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PERFORM Operating Document

Radiation Dose Estimates, Calculations and Tracking Methodology

PC-POD-IM-003-v03

Revision History

Version	Reason for Revision	Date
01	New POD	Jul/27/2015
02	Update section 2.2 with 50 mSv dose limit	Mar/07/2016
03	Minor updates	Feb/01/2018

Summary

The content of this Perform Operating Document (POD) provides guidelines for radiation dose estimates, calculations and the tracking methodology that will be used for the CT, DEXA, SPECT and PET for human research participants.

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1. Definition of Terms and Abbreviations

AAPM	American Association of Physicists in Medicine
Absorbed Dose	The amount of energy deposited in any substance by Ionizing Radiation per unit mass of the substance, expressed numerically in Grays.
Bq	Bequerel
Code 35	Health Canada Safety Code 35: Safety Procedures for the Installation, Use and Control of X-ray Equipment in Large Medical Radiological Facilities
CT	Computed Tomography
CTDIvol	CT Dose Index is a weighted average measurement in a reference phantom. This dose is expressed in milliGrays.
DEXA	Dual Energy X-ray Absorptiometry
Effective Dose	The sum of products, in Sieverts, obtained by multiplying the Equivalent Dose of Radiation received by, and committed by, each organ or tissue by the weighting factor of that item. This is used when various tissues of differing sensitivities are irradiated.
Gray (Gy)	The SI unit of absorbed radiation dose, one joule per kilogram of tissue.
PET	Positron Emission Tomography
Radiation Weighting Factor	In reference to an organ or tissue, this is the proportion of the risk of Stochastic Effects resulting from irradiation of that organ or tissue to the total risk of Stochastic Effects when the whole body is irradiated uniformly
RSO-NM	PERFORM's Radiation Safety Officer – Nuclear Medicine
SPECT	Single Photon Emission Tomography
Sievert (Sv)	The SI unit of absorbed radiation dose in living organisms modified by radiation type and tissue weighting factors. The Sievert is the unit of dose measuring the "equivalent dose" and "effective dose". It replaces the classical radiation unit the rem.

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2. Introduction

2.1. Background

The imaging facility at PERFORM consists of specialized radiation emitting and radiation detecting devices known as PET-CT, SPECT-CT, and DEXA scanners. As their operation is associated with exposure to ionizing radiation, there is a requirement by licensing bodies to be able to track radiation doses to participant.

2.2. Purpose

This POD is created to describe dose estimates for typical exams, how to calculate effective dose estimates as well as describe the methodology for tracking participants estimated radiation dose. The estimated doses will be used to track equipment functioning as well as for reporting purposes. Health Canada requires that research participants obtain no more than 50mSv per year.

2.3. Scope

This POD applies to the imaging procedures using the following devices which are found in the Bio-Imaging suite at PERFORM: CT, DEXA, PET and SPECT in any combination.

2.4. Responsibility

It will be the responsibility of the RSO-NM to maintain the estimated dose records for the imaging procedures done in the Bio-Imaging suites.

2.5. Relevant Documents

PC-SOP-IM-001 General Procedures for Bio Imaging Suite Access at Perform
PC-POD-IM-002 Imaging Participant Tracking

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3. Procedure

3.1. CT

The CT scanners can be used alone or in conjunction with the paired SPECT and PET systems. They can be used to provide diagnostic quality images or for attenuation correction for the SPECT/PET images.

3.1.1. CT protocol estimated values

Health Canada has produced a safety document pertaining to radiological equipment and has recommended that each centre create a list of diagnostic reference levels for the most popular exams being performed. The following is the Code 35 guideline for diagnostic reference levels.

Table 4: Representative DRLs for CT procedures (IPEM 2004), (Aldridge 2006), (Shrimpton 2004)

Examination	CTDIvol (mGy)	Dose Length Product (mGy_cm)
Head	60	930-1300
Chest	30	580-650
Abdomen-Pelvis	35	560-1100
Liver and Spleen	35	470-920

Table 4, Radiation Protection in Radiology-Large Facilities, Safety Code 35, 2008, Pg.17

The CT software has preinstalled protocols that can be used as is or copied and changed according to the needs of the user. The following table is based on these pre-installed protocols.

