Radiation Protection for Equine Scintigraphy 2008
Quality Control, Radiation Safety & Legal Requirements

Alan Perkins
Medical Physics
University of Nottingham
Summary

• Introduction
• Background and Regulations
• Basic principles of Radiation Management
• Basic safety standards in clinical laboratories
• Quality Control
• Audit
Peter Parker

Spider Man
He became the spider man after being bitten by a radioactive spider.
David Banner

The Incredible Hulk
Became the incredible hulk after being exposed to gamma radiation
Radioactivity and Ionising Radiation
X-rays are safe!
Medical X-rays
Medical radiation protection

• Potential biological effects
• Safe use of radiation for patients, staff and the public
Hiroshima Japan
Flash burns at Hiroshima, 2 kilometers from the hypocenter. This man was burned when the bomb exploded. He had a skin graft, taken from his hip, on his right arm in 1945. (Shunkichi Kikuchi, Hiroshima–Nagasaki Publishing Committee.)
Origins of accepted safety standards

ICRP
(Published Documents of the ICRP)

European Law

Euratom Directives

Basic Safety Standards Directive

UK Law

Legislation made under the Health & Safety at Work Act 1974
Legislation

Health and Safety at work Act 1974

Radioactive Substances Act 1993
IRR 1999 Ionising Radiations Regulations 1999
ACoP


The Medicines (Administration of Radioactive Substances) Regulations (MARS)1978.

IRMER 2000
Ionising Radiation (Medical Exposure) Regulations
References
5. Medical and dental guidance notes. IPEM York 2002
Basic Principles of Radiation Protection

- Benefits must be greater than any harm.
- Radiation exposure - As Low As Reasonably Achievable (ALARA/ALARP).
- Justification of procedure.
- Optimisation of dose.
- Prior risk assessment
Factors Affecting Radiation Dose

• Time

• Distance

• Shielding
Time

Working with horses

• Minimise time near radioactive sources.

• Do not sit, read, chat or take telephone calls near sources.

• Once injected animals are radioactive:

  perform marking etc. prior to administration.

• Quickly remove waste and contaminated items to a safe place.
Distance

Inverse Square Law:

Double distance reduces the dose by a factor of 4.

Stand away from sources!

Use carrying boxes, forceps and handling tools.
Radiation exposure from patients

Measurements following administration of 500MBq Tc-99m

<table>
<thead>
<tr>
<th>Distance</th>
<th>Dose Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 cm</td>
<td>6.5μGy/h</td>
</tr>
<tr>
<td>1 metre</td>
<td>2μGy/h</td>
</tr>
</tbody>
</table>

*X 3 for equine situation!*
Shielding

- Use shielding whenever possible:
  Syringe shields, lead blocks, lead glass
  (perspex may be adequate for β emitters).

- Keep stock solutions in lead pots.
Shielding of radioactive sources

- Alpha
- Beta
- Gamma
- Neutron

Materials:
- Paper
- Water
- Concrete
Use of shielding for foot and fellock
Use of syringe shield during iv injection

<table>
<thead>
<tr>
<th></th>
<th>Right hand</th>
<th>Left hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use with shield</td>
<td>3.2mSv</td>
<td>0.4mSv</td>
</tr>
<tr>
<td>No shield</td>
<td>0.9mSv</td>
<td>0.7mSv</td>
</tr>
</tbody>
</table>
Controlled areas

Any area where the dose rate exceeds 7.5 μSv/h

(8h x 5d x 50wks = 2000hrs - previous 3/10 limit)

• Dispensing room and camera room

• Know the layout of the department.

• Do not enter without a reason.

• Be aware of local rules and systems of work.
Radiopharmaceutical Laboratory

Sterile pharmaceutical production area

Radiation laboratory area

Regulatory certificates and licences
  e.g. UK Environment Agency
  Health and Safety
  Dept of Health.
## Main Radionuclides Used in Nuclear Medicine

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Half-life</th>
<th>( \gamma ) energy (keV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc -99m</td>
<td>6h</td>
<td>141</td>
</tr>
<tr>
<td>In -111</td>
<td>2.8d</td>
<td>171 &amp; 245</td>
</tr>
<tr>
<td>I -123</td>
<td>13h</td>
<td>159</td>
</tr>
<tr>
<td>I -131</td>
<td>8.0d</td>
<td>365</td>
</tr>
<tr>
<td>Tl -201</td>
<td>3.0d</td>
<td>80</td>
</tr>
<tr>
<td>Gases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kr-81m</td>
<td>13s</td>
<td>190</td>
</tr>
<tr>
<td>Xe -133</td>
<td>5.3d</td>
<td>81</td>
</tr>
</tbody>
</table>
Radiopharmaceuticals

