Radiation Exposure Reduction to PET Imaging Technologists with the Use of an Automated Dosage Infusion System
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Introduction

• Operator radiation protection is achieved by reducing the time the operator spends near the radiation sources, increasing the distance from the source and the use of shielding.

• The presence of lead shielding in PET suites as well shielded containers used for 18FDG reduces potential radiation exposure. The preparation of 18FDG, the administration and the time with the patient after injection are exposure risks.

• The patient becomes an emitting source post-injection. There have been studies to evaluate the attenuation of radiation post-injection taking into account the body habitus and distribution of the radiopharmaceutical in the body.
Introduction

• The administration of 18F-FDG manually is a major contributor to the occupational radiation. As demonstrated by Covens et al, the whole-body dose is generally received over the course of the entire PET procedure, whereas extremity doses are mainly received during the steps involved in handling the radiopharmaceutical.

• While the dose injected for PET studies has decreased, the growth and frequency of studies is increasing. The PET technologist is still at risk for over exposure.

• In an effort to quantitate potential radiation exposure reduction to PET imaging technologists, a retrospective review of ring and body radiation dosimeter badges was performed on our PET imaging technologists before and after the initiation of an automated dose infusion system.
Materials and Methods

• Institutional Review Board determined this quality practice improvement was exempt and the requirement for informed patient consent was waived for this HIPAA compliant retrospective study.

• At our institution, we perform thousands of clinical PET/CTs per year. All PET radiopharmaceuticals are administered by our PET imaging technologists with over 90% of the doses being $^{18}$F-FDG.

• A typical dose for our patients is 15 mCi (+/- 10%) of $^{18}$F-FDG. We have a dedicated “core” group of PET imaging technologists (n=7) who only work in PET/CT (i.e., spend no time in our cardiac or general imaging practice) and a “rotating” group of PET imaging technologists (n=21) who divide time between PET, general nuclear medicine, and nuclear cardiology practice.
Materials and Methods

• All PET imaging technologists wear both body and ring radiation dosimeter badges that are monitored monthly for the core group and quarterly for the rotating group of PET imaging technologist. Separate badges are not worn in each of the imaging practices.

• Prior to mid-second quarter of 2011, all PET doses were provided to the technologists as individual unit doses from our PET pharmacy. These individual doses were then injected by the PET imaging technologist who would then be in charge of imaging the patient, regardless of whether the technologist was a member or the core or rotating group.
Materials and Methods

• During the mid-second quarter of 2011, the use of an automated dosage infusion system was initiated (Intego PET Infusion System, MEDRAD, Inc., Warrendale, PA USA).

• The automated dosage infusion system is a mobile computerized PET infusion system which houses fluid delivery pumps, an ionization chamber, flow management valves, and air detectors in a shielded portable cart.
Materials and Methods

• This system allows real-time, automated dose preparation and infusion directly from a multi-dose vials containing up to 700 mCi of radiopharmaceutical. The dose is delivered through disposable tubing connected to the patient’s intravenous catheter allowing minimal contact with the unshielded radiopharmaceutical by the PET imaging technologists.

• This protocol and practice with the Intego automated dosage infusion system has been previously validated by Lechhi, et al.
Statistical Analysis

• For both the core and rotating group of PET imaging technologists, the total number of dosages administered was counted for the given quarter.

• To account for the variability between the number of dosages administered between technologists, the cumulative dosage reading was divided by the number of dosages administered to give an average exposure reading per dosage administered for the quarter for an individual technologist.

• Two-sided $t$ tests were used where appropriate to compare trends, with a $p$ value less than 0.05 considered statistically significant.
Results

Body Exposure per Dosage Administered

Body Exposure per Administration (mrem/admin.)

- 2011-Q1: 1.86
- 2011-Q2: 1.60
- 2011-Q3: 1.46
- 2011-Q4: 1.48
- 2012-Q1: 1.37
- 2012-Q2: 1.38
- 2012-Q3: 1.38
- 2012-Q4: 1.37
Results

Ring Exposure per Dosage Administered

Ring Exposure / Administration (mrem / admin.)

- 2011-Q1
- 2011-Q2
- 2011-Q3
- 2011-Q4
- 2012-Q1
- 2012-Q2
- 2012-Q3
- 2012-Q4
Discussion

• Nuclear medicine technologists consistently have some of the most elevated radiation exposure levels in the radiology department. This is particularly true of those that work in PET/CT. As PET/CT continues to increase in volume as a percentage of all of nuclear medicine, we have also developed dedicated PET/CT technologists who are at an even higher risk of significant exposure. While many safety features have been added to help mitigate this risk (ie, shielding, job rotation, etc), the risk is ultimately directly proportional to how many dosages a technologist handles.

• Significant dose reduction was seen over time in our PET/CT technologists. In addition, this dose reduction appears to increase over time, likely due to increased familiarity and use of the automated system. The ring exposure adjusted for the number of doses administered was reduced 57.1% (p < 0.05) between quarters Q1-to-Q8. The body exposure adjusted for the number of doses administered was reduced 20.6% (p < 0.05) between quarters Q1-to-Q8.

• While the maintenance or troubleshooting incurs additional exposure not seen with manual injection, the increased familiarity with the device lead to progressive declines in ring exposure.
Discussion

• The whole-body and extremity doses during administration of a single 18FDG dose were measured using a manual and automatic technique. The whole-body exposure was reduced 20.4% and the extremity exposure 49.5% with automatic administration and injection.

• These results can be explained by the reduced handling and increased shielding from 18FDG. The multi-dose vial allows for multiple doses to dispensed through the touch screen rather than handling multiple single dose vials.

• While the extremity dosimeter was measured at the ring, the exposure at the fingertips can be even greater. A reduction at the ring can infer a reduction at the fingertips, where exposure can be multiples higher.
Discussion

• The automated injection allows the PET technologist to perform the injection without being present in the PET suite. There is variability among the literature regarding the quantitative reduction in extremity exposure. The use of lead box for transport administration, syringe shields for injection and variation in the steps of a procedure among institutions partially account for the variability in reduction.

• There is considerable startup expense associated with the automated dose infusion system. Infusion system is only applicable in larger volume practices with onsite cyclotron. Only a single patient can be injected at any given time which has the potential to slow down a busy practice.

• Further study is needed regarding the effects of a single automated system upon efficiency of workflow. The PET pharmacy drew the dose into the vials for manual injection, an exposure the PET technologist was not exposed to.
In conclusion, the use of an automated dosage infusion system for PET imaging can lead to significant reduction in imaging technologist radiation exposure. This benefit is significant both for those technologists who work exclusively with PET imaging as well as in those who rotate through PET on a more limited basis. Radiation exposure reduction per dosage appears to increase over time, likely due to improved efficiency and familiarity with automated dosage infusion system.