Improving Optimization in Occupational Radiation Protection in Medicine

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Atoms for Peace

1. Introduction
2. Occupational dose in medicine
3. Optimization of occupational dose in:
   - Diagnostic & interventional radiology
   - Interventional cardiology
   - Diagnostic & therapeutic nuclear medicine
   - Radiotherapy
   - Dental radiology

Introduction

- UNSCEAR reports:
  - ¤ **3.6 billion** diagnostic radiology per year
  - ¤ **33 million** nuclear medicine per year
  - ¤ **5.1 million** radiotherapy per year

- The largest contribution to medical occupational dose is from interventional procedures due to:

✓ increasing number of procedures per year

✓ complexity of procedures

Europe
1992 -2001

416%

264%

coronary angiography

Percutaneous transluminal angioplasty

- **Occupational exposure**
  - **All exposures of radiation workers incurred in the course of their work** (with the exception of exposures excluded from the basic safety standard (BSS) and exposures from practices or sources exempted by the BSS).

Optimization of protection and safety:

- IAEA Basic safety standard (BSS)
- IAEA Safety Guidance on Occupational Radiation Protection (RS-G-1.1 & RS-G-1.3)

“For occupational exposures, dose constraint is a source-related value of individual dose used to limit the range of options considered in the process of optimization”. (BSS)

ERPAN SURVEY →

Majority of European countries have adopted the concept of dose constraints as an optimization tool for occupational exposure in the non-nuclear energy sector in their national legislation.

