ESTIMATION OF OCCUPATIONAL RADIATION DOSE IN PET/CT FACILITY USING AUTOMATIC INFUSION SYSTEMS

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PROBLEMS IN NUCLEAR MEDICINE USING POSITRON EMISSION TOMOGRAPHY FACILITIES

Radiation protection in PET/CT facilities is becoming a real challenge due to production of high-energy annihilation photons;

In our clinics monitoring of radiation exposure of the staff working in nuclear medicine is permanent and an ongoing process;

- TLD (Thermoluminescence dosimeters)
- EPD (Electronic personal dosimeters)

The higher energy of positron-emitting isotopes (511 keV) of Fludeoxyglucose $^{18}$F ($^{18}$F-FDG) means that medical staff could receive a higher whole-body dose than those working only with conventional nuclear medicine radionuclides.
The aims of the work

- To estimate occupational exposure by personal electronic dosimeter during PET/CT procedures, such as activity preparation, dispensing, injection, patient positioning, discharge;
- To compare occupational exposure of two system IRIDE and ALTHEA.
PET/CT facilities

- PET/CT SCAN (PET scan shows areas with increased metabolic activity (functional), the CT scan shows detailed locations (anatomical));

- DISPENSING AND INFUSION SYSTEMS
INTEGRATED RADIOPHARMACEUTICAL DISPENSING AND INFUSION SYSTEM (IRIDE)

The command display

Saline and radiopharmaceutical pumps

Patient administration kit

$^{18}$F-FDG vial with container

Source administration set
THE DISPENSING HOT CELL ALTHEA WITH WIRELESS INJECTION SYSTEM

Shielded hot cell

Wireless injection system

Wireless remote controller
SHIELDED CONTAINERS AND $^{18}$F-FDG MOVING CHAIN

$^{18}$F-FDG transportation 30 mm tungsten container

Prepared dose 20 mm tungsten and aluminium container with additional syringe shielding
Contact with radiation activity source $^{18}$F-FDG

- Container transportation, unpacking and loading to IRIDE or ALTHEA;
- Administration of $^{18}$F-FDG:
  - IRIDE (injection, patient kit replacing)
  - ALTHEA system (radiopharmaceutical handling to ALTHEA, dispensing, injection, patient kit replacing)
- Mother vial changes (depending on number of patients and received $^{18}$F-FDG activity);
- Performing PET/CT exam (accompanying the patient to the PET/CT scanner, positioning, connecting contrast and discharge).

- Daily quality control with calibration source ($^{22}$Na, ~ 3 MBq)
Materials and methods

- The data was collected from September 2014 till August 2015 in Vilnius University Hospital Santariskiu Clinics Nuclear medicine department with Philips Ingenuity TF PET/CT scanner;
- More than 400 measurements were performed;
- The average number of patients injected and scanned was 7;
- $^{18}$F-FDG examinations were performed one-two times per week and were administered with $330 \pm 28.8$ MBq $^{18}$F-FDG for one person;
- Total workday activity received from the $^{18}$F-FDG manufacturer was $8 \pm 3$ GBq;
- The dose estimation of external exposure was performed for 9 nuclear medicine workers.
Electronic personal dosimeter

(EPD) POLIMASTER PM1610B-01

EPD characteristics:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Detector</strong></td>
<td>Geiger-Mueller tube</td>
</tr>
</tbody>
</table>
| **Dose Rate display**        | Indication range: 0.01 μSv/h - 12.0 Sv/h (1 μrem/h - 1200 rem/h)  
Measurement range: 0.1 μSv/h - 10.0 Sv/h (10 μrem/h - 1000 rem/h) |
| **Dose Rate Accuracy**       | ±(10 + 0.0015/H + 0.0015°H) %, where H - DER value in mSv/h |
| **Dose measurement**         | Indication range: 0.001 μSv - 24.0 Sv (0.1 μrem - 2400 rem)  
Measurement range: - continuous photon radiation (current)  
0.05 μSv - 20.0 Sv (5 μrem - 2000 rem)  
- pulsed photon radiation (pulse duration not less than 1 ms)  
10 μSv - 20.0 Sv (1000 μrem - 2000 rem) |
| **Dose Accuracy**            | ± 20 % in the range 0.05 μSv - 20.0 Sv |
| **Energy range**             | 20 keV - 10 MeV                                  |

http://www.polimaster.com/products/electronic_dosimeters/pm1610b_b-01/
RADIATION EXPOSURE GRAPH
RADIATION EXPOSURE GRAPHS
Results

- Radiation exposure data was estimated for more than 400 patient procedures performed from 58 working days.

