Validation of the MEDRAD Intego PET Infusion System in the Clinical Nuclear Medicine Setting

Mark Weir  BSc, MRT(N), CTIC(N)
C. Vollrath  BSc, CRPA(R)
A. Bonnell  OT Reg. (On.)
Disclaimer

• Unbiased review
• St. Joseph’s Healthcare received no financial aid from Bayer MEDRAD, nor does there exist any vested interest in the outcome of this review
• Funding for this work was received via a MEDBUY research grant
St Joseph’s PET/CT

- Perform roughly 45-50 18-FDG oncology scans weekly
- Maintain a robust 82-Rb myocardial perfusion imaging program
- Employ 6 FT NM technologists rotating through General NM about 1 week per every 4 weeks in PET/CT
- 12 hr work days/8 hr shifts
- 6 day work weeks

Only PET/CT scanner for the entire Niagara corridor, city of Hamilton and surrounding area
St Joseph’s PET/CT

• 28400 new lung cancer diagnoses in Canada in 2016 (2\textsuperscript{nd} only to non-melanoma skin cancer)
• Many tumors are hypermetabolic, and FDG avid, making PET/CT an invaluable tool for disease staging and treatment planning
• Lung (primarily NSCL cancer)
• Lymphomas (Hodgkin’s and NHL)
• Esophageal
• Colorectal
• Melanoma/Testicular/F-18 Research
St Joseph’s PET/CT
F-18 decay scheme

- 110 minute T1/2
- 3 % EC
- 97 % B+ decay
- 193 % 511 keV gamma photons
- Decays to O-18 which is stable
Dilemma

• 511 keV positron annihilation photons are much higher energy than the 140 keV photons typically found in general NM procedures
• Higher average patient doses (~425MBq)
• Lack of unit doses due to 5MBq/kg dosing and short half life
• Therefore, NM techs receive significantly higher equivalent dose in PET/CT
Some History

• Manual draw ups were technically difficult
Some History

- 0.8 cm tungsten syringe shields provided no shielding at either end
- Attaching to patient line, injection, and flushing required up to 30 seconds of direct handling
- PET technologist exposures were 3-4 fold higher than NM techs
- Patient receiving 460 MBq FDG injection has contact dose rate of 650 µSv/hr
Project Overview

• Awareness of an opportunity for dose savings with the use of an automated injection system
• Literature on the anticipated dose savings from use of the MEDRAD Intego is available, but varies depending on the source
• However, ancillary benefits such as staff safety, patient safety and process improvement, have not been as readily investigated
Materials and Methods

• In 2013, a dose survey was performed on 4 full time PET technologists to help determine which parts of the process were responsible for delivering the most dose to staff.
• Data was acquired for 1 month using Aloka EPD direct read dosimeters.
Materials and Methods

• In 2013, all PET doses were drawn up and injected into patients using a manual process
• We repeated this staff dose survey in 2016 to determine what the Intego saves you, per procedure, at the same points in the process
• We compared our quarterly dosimetry data pre and post Intego use to quantify the dose savings
• Occupational Therapist review and staff evaluations of the old and new procedures were obtained
• Review of Radiation Safety Reports/Spill Records
• Patient Throughput/Department Design Considerations
St Joseph’s PET/CT

<table>
<thead>
<tr>
<th></th>
<th>RX Receipt</th>
<th>Draw Ups, Injections, After Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>4.13 µSv</td>
<td>3.19 µSv</td>
</tr>
<tr>
<td>2016</td>
<td>5.34 µSv</td>
<td>1.11 µSv</td>
</tr>
</tbody>
</table>

- Considerable dose savings from lack of draw up and being able to stand back when injecting
- Slight loss on receiving the radiopharmaceutical shipments
Dosimetry

- Landauer dosimetry service
- All our PET/NM techs wear ring badges due to working with F-18 in PET/CT and/or participation in our high dose I-131 therapy program
- We began using the MEDRAD Intego in the late fall of 2015. We therefore have lots of quarterly dosimetry data from both before and after commencement of use.
Dosimetry

• Our PET/CT program has grown from 2013. However, the increase in clinical exams has been commensurate with increase in staff and lengthening of hours, so the caseload per worker has stayed essentially the same through our growth.