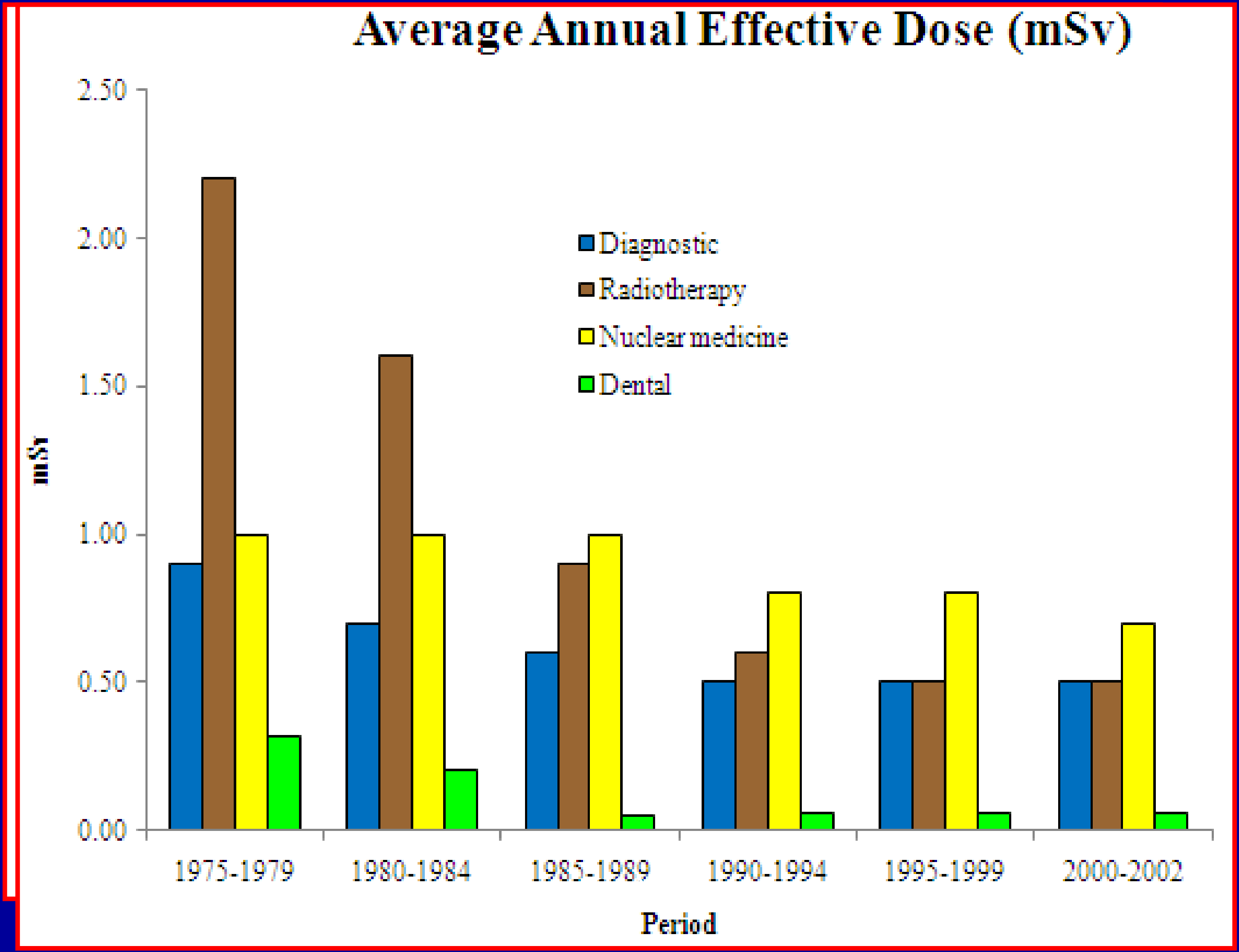
Occupational Exposure in Medicine

TABLE I. AVERAGE ANNUAL EFFECTIVE DOSE FOR STAFF IN DIAGNOSTIC RADIOLOGY, INTERVENTIONAL RADIOLOGY, INTERVENTIONAL CARDIOLOGY, NUCLEAR MEDICINE, RADIOTHERAPY AND DENTAL RADIOLOGY.

Specialty	Category of staff	Average annual effective dose (range) (mSv)		
Diagnostic radiology	Radiologists	0.08 - 0.23[a]	0.15[b]	
	Radiographers	0.06[b]		
	Nurses	0.07[b]		
Interventional radiology	Radiologists	0.35[b]	0.4[c]	2-4[d]
	Radiographers	0.25[c]		
	Nurses	0.31[c]		
Interventional cardiology	Cardiologists	0.20[b]	5[e]	0.536 (0.069 – 1.984)[f]
	Radiographers	0.154 (0.060 – 0.277)[f]		
	Nurses	0.154 (0.060 – 0.277)[f]		
Nuclear medicine	Physicians	0.4 (0.1-1.0)[g]		
	Radiographers	0.71[b]	1.4 – 3.2[h]	1.8 (0.1-18.6)[g]
	Nurses	4.2 (0.4-13.4)[g]	0.70[b]	
Radiotherapy	Radiographers	0.5 - 2.5[i]		
	Nurses	1.0[i]		
Dental radiology	Radiographers	0.2[j]		

[a][8], [b][9], [c][10], [d][11-13],e[14-15], [f][16],[g][17], [h][18], [i][19], [j][20]

The worldwide level of occupational exposures published by UNSCEAR 2008



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Optimization of Radiation Protection of Medical Staff (ORAMED 2008)

- Collaborative project in the 7th EU Framework Programme focused on improving knowledge on extremity and eye lens exposures in medicine, combined with an optimization of the use of active personal dosimeters.

- **THREE** guidelines were published:
  - ¤ Extremity dosimetry in Interventional Radiology.
  - ¤ Use of APDs in Interventional Radiology.
  - ¤ Extremity dosimetry in Nuclear Medicine.

ICRP 2011 Statement on Tissue Reactions (April 2011)

Lens of the eye

- Threshold now considered to be 0.5 Gy.

- For occupational exposure:
  - Reduction in the annual occupational eye dose limit from 150 mSv per year (ICRP 103) to 20 mSv per year.

  - Averaged over 5 year periods, with no single year exceeding 50 mSv.

  - For public exposure
    – unchanged from ICRP 103

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Optimization in Diagnostic and Interventional Radiology

- Cardiologists, vascular surgeons and radiologists – Higher dose.
- Interventional radiologist who takes all appropriate radiation safety precautions is likely to receive 2 - 4 mSv/year

The main source of scattered radiation is from the **patient's body.**

Major findings in **ORAMED project** which should be considered for optimization process are:

- ¤ Ceiling suspended shield can reduce the eye dose (2-7times)
- ¤ When ceiling suspended shield is not available, protective glasses with side shield can be used (90% dose reduction).
- ¤ The proper use of table shield can reduce the doses to the legs (2-5 times).
- ¤ If biplane configuration is used, the proper use of lateral shield is very important.
- ¤ The doses are lower in the femoral access compared to radial access (2-7 times).
- ¤ Care should be taken for the table shield when assisting personnel stands close to the primary beam or when the operators need to move around the table for medical reasons

Optimization in Interventional Cardiology

- Recent studies reported that the most active and experienced of interventional cardiologists (ICs) in high volume catheterization laboratories have an annual exposure equivalent to around 5 mSv per year.

