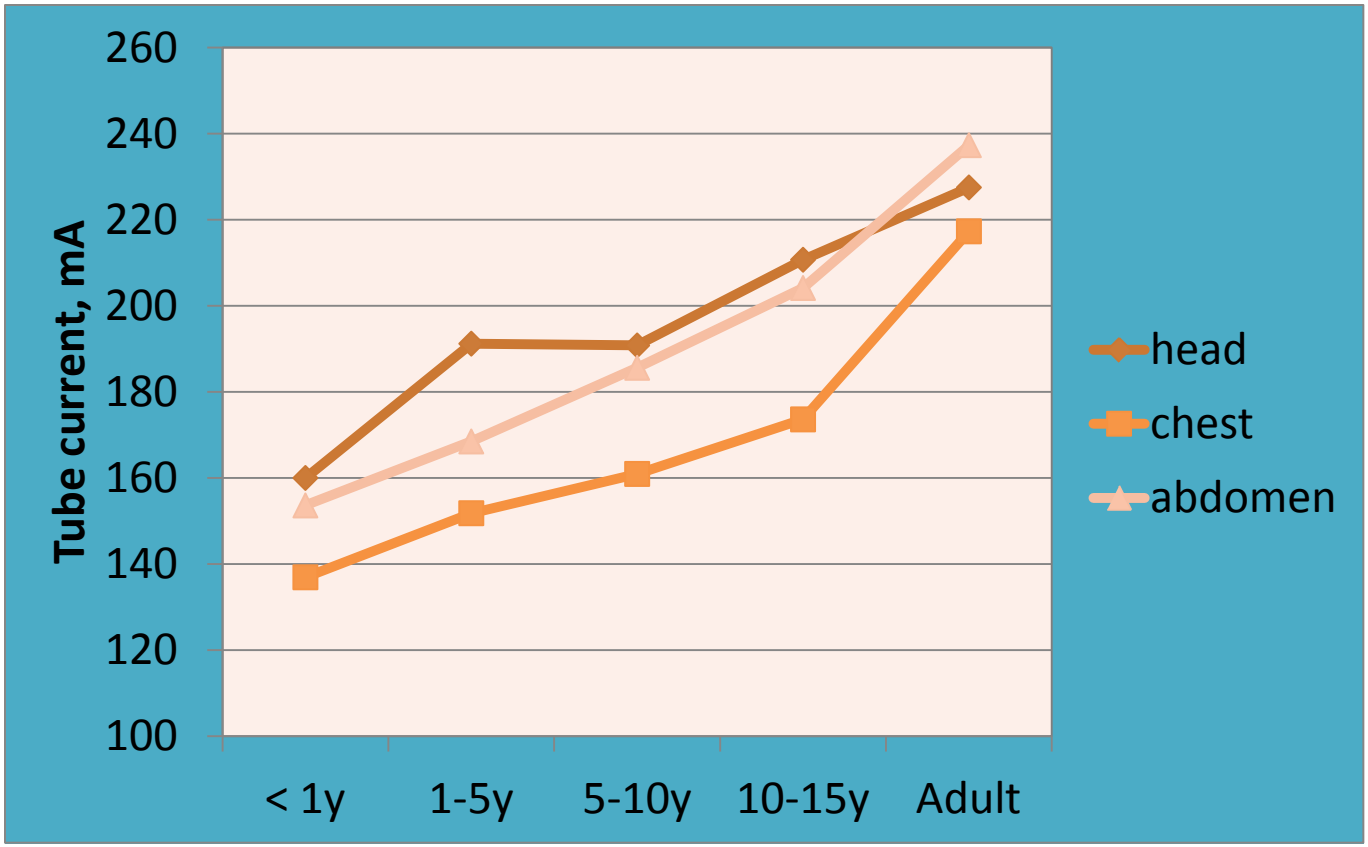
IAEA Survey in 40 countries

Most commonly used kVp=120 **Chest CT** **[80-110 in 30% in newborn and 12% only for older]**



RESULTS: Typical exposure parameters

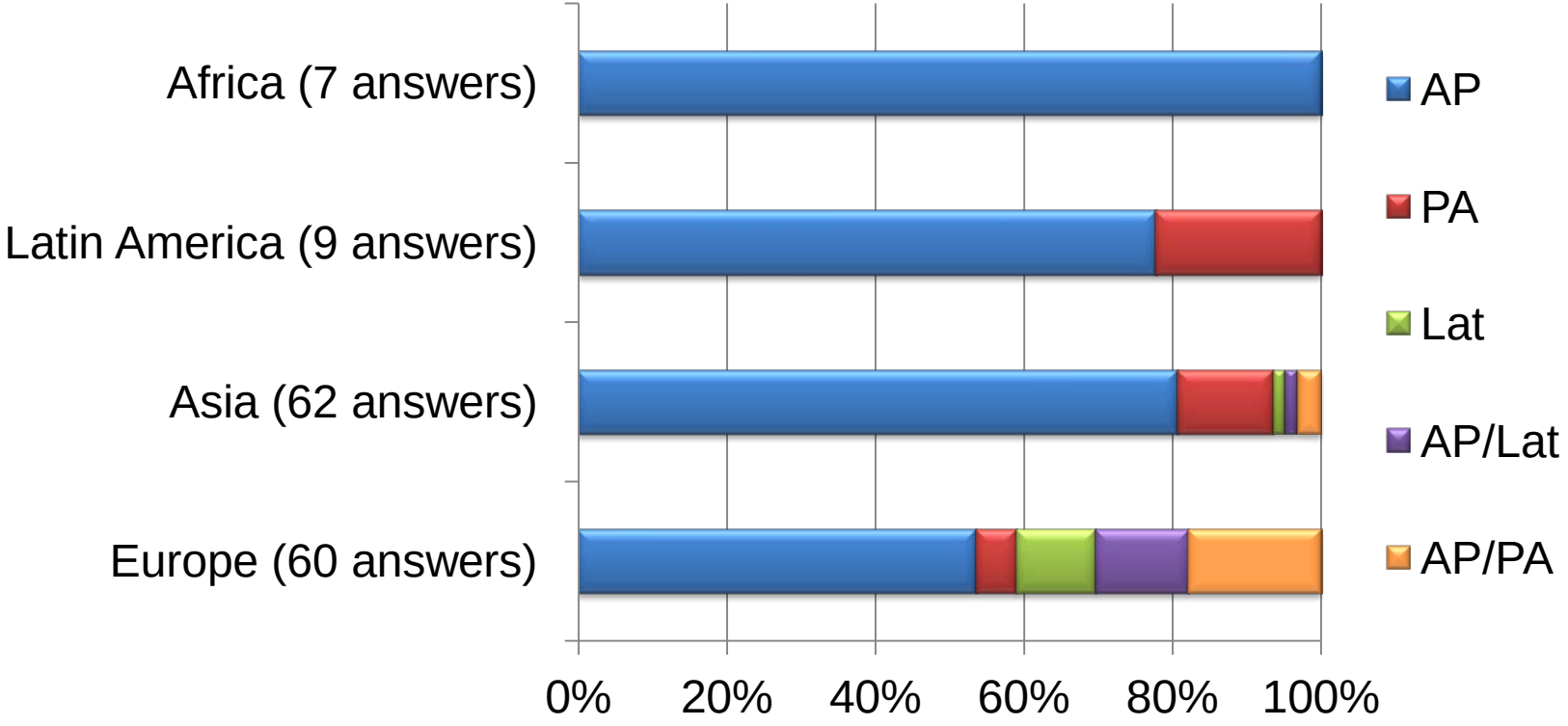
Mean values of tube current utilized for head, chest and abdomen exams w.r.t patient age



IAEA Survey in 40 countries

- **138 radiologographers/ technologists answered**

  Scout image for pediatric patient is performed usually in PA or AP projection?