• 2013 was full time PET. In 2014 we started rotating staff through a 1 week NM shift about every 4th or 5th week. Rotation has been essentially unchanged since 2014.
Dosimetry

- **RECALL!**
  - Concerns over coring of stopper by needles prompted a 5 week hiatus from clinical use
  - This was reflected in our 4th quarter dosimetry reports
  - Used spare badges during hiatus
<table>
<thead>
<tr>
<th>Year</th>
<th>Body 1</th>
<th>Ring 1</th>
<th>Body 2</th>
<th>Ring 2</th>
<th>Body 3</th>
<th>Ring 3</th>
<th>Body 4</th>
<th>Ring 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>3.58</td>
<td>28.9</td>
<td>5.81</td>
<td>63</td>
<td>2.57</td>
<td>31.9</td>
<td>4.79</td>
<td>72.5</td>
</tr>
<tr>
<td>2014</td>
<td>3.38</td>
<td>23.2</td>
<td>5.62</td>
<td>53.3</td>
<td>1.82</td>
<td>23.4</td>
<td>4.73</td>
<td>60.7</td>
</tr>
<tr>
<td>2015</td>
<td>3.64</td>
<td>25.2</td>
<td>6.02</td>
<td>48</td>
<td>2.01</td>
<td>19.9</td>
<td>6.32</td>
<td>66.1</td>
</tr>
<tr>
<td>2016</td>
<td>2.58</td>
<td>15.4</td>
<td>4.5</td>
<td>27.6</td>
<td>1.52</td>
<td>10.9</td>
<td>3.78</td>
<td>30.5</td>
</tr>
<tr>
<td>'16 Q1</td>
<td>0.54</td>
<td>2.7</td>
<td>0.78</td>
<td>6.8</td>
<td>0.36</td>
<td>3.5</td>
<td>1.1</td>
<td>8.7</td>
</tr>
<tr>
<td>'16 Q2</td>
<td>0.59</td>
<td>4.7</td>
<td>1.13</td>
<td>7.4</td>
<td>0.34</td>
<td>1.4</td>
<td>1.04</td>
<td>4.9</td>
</tr>
<tr>
<td>'16 Q3</td>
<td>0.65</td>
<td>1.5</td>
<td>1.19</td>
<td>4.6</td>
<td>0.32</td>
<td>2.1</td>
<td>0.78</td>
<td>4.5</td>
</tr>
<tr>
<td>'16 Q4</td>
<td>0.8</td>
<td>6.5</td>
<td>1.4</td>
<td>8.8</td>
<td>0.5</td>
<td>3.9</td>
<td>0.86</td>
<td>12.4</td>
</tr>
<tr>
<td>Q4corr</td>
<td>0.49</td>
<td>2.6</td>
<td>1.1</td>
<td>4.1</td>
<td>0.38</td>
<td>1.75</td>
<td>0.72</td>
<td>5.82</td>
</tr>
<tr>
<td>n2016</td>
<td>2.27</td>
<td>11.5</td>
<td>4.2</td>
<td>22.9</td>
<td>1.4</td>
<td>8.75</td>
<td>3.64</td>
<td>23.92</td>
</tr>
<tr>
<td>14+15</td>
<td>3.51</td>
<td>24.2</td>
<td>5.82</td>
<td>50.65</td>
<td>1.92</td>
<td>21.65</td>
<td>5.53</td>
<td>63.4</td>
</tr>
<tr>
<td>% red</td>
<td>35%</td>
<td>52%</td>
<td>28%</td>
<td>55%</td>
<td>27 %</td>
<td>60%</td>
<td>34%</td>
<td>62 %</td>
</tr>
</tbody>
</table>
Dosimetry

- 2013 year dosimetry not included in calculations (no NM work)
- Q4 values corrected for 5 week stretch when we reverted to manual draw ups and injections
- Body dose reductions ranged from 27-35 %
- Extremity dose reductions ranged from 52-62 %
- You can infer that dose savings to fingertips is even greater still!
Annual Extremity Dose (mSv)

Tech 1 | Tech 2 | Tech 3 | Tech 4
---|---|---|---
2014 | 2015 | 2016

Legend:
- Red: 2014
- Black: 2015
- Green: 2016
### Literature Review

<table>
<thead>
<tr>
<th>% Dose Reduction</th>
<th>Body Badge</th>
<th>Extremity Badge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecchi, M. et al *</td>
<td>38 %</td>
<td>94 %</td>
</tr>
<tr>
<td>Carolan, P. et al</td>
<td>21 – 23.4 %</td>
<td>43.9 - 47.5 %</td>
</tr>
<tr>
<td>Alexander, R. et al</td>
<td>20.4 %</td>
<td>49.5 %</td>
</tr>
<tr>
<td>Sanchez, R. et al</td>
<td>N/A</td>
<td>60.2 %</td>
</tr>
<tr>
<td>This Study</td>
<td>31 %</td>
<td>57 %</td>
</tr>
</tbody>
</table>

- *Injection step only*
- There was significant variability in dosimetry data from study to study largely attributable to time spent in PET vs. NM shifts. Those who spent the majority of their time, or all of their time in PET rotations recognized more dose savings than those whose shifts were split between PET and NM.
It’s important to note that the INTENT, is for assayed vials to come from the radiopharmacy already in the Intego tungsten pots as shown in the picture.