- After several years of practice, without eye protection, ICs may exceed the new ICRP lifetime eye dose threshold of 500 mSv and be at high risk of developing early radiation-induced cataracts.

European Commission DIMOND III

- Preliminary occupational dose constraint value by calculating cardiologists' annual effective dose and found to be 0.6 mSv.
- Difficult to predict operator's dose from patient's kerma area product mainly due to the different use of protective measures.

Lower patient dose

Lower scattered radiation

Lower operator dose

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Optimization in Diagnostic and Therapeutic Nuclear Medicine

Highest radiation doses

- Handling unsealed radionuclides
- Preparing radiopharmaceuticals

- The application of beta emitters like Y-90 in workplaces requires the use of appropriate beta shielding of the working place and of rubber fingertip dosimeters on each finger to prevent overexposures

Major findings in **ORAMED project** which should be considered for optimization process are:

- ¤ Doses are statistically higher in non-dominant hand than in dominant hand.
- ¤ The highest dose is often found to be received by the index tip of non-dominant hand.
- ¤ Dose distribution over the hand is inhomogeneous.
- ¤ The ratios between the maximum skin dose and the dose at the possible monitoring positions in non-dominant hand are smaller than those in dominant hand, except for the wrist.
- ¤ The smallest ratio between the dose at the maximum and the dose at a given position is found in the tip of the index finger of non-dominant hand. However, this is not a practical monitoring position.

Cont.

- ¤ The annual dose estimation is above 150 mSv (3/10 of the annual limit) for 51% of the workers.
- ¤ 20% of the workers exceed the annual dose limit of 500 mSv.
- ¤ A dose reduction between 1 and 3 orders of magnitude is achieved when using the appropriate shielding.
- ¤ Training and education in good practices are more relevant parameters than worker's experience level.

Optimization in Radiotherapy

- Occupational overexposures are rare.
- Non optimized treatments due to over- or underexposures often arise from systematic or technical errors and harmful to a group of patients.
- Analysed incidents and accidents could have been avoided by simulation and training of critical events.
- Several studies had reported the average annual effective dose for radiotherapy workers were 0.9 -1.6 mSv.

- In the 1980's when radiotherapy sealed sources were implanted manually inside body cavities.
- Radiation oncologists and the nurses assisting them where amongst those receiving the highest radiation doses.
- The introduction of remote afterloading has greatly reduced the radiation exposure of these employees.

Still,

Brachytherapy requires special attention due to :

- The storage of sealed sources emitting radiation constantly.
- Permanent implants.
- The need of source manipulation in permanent implant applications.
- Applications involving manual source loading.

Optimization in Dental Radiology

Based on UNSCEAR publication, the average annual effective dose for dentistry radiology is significantly lower, which was 0.06 mSv over the period 1990 to 2002.

ARPANSA Code of Practice (2005)

- Radiation protection for occupational exposure requires justification, optimisation and limitation to be applied to the practice which causes the exposure.
- It is recommended that dose constraints be used for appropriate work categories in the design of the working environment.

While dose limits mark the lower bound of unacceptability, dose constraints promote a level of dose control which should be achievable in a well-managed practice.

Summary

- Highest occupational exposure has been recorded in interventional radiologists, interventional cardiologists and nuclear medicine staff members.
- It is expected that occupational exposure will increase as there is increase in frequency and complexity of interventional procedures.
- Dose constraints should be established and use as part of optimization of protection.
- Optimizing of patient dose will contribute to optimizing of occupational exposure.

- Improving optimization will be achieved by placing greater emphasis on education and training amongst the staff.
- More efficient regulatory framework and better equipment design.
- The staff of regulatory authorities should have the training necessary to ensure that optimization of protection and safety is appropriately applied and enforced.
- Participate in the IAEA clinical quality audit (QUADRILL, QUATRO and QUANUM).

Bonn Call-for-Action 2012

- **Action 6** - Increase availability of improved global information on medical exposures and occupational exposures in medicine by :

¤ Improve collection of dose data and trends on medical exposures globally, and especially in low- and middle-income countries, by fostering international co-operation;

¤ Improve data collection on occupational exposures in medicine globally, also focusing on corresponding radiation protection measures taken in practice;

¤ Make the data available as a tool for quality management and for trend analysis, decision making and resource allocation.