Scout Image

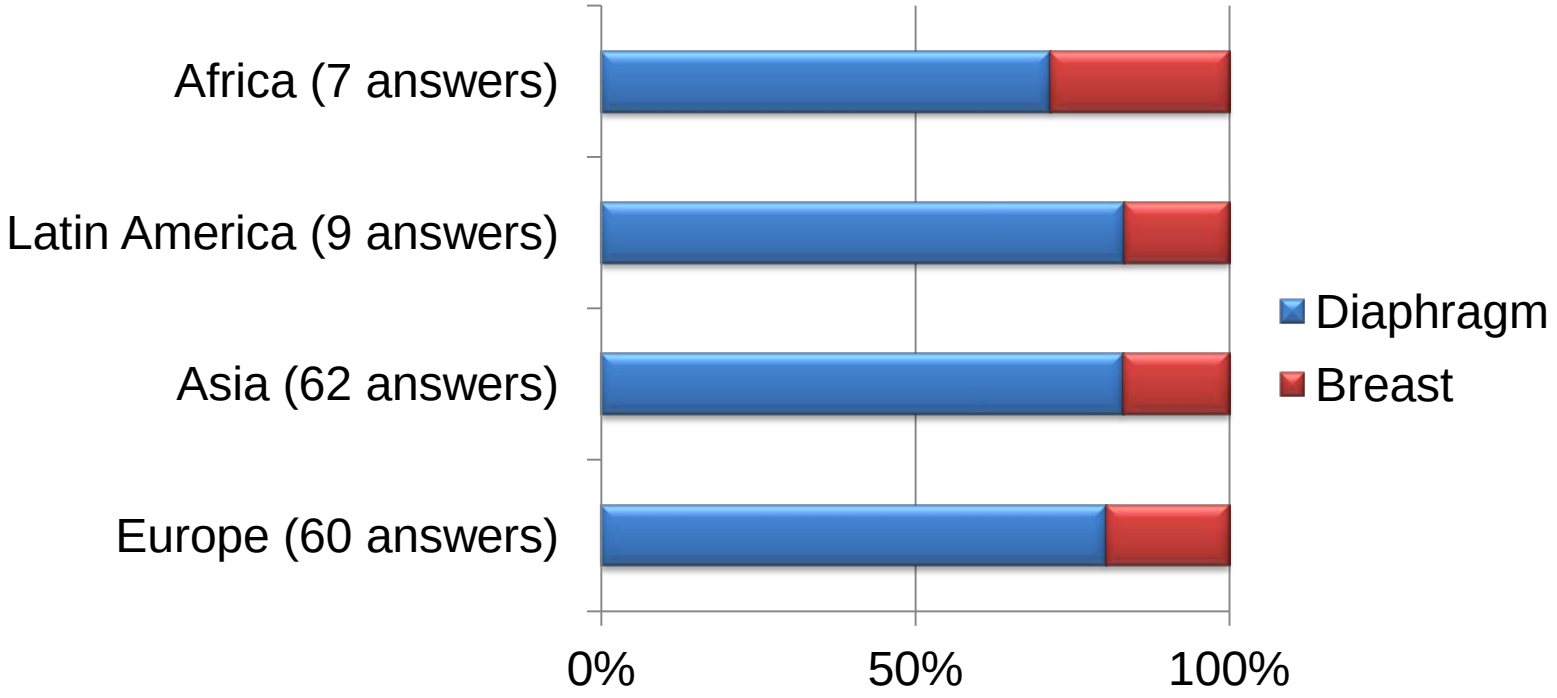
Recommendations given

- 80 kVp instead of 120 kVp,
- minimum X-ray tube current,
- 180° tube position (PA projection)

QUESTIONNAIRE - RADIOGRAPHER

- **138 radiolographers/ technologists answered**

  Is typical scout image and CT scan of the pediatric abdomen extend to the breast (B) or to diaphragm (D)?



16% extends to breast

IAEA study covering 40 countries

1. **Technology**
2. **Pediatric CT practice**
   a. Technique
   b. Dose

RESULTS: Typical exposure parameters

Protocols for chest examination of infant **(<1 y)** in 8 CT facilities with **the same 64-detector scanner** model (Light Speed VCT, GE)

Mode	Tube voltage, kV	Tube current, mA	t rot, s	Pitch value	$CTDI_{vol}$, mGy
helical	80	129	0.5	1.3	1.89
helical	120	120	0.5	0.984	10.21
helical	80	240	0.5	0.984	2.64
helical	80	100-250	0.5	0.96	4.26
helical	100	180	0.4	0.98	3.2
helical	120	80	0.4	1.375	4.5
helical	80	25	0.5	0.9	0.71
helical	120	80	0.6	0.9	10

Scope for improvement and harmonization

$CTDI_{vol}$ – Abdomen examination

		< 1y	1-5y	5-10y	10-15y	Adult
CTDIvol (mGy)	min	0.8	0.8	2.0	2.0	2.0
	max	40.1	75.0	29.8	45.0	61.0
	average	8.0	11.2	9.0	11.4	16.2
	median	5.0	6.3	7.6	9.6	13.4
	3d quarter	10.7	13.0	12.0	14.3	18.2
DRL in $CTDI_{vol}$ (mGy)	UK, 2005	20*	20*	30*	-	14
	Switzerland, 2008	7	9	13	16	-
	Germany, 2007	2.5	4	6.5	10	-
	France, 2009	4	4.5	7	-	-

*DRLs in $CTDI_{vol,16,}$ Swiss as displayed by scanner, others 32 cm

Chest & Abdomen

- $CTDI_{vol}$, values are similar or higher than the DRL values in UK and Switzerland, with a maximum difference of 53% for age group <1 y.
- Compared with the DRLs in France, values from this survey are higher by 42-63%, but they are higher than the DRL values in Germany by 85 – 320 %.

Head CT

- $CTDI_w$ values were higher than the latest UK DRL values for children by,
  - 62% for age group <1y,
  - 27% for (1-5) y,
  - 22% for (5-10) y.
- The third quartile $CTDI_{vol}$ values are lower by 3 to 16% than the DRLs in UK, Germany and France, depending on the age group, but they are higher than corresponding values in Switzerland by up to 45%.
- **Gantry tilt or patient head repositioning was applied by more than 75% of operators**