- The estimated median dose received per one patient:
  - For medical physicist was $0.29 \pm 0.15 \mu Sv$;
  - For the radiology technologist that worked with ALTHEA system was $1.39 \pm 0.12 \mu Sv$;
  - For the radiology technologist that used IRIDE system was $1.13 \pm 0.32 \mu Sv$;
  - For the radiology technologist who was positioning patients was $0.54 \pm 0.21 \mu Sv$. 
<table>
<thead>
<tr>
<th>Study</th>
<th>Infusion automatic system</th>
<th>Techni-cian or operator radiation dose (μSv/patient)</th>
<th>Radiation dose per one patient to the staff (μSv/patient)</th>
<th>The mean prescribed activity (MBq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This study</td>
<td>IRIDE (Comecer)</td>
<td>1.13 ± 0.32 (step 3 and 5)</td>
<td>1.96 (5 steps)</td>
<td>330 ± 28.8</td>
</tr>
<tr>
<td>This study</td>
<td>ALTHEA with WIS (Comecer)</td>
<td>1.39 ± 0.12 (step 3 and 5)</td>
<td>2.22 (5 steps)</td>
<td>330 ± 28.8</td>
</tr>
<tr>
<td>M. Lecchi et al. [1]</td>
<td>The Intego (Medrad)</td>
<td>1.26 ± 0.28</td>
<td>2.43 ± 0.24</td>
<td>254.6</td>
</tr>
<tr>
<td>A. Robert Schleipman and Victor H. Gerbaudo [10]</td>
<td>The Intego (Medrad)</td>
<td>1.29 ± 0.5 (step 3)</td>
<td>-</td>
<td>431.9 ± 22.7</td>
</tr>
<tr>
<td>P. Covens, D. Berus et al. [5]</td>
<td>The Posijet</td>
<td>3.6 ± 0.4 (step 3)</td>
<td>15.9 (5 steps)</td>
<td>-</td>
</tr>
<tr>
<td>B. Cuillet et al. [4]</td>
<td>Home-made drawing device.</td>
<td>2.5 ± 0.84</td>
<td>2.84 (5 steps)</td>
<td>318 ± 37</td>
</tr>
<tr>
<td>V. Antic, O. Ciraj-Bjelac et al. [1]</td>
<td>The Intego (Medrad)</td>
<td>-</td>
<td>4.2-7 (5 steps)</td>
<td>-</td>
</tr>
</tbody>
</table>
CONCLUSION AND DISCUSSION

- Our results revealed that the estimated dose received by the staff from one PET examination working with IRIDE was 1.96 μSv (5.93± 0.26 nSv/MBq) and working with ALTHEA system was 2.22 μSv (6.72 ± 0.26 nSv/MBq);
- The estimated dose values do not exceed and are far below dose limits for radiation workers determined by National radiation protection regulations.
RADIATION LIMITS

- In 2007 the ICRP recommended that medical workers receive a maximum radiation effective dose of 20 mSv per year, averaged over 5 years, with no more than 50 mSv in 1 year.

- 500 mSv is the annual equivalent dose radiation limit to the skin, hands, and feet.

- For the lens of the eye, the equivalent dose limit was initially 150 mSv, but in 2011 the ICRP reduced this to 20 mSv per year, averaged over 5 years, with no single year exceeding 50 mSv.

- Ministry of Health of The Republic of Lithuania and Lithuanian Radiation Protection Centre in 2015 reduced eyes equivalent dose limit to 15 mSv.

Using our study results as reference, we estimated the annual dose to one radiation technologist. Presuming that this technologist’s work load is 250 days and 10 patients per one day, the annual dose would be up to 5 mSv.
CONCLUSION AND DISCUSSION

- The critical groups that get exposure from radioactive source (¹⁸F-FDG administration, radioactive patients and esc.) in a PET facility are the technologists performing the injection and scanning, medicine physicist and physicians;

- Occupational exposure could be significantly reduced by implementing radiation safety culture and using a properly shielded system.
Thank you for your attention

Any questions?