- Dispensed in the radiopharmacy as sterile products.
- Use licensed products when possible.
- Written procedures for all preparations.
- Batch manufacturing records,
  lot No, staff names etc.
- QC and sterility tests
  Essential for therapeutics
  (some tests may be retrospective)
- Adverse reactions reported.
Specific issues with equine scintigraphy

- Amount of activity administered
- Staff doses from holding and positioning
- Contamination
Administration to Horses

Checklist

1. Full patient history including home circumstances
2. Owners consent?
3. Animal identification
4. Check radiopharmaceutical,
   Radionuclide & chemical form.
5. Amount of radioactivity prescribed for the procedure.
   Administration set
   Gloves and syringe shield.
6. Route and speed of injection.
7. Flushing of the line.
Urine Contamination!

– protective boots
**Breast feeding animals**

*(Physical and chemical characteristics of emitted radiation)*

**HUMAN MISADMINISTRATION**

Case Study:
A nursing mother was given 180 MBq of I-131 that resulted in absorbed doses to her infant estimated as 300 Gy to the thyroid and 0.17 Gy to the whole body.
The error was detected when the patient returned to the hospital for a whole body scan. The scan indicated an unusual high breast uptake of I-131.

The infant will require artificial thyroid hormone medication for life to ensure normal growth and development.
Pregnant animals

• Most sensitive period 8 - 15 wks.

• Avoid administration of radiopharmaceuticals if possible.

• Absorbed doses may be estimated for inadvertent administration.
Information for owners and handlers
Security Awareness

Airport Security increased as a result of dirty bomb threat

4 August 2006, Therapy 'sets off airport alarms'

Advice follows the case of a patient who set off a US airport security alarm at check-in six weeks after receiving radioiodine therapy. He was interrogated, strip-searched and finally released, after a long delay and much embarrassment.
1986, two patients were detained and later released after trying to enter the White House for a public tour 4 days after stress testing with thallium-201.

Reports of air and ground crew detained after setting off airport radiation detector alarms.

Patients having radiation treatments may trigger security Alarms up to 12 weeks after treatment. (In the UK 10,000 patients are treated with radioiodine a year.)

*Any instances of animals during international travel?*
Disposal of Radioactive Waste

Types of waste

**Solids:** Used syringes and needles
- Soiled dressings
- Soiled bedding/linen
- Faces

**Liquids:** Unused preparations
- Blood
- Urine* 

**Gases:** Exhaled gas from lung studies

*Discharge to drains EA figure 100% of iv activity.

Records must be kept and be available for inspection.

Legal requirement!
Audit and Standards

Valuable aid in maintaining good standards


If performed well the audit procedure should be non-threatening and should be regarded as a mutually beneficial exercise to both the department and the auditors.
Radiation Protection Standards

- Registration and Authorisation Certificates
- Local rules dated and reviewed
- Warning signs for Controlled/Supervised areas
- Staff monitoring
- Appropriate use of shielding
- Calibration of contamination monitors
- Storage of radioactive materials
- Disposal of radioactive waste
- Safe to clean/permit to work
- Radiation audit
Camera Room Inspection

1. Instrumentation (routine calibration)
2. Electrical Safety
3. Mechanical Safety
4. COSHH
5. Trip hazards
6. Radiation sources
7. Safety equipment
8. Lifting hazards

*Risk assessments !!
Stables and camera equipment rooms

There should be evidence of a well organised environment for both patients and staff.

Particular problems occur with laboratories having multiple users where there is no named individual with responsibility.
Use of appropriate warning signs
Staffing

1. Grade and qualifications of staff
2. Adequate number of staff in post
3. Written job descriptions
4. Evidence of individual performance review (IPR/IPM)
5. Evidence of continuing education (CPD)
6. Competency training records (patient protection regulations)
Monitoring

Saff Laboratories

- Staff monitoring and records
- Appropriate monitor for the type of radiation use
- Battery check
- Count rate or dose rate
- Date of calibration
Camera QC

- Detector Uniformity
  Flood or point source
- Sensitivity
  Counts/s/MBq
- Energy Resolution
  FWHM
- Spatial Resolution
  FWHM
Camera Performance

- Detector Uniformity
  - Using a flood or point source of radioactivity
- Sensitivity
  - Using a known amount of activity
  - Measured in Counts/s/MBq
- Energy Resolution
  - FWHM of photopeak
- Spatial Resolution
  - Using phantom of lines or dots
With thanks to Bartec Technologies Ltd, Camberley, UK.

alan.perkins@nottingham.ac.uk