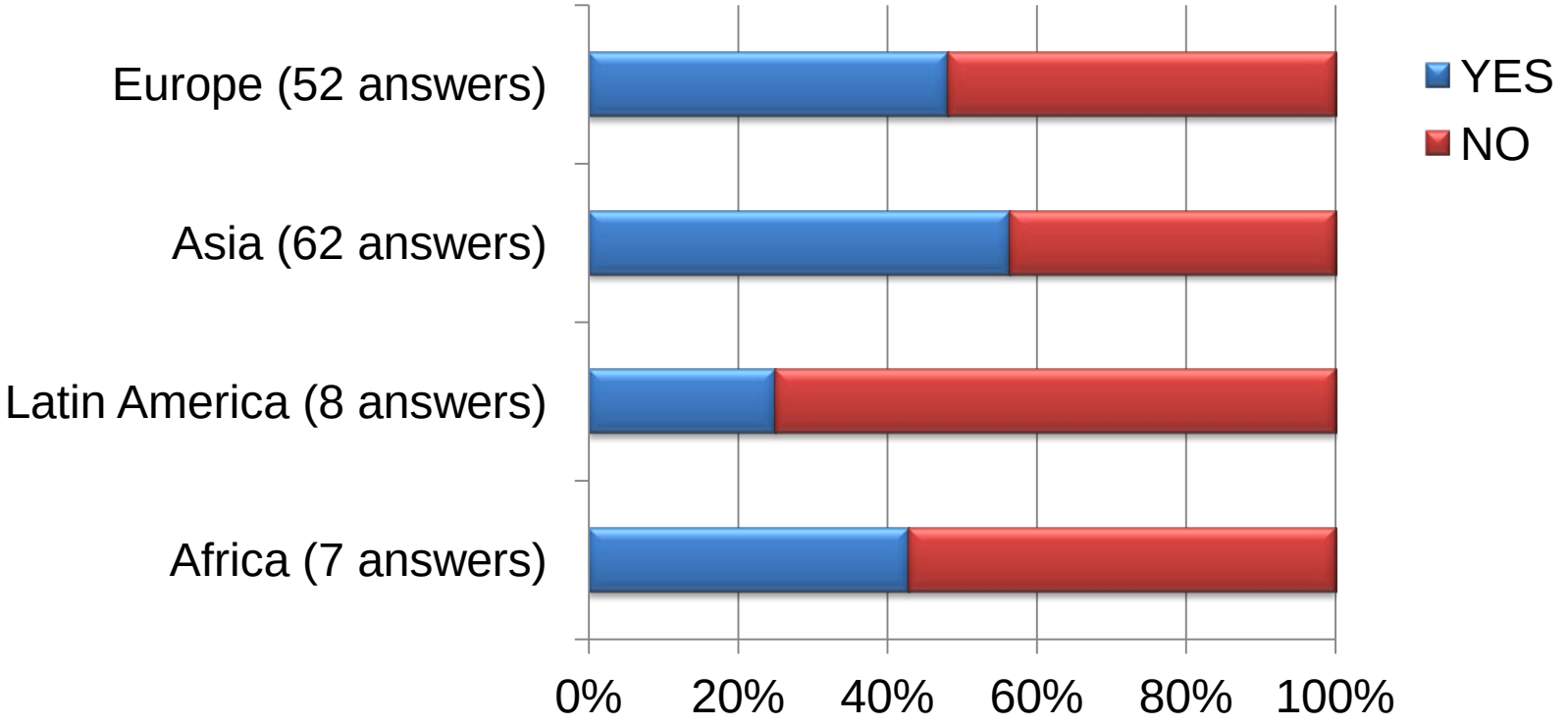
IAEA study covering 40 countries

1. **Technology**
2. **Pediatric CT practice**
   a. Technique
   b. Dose
   c. Appropriateness

QUESTIONNAIRE - RADIOLOGIST

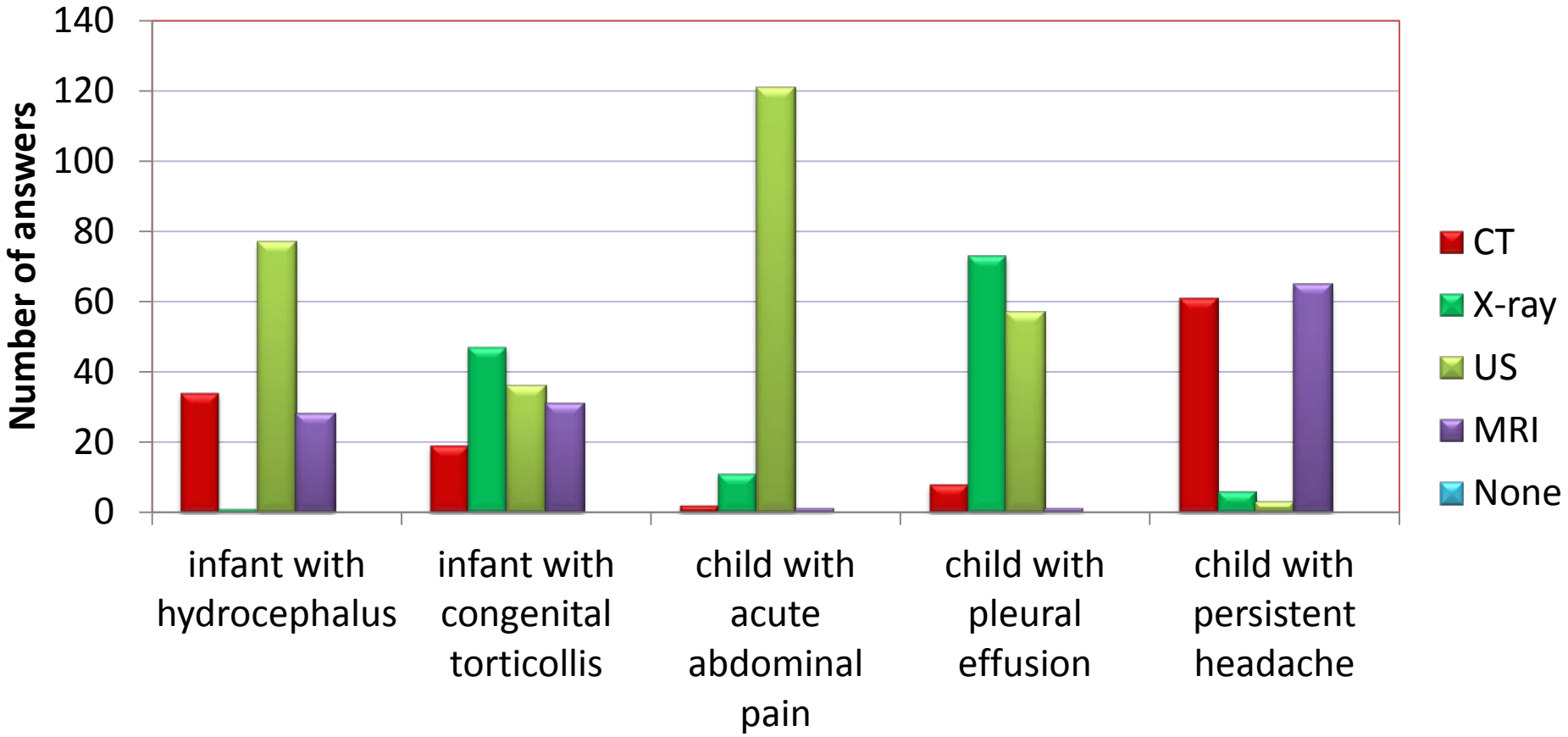
- **129 radiologists answered**

Are written referral guidelines for imaging available in your hospital? *Not available in about Half*



Appropriateness Issues

Which examination is " the first choice examination" in case of:



Appropriateness Issues

Not according to available guidelines in

- Accidental head trauma, (not in about 50%. Minor trauma and suspected abuse)
- Infants with congenital torticollis;
- Children with possible ventriculo-peritoneal shunt malfunction and
- Young children (<5 years old) with acute sinusitis.
- _____

Mostly according to guidelines

- Infant with hydrocephalus (76% use other than CT)
- Child with indication for appendicitis (acute abdominal pain)
- Child with persistent headache

IAEA study covering 40 countries

1. **Technology**
2. **Pediatric CT practice**
   a. Technique
   b. Dose
   c. Appropriateness
   d. Frequency