This has not been implemented at our site but is a targeted outcome of this work.
Dosimetry

• Average 40 FDG deliveries in a normal month. Estimate conservatively for 420 deliveries per year, shared amongst 6 staff, for about 70 per person
• Mean vial activity is 8550 MBq
• From 2016 dose study, mean exposure from receiving these shipments is 4.5 µSv
• So not assaying the vials would save an estimated 315 µSv of exposure per year for each PET/CT technologist
St Joseph’s PET/CT

- We currently have to remove the vial from the lead shipping pig and assay it by hand before it goes into the Intego tungsten pots for use in the infuser
Ergonomic Assessment

- Intego tungsten pot and handle weighs 7.4 kg, compared to the lead syringe box and tungsten syringe holder which weighs 6.9 kg
- Generally accepted that holding weighted objects away from the body increases force exerted on the spine
Ergonomic Assessment

- Counter height and lead shielding make manual draw-ups physically awkward for some.
- Due to the automated nature of the Intego system, there are significantly less physical demands required of the workers.
Ergonomic Assessment

• Working with very small volumes and poor sight lines means often being outside of +/- 10% of patient target dose
• Multiple assays further increases dose
Staff Review

• Each staff member was asked to opine on what their most/least favorite thing was with regard to using the Intego

• Everybody agreed that use of the MEDRAD Intego made life easier while reducing staff exposures

• Staff were asked to consider offering something OTHER than dose savings as a “PRO”
Staff Review (Pros)

• Elimination of draw up phase (2)
• “Inject at a distance” (2)
• Increased dosing accuracy
• Feeling less tired at end of shift
Staff Review (Cons)

- Occasional error messages/TS
- Swapping out SAS (midday)
- Loading of the tungsten pots (2)
- Automated drive/tight corners
- Cost
Incidents

<table>
<thead>
<tr>
<th>YEAR</th>
<th># of RIRs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>7</td>
</tr>
<tr>
<td>2014</td>
<td>11</td>
</tr>
<tr>
<td>2015</td>
<td>8</td>
</tr>
<tr>
<td>2016</td>
<td>3*</td>
</tr>
</tbody>
</table>

- Considered only incidents attributable to manual manipulation of dose (personal/object contamination)
- Biggest takeaway was that the 3* contamination incidents in 2016 were all during the Intego recall (5 week period)
- ZERO incidents while Intego was in use in 2016
Observations

• Department was designed prior to purchase/use of Intego
• Physically difficult to access some patient bays
• Should consider future use of automatic injector during design phase of any PET/CT facility
Observations

- Prescribed touchpad dosing allows for far more accurate FDG delivery
- More consistent dose delivery improves patient care, especially within return patient population
Conclusions

• Staff exposure recognized through use of the MEDRAD Intego were in keeping with those recognized by some other centers
• Use of the MEDRAD Intego offers other ergonomic gains, as well as help in reducing patient over-dosing, while drastically reducing instances of radioactive spills and contamination
• Although the Intego is a viable dose reduction strategy, it does not significantly increase patient throughput.
• Recommendation to management for additional gains to be made
References

• Lung Cancer Statistics – Canadian Cancer Society;
• MEDRAD Intego PET Infusion System;
  www.radiologysolutions.bayer.com/products/molecularimaging/intego/
• Evaluation of an Automated FDG Dose Infuser to PET-CT Patients; Sanchez, Roberto M. et al. Radiation Protection Dosimetry, 2015: 10.1093
• Radiation Exposure Reduction to PET Technologists with the Use of an Automated Dosage Delivery System; Carolan, P. et al. J Nucl Med 2012;53 (Supplement 1);1519
• Radiation Exposure Reduction to PET Imaging Technologists with the use of an Automated Dosage Infusion System; Alexander, R. et al Mount Sinai Medical Center
QUESTIONS?