Personal Dosimetry as an ALARA Tool in Medical Practices

Peter Covens
Personal Dosimetry as an ALARA Tool in Medical Practices?

Peter Covens
Contents

Approach on personal dosimetry
Exposure pathways in the medical field
Routine monitoring
Detailed dosimetry studies
Use of dose constraints in optimisation process
Future prospects
Personal Dosimetry

Objectives

Demonstrate compliance with regulatory limits / constraints
Identify new exposure pathways / risks
Indicate good/bad radiation protection practice
Implement ALARA policies
Optimisation (ICRP 2007)

1. Evaluate exposure situation
2. Identify possible protection options
3. Select best option
4. Implement selected option
5. Select appropriate constraint
Evaluation of Dosimetric Data

Average: 0.19mSv/y all exposed workers

Meaningless!

Average: 1.05mSv/y measurably exposed workers

Meaningless!
Occupational exposures in the medical field differ substantially!
- distribution of yearly doses is important
- how many people receive dose lower than X and higher than Y?

Order of magnitude of doses defined by
- nature procedure?
- workload?
- level of radiation protection?
- methodology of the assessment?
Departments Overlap

- RADIOLOGY
- NUCLEAR MEDICINE
- RADIOTHERAPY
- IN-VITRO APPLICATIONS/RESEARCH
Distribution of doses

![Box plot showing the distribution of doses for different procedures.]

- **TOTAL**
- **A**
- **B**
- **C**
- **D**
- **E**
- **F**
- **G**
- **H**

**DOSE (mSv/y)**

**Procedures**
Evaluation Based on Routine Dosimetry

Nature of procedure
- Indicator of exposure condition
- Sometimes overlap

Analysis within procedure
- Personal habits
- Use of radiation protection devices

Multi-Centre follow up
- Can eliminate/identify local practices
- Can identify new parameters
Multi-Centre follow up

Do you use a lead apron during nuclear medicine procedures?

<table>
<thead>
<tr>
<th>Often</th>
<th>Rarely</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

Individual Hp(10)/procedure (μSv)
Limitations on Routine Dosimetry

Passive dosimetry
- Delay of results towards RPO (min 1 month)
- Delay of results towards exposed individuals (sometimes 1 year!)

Detection limit ~ 50-100µSv/month

Accuracy in relation to E?
- Use of operational quantities Hp(10), Hp(0.07)
  In some fields far from reality
- No indicator for the magnitude of internal exposures
Where Routine Passive Dosimetry is Limited...

Active Personal Dosimetry

Detailed Dosimetry Studies
Active Personal Dosemeters (APD’s) as ALARA Tool?

Superior characteristics compared with passive dosemeters

- Direct dose reading could allow both RPO and worker to optimise radiation protection
- Lower detection limit
- Lower background influence (dosemeter does not record when not in use)
- Faster identification of new exposure pathways / risks
Active Personal Dosemeters for Routine Dosimetry?

Many APD’s not suitable for large scale routine dosimetry in hospitals

- Investment costs
- Energy response (< 50keV), accuracy in pulsed radiation fields?
- Weight, mechanical resistance, battery life
- Too much programmable functions / complicated software
- Alarm function suitable during routine procedures?
Active Personal Dosemeters for Routine Dosimetry?

Reliability of APD’s is improving
More countries plan to accept them for legal routine dosimetry
More and more lightweight APD’s
Compromise active-passive (DIS)?

...to Be Continued
Bolognese-Milsztajn et al
“Active Personal Dosemeters for Individual Monitoring and Other New Developments”, Radiation Protection Dosimetry 2004, 112-1

Luszik and Perle
“Electronic Personal Dosemeters Will Replace Passive Dosemeters in the Near Future”, Radiation Protection Dosimetry 2007, 123-4

Clairand et al
“Intercomparison of Active Personal Dosemeters in Interventional Radiology”, Radiation Protection Dosimetry Advanced Access Published May 2008
Detailed Dosimetry Studies

Calculations

Measurements

High exposure procedures

Whole Body

Parts of the Body
Why Detailed Dosimetry Studies?

Where routine dosimetry...
  – Fails
  – Inappropriate
  – Inconvenient

Normalise on workload and extrapolate to individual exposures

Link to daily practices
  – Relate to routine dosimetry (adjustment)
  – Indicate / reject / confirm value protection options
Detailed Dosimetry Studies
Extremity Doses NM

Poor dose reduction when increasing thickness syringe shield!
Detailed Dosimetry Studies
Extremity Doses NM

The contribution of syringe dispensing to the total extremity dose!