Frequency of pediatric CT exams

95 CT facilities in 28 countries

Region	Number of CT facilities	Frequency of pediatric examinations in 2007 (%)		Frequency of pediatric examinations in 2009 (%)	
		mean	range	mean	range
Europe	30	4.6	0.1 – 18.2	4.3	0.2 – 26.8
Asia	57	9.4	0.1 – 29.0	12.2	0.1 – 49.4
Latin America	1	-	-	-	-
Africa	7	9.6	4.2 – 19.7	7.8	2.2 – 18.2
All countries	95	7.5	0.1 – 29.0	9.0	0.1 – 49.4

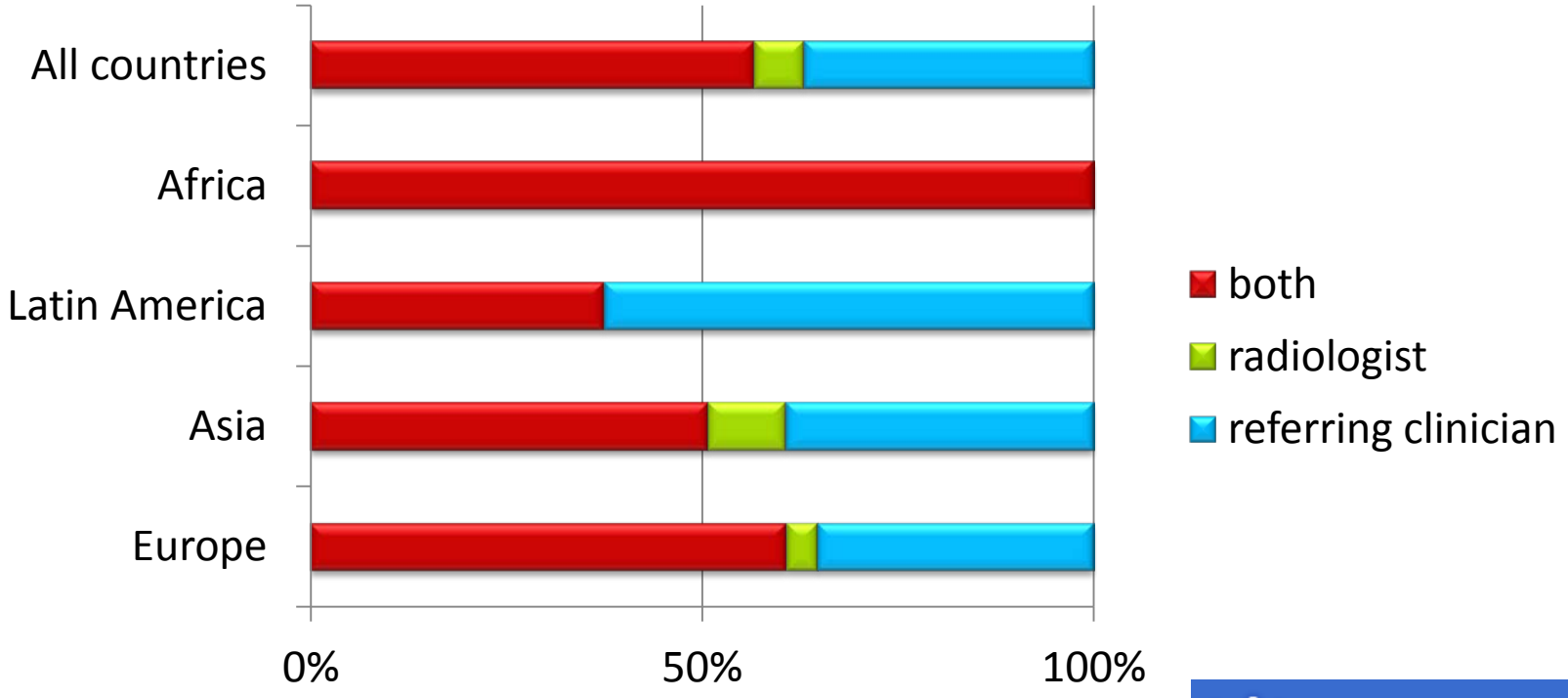
IAEA study covering 40 countries

1. **Technology**
2. **Pediatric CT practice**
   a. Technique
   b. Dose
   c. Appropriateness
   d. Frequency
   e. Referral

QUESTIONNAIRE - RADIOLOGIST

- **129 radiologists answered**

Who decides whether a CT examination of pediatric patient is to be performed?



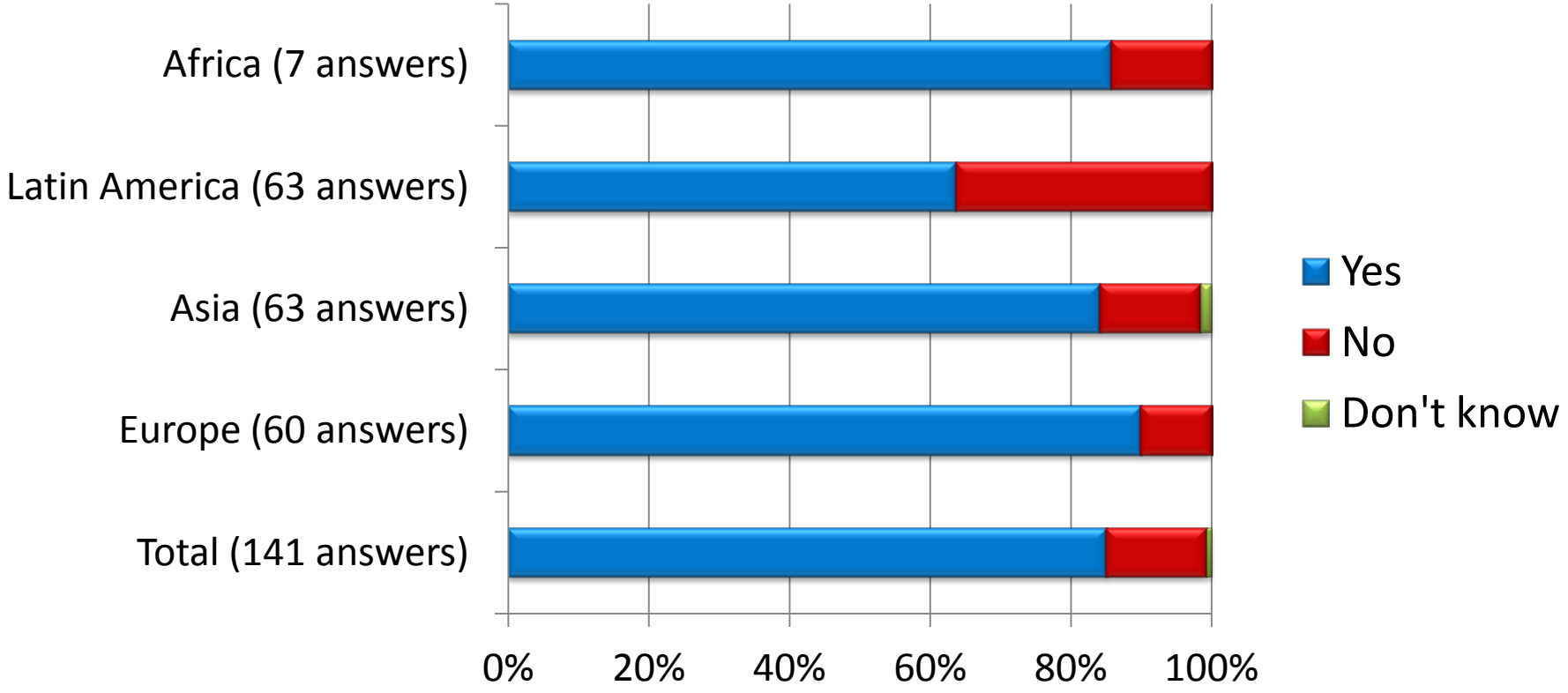
IAEA study covering 40 countries

1. **Technology**
2. **Pediatric CT practice**
   a. Technique
   b. Dose
   c. Appropriateness
   d. Frequency
   e. Referral
   f. Patient support & sedation

