The management of new radionuclides in clinical trials: radiopharmacy perspective
Was not the session about the medical physicist role?
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...maybe we can talk about Radiation Protection of new radionuclides from the perspective of who need to apply all the protocols.

Since I am a Radiopharmacist...
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01 Radionuclides for Therapeutic Applications

Well established and new ones.
Radionuclides for Therapeutic Applications: well established.

The use of radionuclides in the radiopharmacy field has existed for many years, but the last decades some of them are gaining attention due to the potential for prolonging patient survival across differing cancer types, often with minimal toxicity for healthy tissue. Almost all of them are β-emitters.
The new radionuclides are alpha emitter

α-emitter vs. β-emitter
- Superior cytotoxicity
- +++ Energy deposition per distance unit
- Limited range in tissue (0.1 mm)

The new radionuclides are alpha emitter

177Lu
β-particles
7.4 GBq
0.498 MeV/Bq.s

225Ac
4 α-particles + 2 β-particles
8 MBq
27.7 MeV/Bq.s

224Ra
4 α-particles + 2 β-particles
7 MBq
29.26 MeV/Bq.s

Treatment of micrometastatic disease

To deliver therapeutic absorbed doses at low administered activity levels
Actinium is attached by a chelating moiety integral to the molecule (vector).

This chemistry is similar as the Lutethium or the Yttrium, but not exactly the same. The use of different radiometal generally implies the need to use different chelators.

The use of different chelators may imply changes in the pharmacokinetic of the complex in vivo.

The isotopes produced during the decay have to be also chemically compatible to the chelator of the actinium to remain attached to the molecule.

4 Clinical Trials in Europe
The radioisotope produces during the decay are CHEMICALLY different from the actinium-225. The BIOLOGICAL behavior is different. The capacity of stay chelated of this isotopes is questions. Possible adverse effects for irradiating healthy tissues.
Radium-223 has been the most commonly used for clinical purposes in the last few years.

Radium isotopes has been mainly used to bone-seeking applications.

Usually used in inorganic solution because of the lack of an appropriate chelating agent for coupling of radium to targeting molecules.

One proposed strategy is to use nanoparticles or micro particles as carriers. CaCO$_3$ is an inorganic material that is promising for different biomedical applications. Administration in ICU (after cytoreductive surgery).

$[^{224}\text{Ra}]\text{RaCaCO}_3$

(Radspherin©)
Radionuclides for Therapy Applications: Radium-224

- CaCO₃ insoluble $\rightarrow$ $^{224}$Ra and progenies are trapped
- CaCO₃ dissolves in the peritoneum $\rightarrow$ $^{224}$Ra is released
- $T_{1/2}(^{220}\text{Rn}) \sim s$ $\rightarrow$ Absorbed into the tissue

- Radioactivity in blood and urine $\approx \emptyset$
- Fluid leaks from catheters or drains $\rightarrow$ Radioactive waste
- Low probability of $^{220}$Rn release from peritoneum
02 Radiation Protection

Working with radium-224: our own experience
02 Radiation Protection: working with radium-224

The CaCO₃ increase the solubility in H₂O, liberating the Radium-224 to the solution. During manipulation a contamination or even a vial break could occur, increasing the probability of Radon-220 liberation to the atmosphere.

<table>
<thead>
<tr>
<th>Dose coefficient mSv/MBq</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingestion</td>
<td>65</td>
</tr>
<tr>
<td>Inhalation</td>
<td>2900</td>
</tr>
</tbody>
</table>

Radiopharmacy and ICU staff (inhalation): % 224Ra released ??????????

In order to prevent internal contamination: **MANDATORY**

- Disposable clothing
- Coal filter-gas mask
- Laminar flow with minimal recirculation
Vial $^{224}$Ra-CaCO$_3$  

Empty vial

Syringe to dispense the radiopharmaceutical

Activated carbon cartridge

02 Radiation Protection: working with radium-224
### Personal dose estimation

- **Radiopharmacy staff** (activity preparation):
  - Distance: 20 cm
  - Time: 1 h
  - N treatments: 1/week
  
  \[
  5 \text{ uSv/treatment} \rightarrow 0.25 \text{ mSv/year}
  \]

- **Caregivers (ICU staff):**
  - Distance: 10 cm
  - Time: 24 h (since the treatment administration)
  - N treatments: 1/week
  
  \[
  13 \text{ uSv/treatment} \rightarrow 0.65 \text{ mSv/year}
  \]

**NO radiation dose limit is exceeded**

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Dose Rate in air (uSv/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>20</td>
</tr>
<tr>
<td>1.0</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Patient Dose Rate (@ 10 cm):

13.4 (10.9 – 16.8) uSv/h
Thank You!

Do you have any questions?

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