Highest dose = 2x to 3x higher than routine monitored dose

Berus et al, 2007
Detailed Dosimetry Studies
Double Dosimetry

Importance thyroid shield!
Importance over-apron dose component!

Worker → 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4

Niklasson et al 1994
Swiss Ordinance 1999
Franken et al 2002
Clerinx et al 2007

Calculated E (mSv)

Ho Component no Thyroid Shield
Ho Component Thyroid Shield
Hu Component no Thyroid Shield
Hu Component Thyroid Shield

Peter Covens, VUB
Detailed Dosimetry Studies
Extremity Doses IR/IC

Confirmed value under-table lead curtain IR/IC

Buls et al, 2007
Detailed Dosimetry Studies
Eye Doses IR/IC

The value of over-apron dosemeter as eye dose indicator in IR/IC

\[ y = 0.73x \]

\[ R^2 = 0.98 \]

Buls et al, 2007
Relate Dosimetry Studies to Routine Dosimetry

Double dosimetry
- Double dosimetry = high exposures = thyroid shield! → reject “algorithms without TS
- Use of a precise algorithm is impossible
- Two dosemeters: better estimation of E
- Value over-apron dose: eye-dose indicator
- Use of under-apron dosemeter should be maintained (exposures without lead apron)

If \( E = a \cdot X_{\text{under apron}} + b \cdot Y_{\text{over apron}} \)
then \( a = “1” \) and \( X = “Hp(10)” \)
Relate Dosimetry Studies to Routine Dosimetry

Parts of the body

- Routine monitoring at the highest dose location is not always possible
  → impractical
  → contamination risk (NM)
  → sterility (IR/IC)
- Be aware of higher doses at certain locations
- Technical problems eye-dose monitoring
- Accuracy problems (contribution of $\beta+$ dose during PET procedures)
Optimisation

1. Evaluate exposure situation
2. Select appropriate constraint
3. Identify possible protection options
4. Select best option
5. Implement selected option
Use of Constraints (ICRP)

Constraint
- Relates to individual dose
- Prospective source-related restriction
- Level of dose above which it is unlikely that protection is optimised
- Is NOT a form of dose limit

Constraint level
- Some procedures: constraints at low level
- Other procedures are only able to meet constraints at higher level
Use of Constraints (ICRP)

Exceeding Constraints
- Has protection been optimised?
- Was appropriate constraint chosen?

Intention of optimisation
- Not to exceed and remain at constraints
- With the ambition to reduce doses to ALARA levels!
- Focus also on the number of exposed individuals → collective dose remains important
Use of Constraints in Practice
Constraints and Routine Dosimetry

On which dose should we focus in some cases?

- Double dosimetry: uncertainty on E-algorithm, large contribution $H_0$
  → Set constraint on over-apron dose! → Constraint on eye dose!

- Extremity dose monitoring in NM: uncertainty on highest dose location, inconvenient location
  → Set constraint on ringdosemeter / wristdosemeter dose
Iterative process of optimisation should have a frequency < one year

- Base your constraint not only on one year, but on the frequency of routine dose results
- Install a monthly constraint and use it as “need for investigation level” when this level is repeatedly exceeded
Find, Select and Implement Protection Options

Radiation Protection Devices
- Large investment for some procedures
- Not always used even when available

Education / Training
- Mandatory basic education mostly fulfilled
- Effort needed in continuing (but sustainable) education of and communication with major stakeholders (exposed workers)
- Increase awareness, safety culture
Communication on Routine Dosimetry Results

Fast feedback personal dose results
- Mostly done after accidental exposure
- Also needed after planned, routine exposures!
- Make passive dosimetry “As Active As Reasonably Achievable”

Pilot project of emailing monthly personal dose results to each worker
- Positive response
- Plans to extend dose report with training elements
Personal Dosimetry in Hospitals
A Closed Book?

More and more procedure overlap
Be prepared for increasing use of some technologies
- Modern rooms in IR/IC: more biplane systems
- Interventional CT (CT-fluoroscopy)
- Introduction of new PET-radiopharmaceuticals

What is (or could be) the contribution of contaminations in NM?
Summary

Personal dosimetry: ALARA tool? **YES!**

But...
- Routine monitoring no always WYSIWYG
- Some technical / accuracy problems
- APD’s and detailed dosimetry studies can help in optimisation process

And...
- Communicate with workers!
- Increasing safety culture (continuing education / training)