IAEA Survey in 40 countries

- **141 radiolographers/ technologists answered**

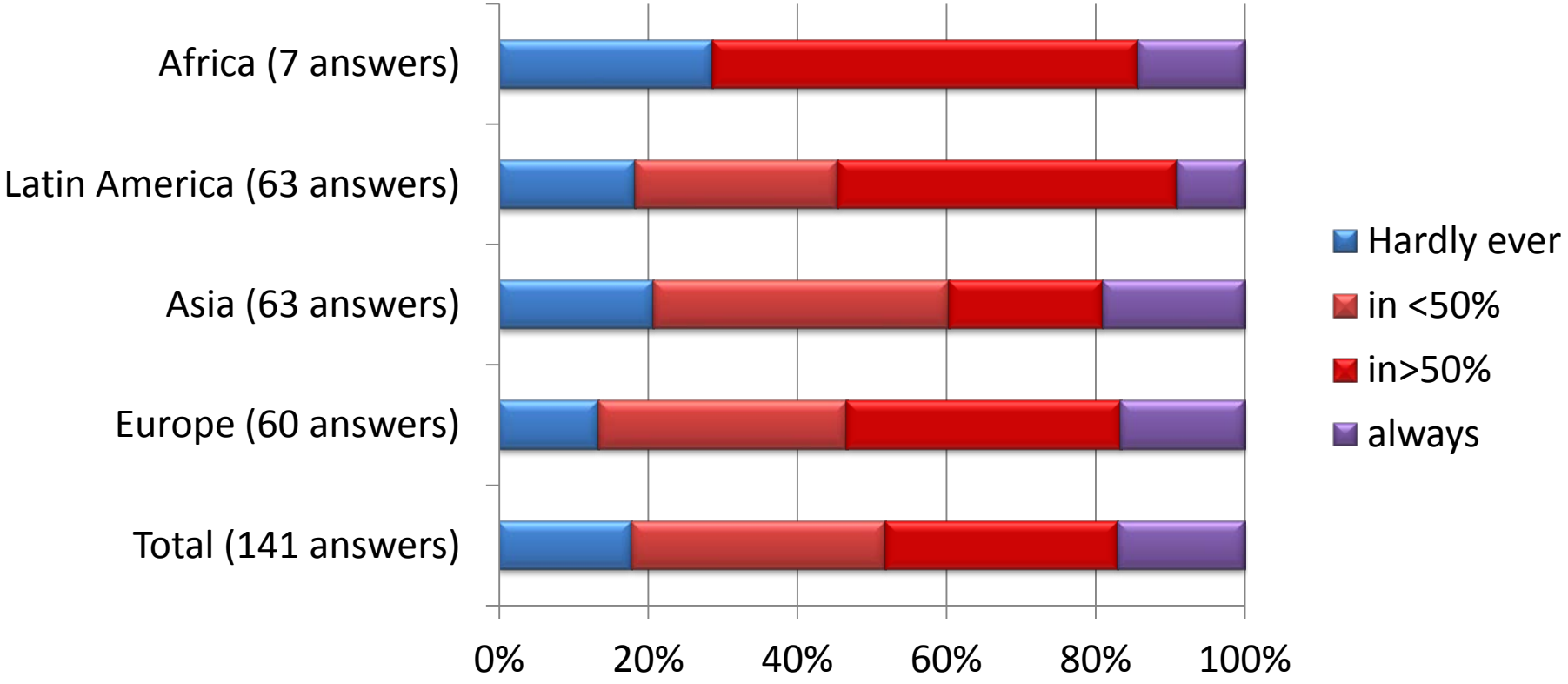
  Are any immobilization means available, e.g. swaddling clothes, straps, etc.?



IAEA Survey in 40 countries

- **141 radiologographers/ technologists answered**

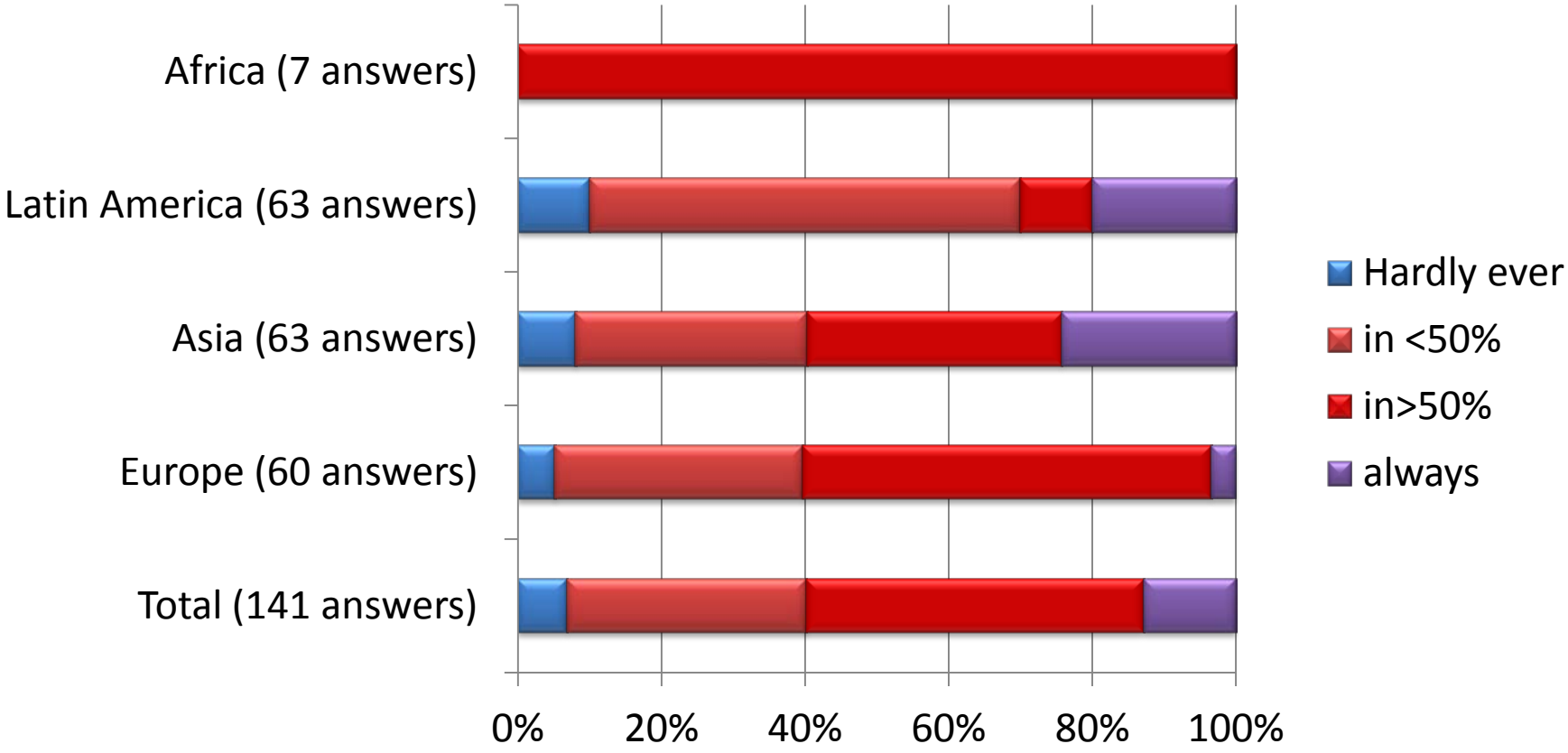
  How often does CT examination of pediatric patient need supporter in the room?



IAEA Survey in 40 countries

- **141 radiolographers/ technologists answered**

  How often is sedation used for small children (< 5 y old)?



IAEA study covering 40 countries

1. **Technology**
2. **Pediatric CT practice**
   a. Technique
   b. Dose
   c. Appropriateness
   d. Frequency
   e. Referral
   f. Patient support & sedation
3. **Publications**

Results under publication in 3 papers

- **Paper I**: Frequency of use and Appropriateness (Already accepted AJR)
- **Paper-II**: Procedures and Protocols (Submitted AJR).
- **Paper- III**: Impact assessment of optimization actions as identified in Paper II above (Likely to be submitted in Dec.11/Jan.2012)

Radiation Protection Dosimetry Advance Access published August 17, 2009

Radiation Protection Dosimetry (2009), pp. 1–9 doi:10.1093/rpd/ncp144

PATIENT DOSES IN CT EXAMINATIONS IN 18 COUNTRIES: INITIAL RESULTS FROM INTERNATIONAL ATOMIC ENERGY AGENCY PROJECTS

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PAEDIATRIC CT EXAMINATIONS IN 19 DEVELOPING COUNTRIES: FREQUENCY AND RADIATION DOSE

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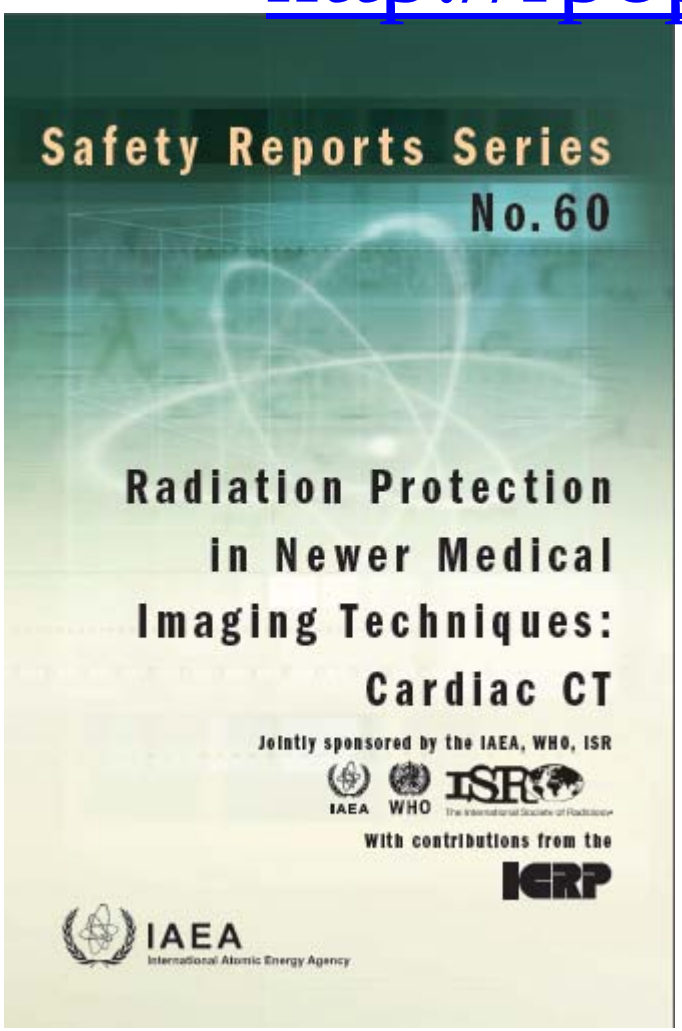

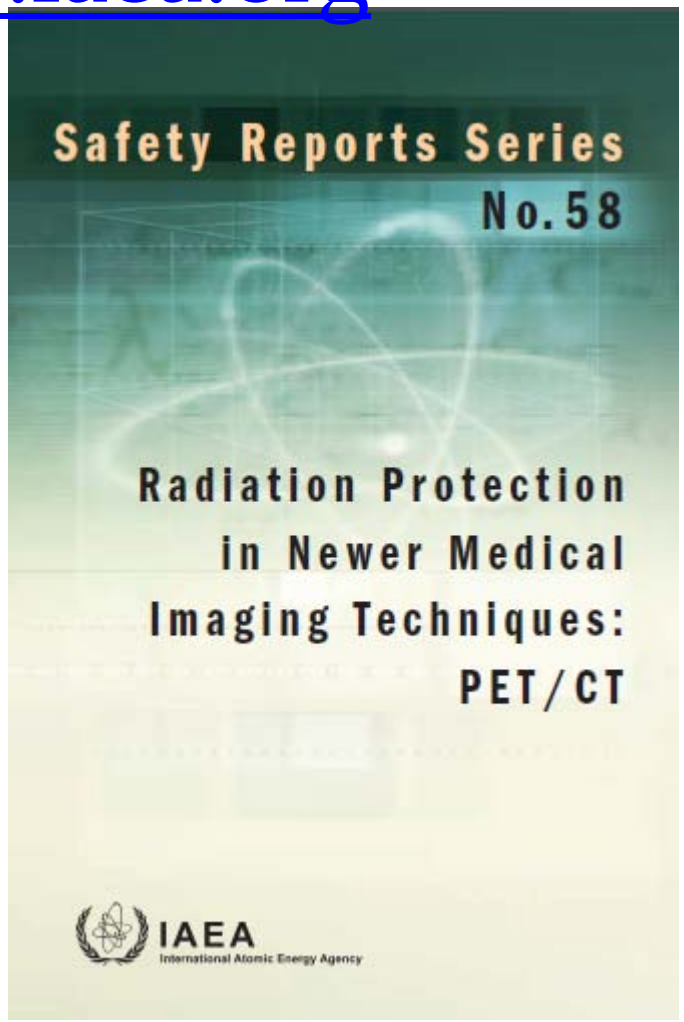

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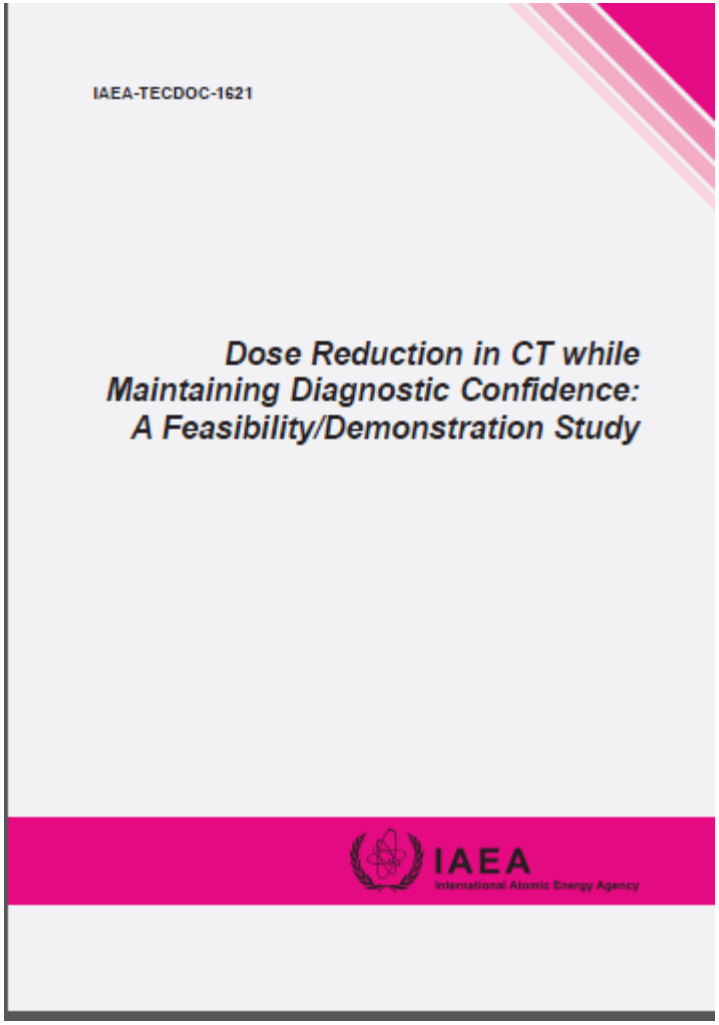

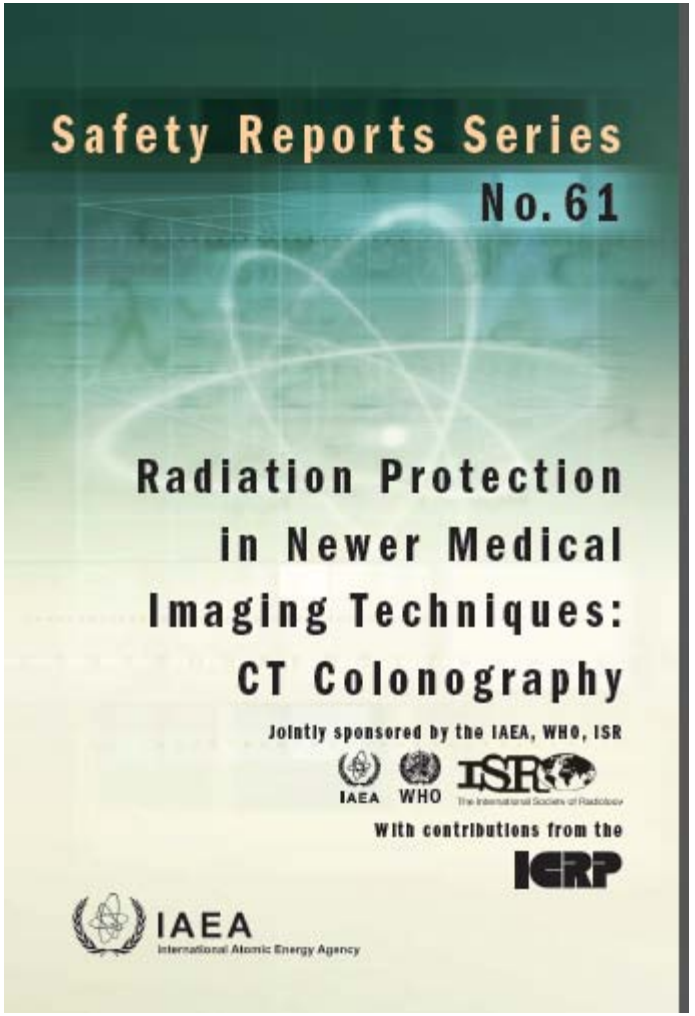

IAEA study covering 40 countries

1. **Technology**
2. **Pediatric CT practice**
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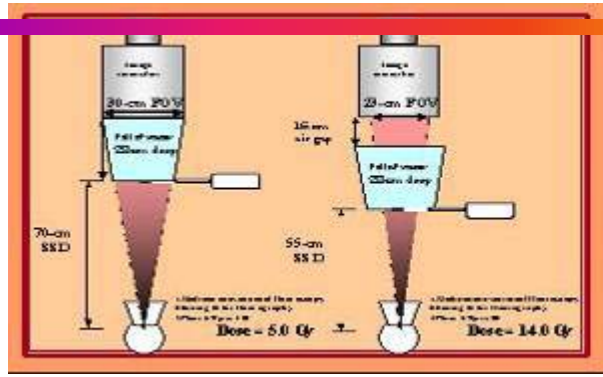
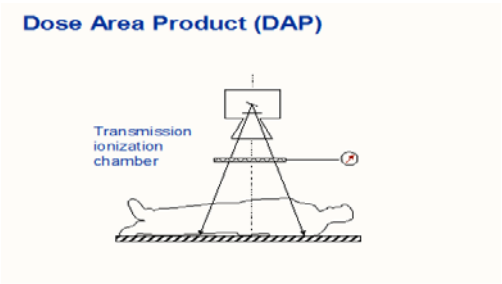
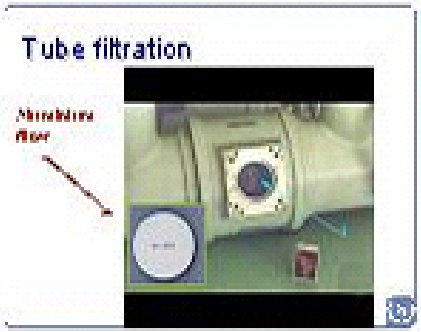
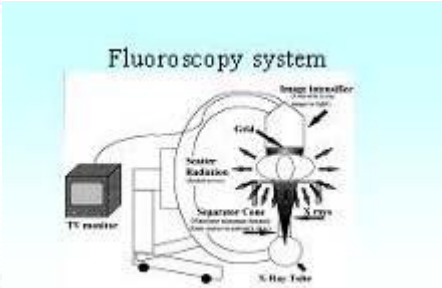
   b. Dose
   c. Appropriateness
   d. Frequency
   e. Referral
   f. Patient support & sedation
3. **Publications**
4. **Training material**

IAEA Training Material on Radiation Protection in Diagnostic and Interventional Radiology









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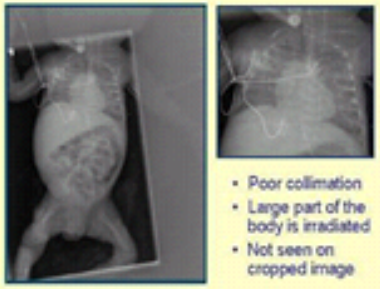

- Poor collimation
- Large part of the body is irradiated
- Not seen on cropped image

Possible radiation effects

Arm of 7-year-old patient after cardiological ablation procedure. Injury to arm occurred due to added attenuation of beam by presence of arm and due to close proximity of arm to the source.

Radiation risk in paediatric radiology

- Every Radiology Department should have information for parents

in collaboration with image gently

Version: November 2010

While DOING is best way to communicate message and to learn, there is limited outreach of projects aimed at making people do

Besides engaging professionals in project work, satisfying their information needs

IAEA study covering 40 countries

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2. **Pediatric CT practice**
   a. Technique
   b. Dose
   c. Appropriateness
   d. Frequency
   e. Referral
   f. Patient support & sedation
3. **Publications**
4. **Training material**
5. **Website**

Website http://rpop.iaea.org

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Information to help health professionals achieve safer use of radiation in medicine for the benefit of patients

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- International Standards
- Training

Special Groups
- Pregnant Women
- Children

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- Drafts Management Area

Actions to Protect Patients In:
- Radiology →
- Radiotherapy →
- Nuclear Medicine →
- Interventional Radiology →
- Interventional Cardiology →
- Other Specialities & Imaging Modalities →

Latest Literature

Ferrandino, M.N., Bagrodia, A., Pierre, S.A., Scales, C.D. Jr., Rampersaud, E., Pearle, M.S., Preminger, G.M.,
Radiation exposure in the acute and short-term management of urolithiasis at 2 academic centers, J. Urol. **181** 2 (Feb. 2009) 668-672.

Keeley, F.X., Jr, Thornton, M.,
Radiation safety: Implications for urologists and patients, J. Urol. **181** 2 (Feb. 2009) 443-444.

Vano, E., Ubeda, C., Leyton, F., Miranda, P., Gonzalez, L.,
Staff Radiation Doses in Interventional Cardiology: Correlation With Patient Exposure, Pediatr. Cardiol. (Jan. 2009)

Did You Know That...

3. It is safe to have an X ray examination of the extremities (feet, legs, hands, arms) in pregnancy, provided the examination is clinically justified and radiation protection principles are observed

« Prev Next »

Latest News

New Publications on Newer Imaging Techniques released
Download FREE three new publications on radiation protection in newer imaging techniques (PET/CT, Cardiac CT and CT colonography)

Cardiologists' Newsletter
Next issue of the Newsletter of the Asian Network of Cardiologists in Radiation Protection is now available

All News

Upcoming Events

Meeting planned to prepare contents for patient information part of this website, Vienna, 4-8 May 2009
Meeting to discuss framework for patient information, draw guidelines and prepare contents

Meeting for Smart Card for long term record of patient doses, Vienna, 27-29 April 2009
The first meeting on this project will be held in IAEA Vienna

All Events

10 million hits/y

≈ 200,000 visits/y, 190 countries

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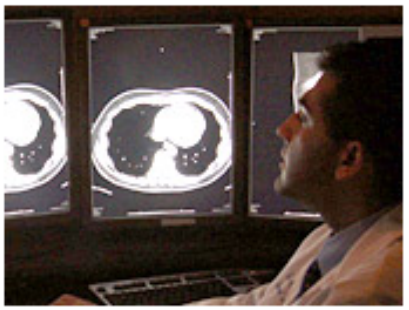
Computed Tomography



- Cardiac CT →
- CT Colonography →
- CT Optimization →

Advances in computed tomography (CT) technology have continued to open new clinical applications, including several procedures for evaluating heart disease. The speed with which CT technology is changing is somewhat unparalleled in medical imaging. The equipment is becoming faster and faster. In the 1990s, a patient had to remain in a CT gantry for a period of approximately 10 minutes for a chest CT, whereas now it takes a few seconds to scan the entire chest. This may give the impression that radiation dose in CT is small,

Radiation protection CT

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CT Radiation Reduction | siemens.com
www.siemens.com/low-dose
Siemens Computed Tomography - Where patient safety means dose reduction

Radiation Protection | Rothband.com
www.rothband.com/**Radiation-Protection**
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L18: Optimization of Protection in Computed Tomography (**CT**). IAEA Training Material on **Radiation Protection** in Diagnostic and Interventional Radiology. IAEA **...**

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IAEA Radiation dose CT

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▸ Scholarly articles for **IAEA Radiation dose CT**

Dose Reduction in CT while Maintaining Diagnostic ... - Tsapaki - Cited by 47
... PET and PET/CT for **radiation** therapy planning: **IAEA** ... - MacManus - Cited by 84
Radiation dose for pedicle screw insertion: ... - Slomczykowski - Cited by 77

PET/**CT** Scanning
rpop.**iaea**.org/RPOP/RPoP/Content/.../6.../PETCTscan.htm - Cached
IAEA Radiation Protection of Patients **...** The **radiation exposure** from **CT** has a very wide range depending on the type of the test, the area of the body scanned **...**

[PPT] **IAEA** Training Material on **Radiation** Protection in Cardiology
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IAEA. Cardiac **CT** - **radiation doses**, dose management and practical issues. L **...**

CT Colonography
rpop.**iaea**.org/rpop/rpop/content/.../1.../ctcolonography.htm - Cached
Nucleus · **IAEA** Radiation Protection of Patients **...** What is the **radiation ...**

IAEA Aims to Reduce Unnecessary Child **Radiation Doses**
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New Era in CT scanning

More than 400 cases of radiation overexposure from CT scan in 8 hospitals, many suffering hair loss and skin injuries including as well a child of less than 2 years getting 150 times more radiation dose- these are newest situations never encountered before even though CT has been around since 1972 and the technology has been considered safe. Manufacturers, radiologists and radiographers never imagined that software problems that keep on getting reported from time to time with high tech radiotherapy machines resulting in serious incidents could ever occur with very well behaved CT machines.

Six years ago it was not easy to spot a case of either accidental exposure to patient in CT scan or a patient having skin injury from CT scans With almost 115 years gone by, after the discovery of X rays by Roentgen, the current interest in radiation protection seems to be what it would have been about a century ago. This follows a period of almost half century (from 1930's to 1980's) when X rays started to be considered safe enough, making some health professionals rather complacent.

Continued occurrence of overradiation in brain CT

A report in the New York Times again brings attention to the problem that was publicized earlier

Continued occurrence of overradiation in brain CT

A report of patients overradiated when undergoing brain perfusion CT was extensively covered by the International Atomic Energy Agency (IAEA) on this website about a year ago.

The incidents resulted in actions by the FDA and the signing of a bill into law in California.

Despite these actions, new reports of overradiation in brain perfusion CT have appeared.

IAEA.org International Atomic Energy Agency

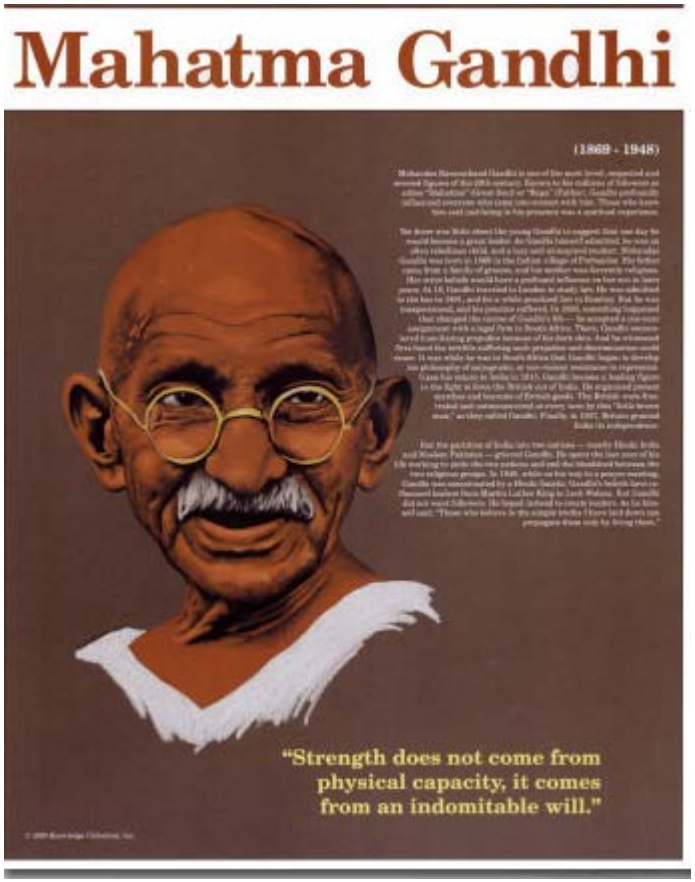
Our Challenges

- Common goal but different settings

30 countries in our study are non-English Medical physicist!!

Some participants in projects

"Whatever you do will be insignificant, but it is very important that you do it"



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Thank You

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