CT protocol Estimate of the Dose Length Product (mGy cm)

Examination	CT 16 (SPECTCT)	CT 64 (PETCT)
Head	1013	1034
Chest	268	400
Abdomen-Pelvis	661	668
Liver and Spleen	179	201

**These are examples taken from the GE software as estimate will change depending on final protocol parameters selected by user.*

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3.1.2. Post Exam values

By default both CT machines are set-up to create a dose report that provides values for Computer Tomography Dose Index (CTDI) and Dose Length Product (DLP). These reports will be transferred with the images when archiving. The values provided for CTDI and DLP will be used to create internal diagnostic reference levels as well as for Effective Dose estimation using the following formulas described in the American Association of Physicists in Medicine Report No.96 "The Measurement, Reporting and Management of Radiation Dose in CT", January 2008. This does not calculate the participant's Effective Dose, but provides a value that can be used to compare or used as an estimated measure of risk.

$$E\ (mSv) \approx k * DLP$$

$k\ (mSv\ mGy^{-1}\ cm^{-1})$	
Region of Body	Adult
Head and neck	0.0031
Head	0.0021
Neck	0.0059
Chest	0.014
Abdomen & Pelvis	0.015
Trunk	0.015

Table 3, The Measurement, Reporting and Management of Radiation Dose in CT, AAPM Report No.96, January 2008, Pg. 13

3.2. DEXA

The DEXA scanner uses low doses of x-radiation to create images for analysis. There is a limit to the manipulation in regards to the output power of the beams being emitted. There are three (3) settings (2.5, 0.625 or 0.188 milliampere) that can be selected or suggested by the program itself depending on participant weight and exam performed. The software calculates the estimated skin entrance dose in micrograys (µGy). Since the Radiation Weighting Factor of X-rays is one (1), the Absorbed Dose (µGy) will equal the Equivalent dose (µSv).

3.2.1. Estimated Dose Values Table

Site	Mode	Current(mA)	Typical Measurement Area (L cm X W cm)	Irradiation Time (sec)	Estimated Skin Entrance Dose (µGy)
AP SPINE	Thick	2.5	19.0x18.0	109	329
AP SPINE	Standard	2.5	19.0x18.0	52	146
AP SPINE	Thin	0.625	19.0x18.0	52	37
AP SPINE	QuickView	2.5	19.0x18.0	23	47
Femur	Thick	2.5	20.5x17.0	112	329
Femur	Standard	2.5	20.5x17.0	54	146
Femur	Thin	0.625	20.5x17.0	54	37
Femur	QuickView	2.5	20.5x17.0	24	47
DualFemur	Thick	2.5	2x20.5x17.2	224	329
DualFemur	Standard	2.5	2x20.5x17.1	107	146
DualFemur	Thin	0.625	2x20.5x17.0	107	37
DualFemur	QuickView	2.5	2X20.5x17.0	48	47
APVAH	Thick	2.5	42.7x18.0	117	146
APVAH	Standard	2.5	42.7x18.0	117	146
APVAH	Thin	0.625	42.7x18.0	117	37
Forearm	Standard	0.188	14.2x10.0	24	10
Hand	Standard	0.188	25.3x18.0	69	10
Total Body	Thick	0.188	196.8x66	796	6
Total Body	Standard	0.188	196.8x66	436	3
Total Body	Thin	0.188	196.8x66	436	3
LVAH	Standard	2.5	42.7x20.0	271	329
LVAH	Thin	0.625	60.0x20.0	381	82
Lateral Spine	Standard	2.5	19.0x18.0	109	329
OrthopedicFemur	Thick	2.5	23.7x15.0	115	329
OrthopedicFemur	Standard	2.5	23.7x15.0	55	146
OrthopedicFemur	Thin	0.625	23.7x15.0	55	37

Current and Typical Dose Tables Lunar iDXA Series, enCORE-based X-ray Bone Densitometer, User Manual, Pg. 270-271

3.2.2. Post Exam Values

The estimated skin entrance dose is calculated and reported in the footer of the exam report. The DEXA exams are archived to an external drive and each Principal Investigators folder is backed up on a server.

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3.3. PET-SPECT

3.3.1. New Radiopharmaceuticals

For newer radiopharmaceuticals that aren't in regular use the effective dose (mSv/MBq) value will be obtained by researching previously established published values. If there is no consistent value among previously published values the highest value shall be used.

3.3.2. Estimated Dose Values Table for established Radiopharmaceuticals

Radiopharmaceutical	Activity (mCi/MBq)	Male (mSv)	Female (mSv)
F-18 FDG	15 / 555	10.5	13.3
F-18 Sodium Fluoride	10 / 370	10.0	12.6
Ga-67	4 / 148	14.8	19.2
Rb-82	40 / 1480	1.8	2.4
Technegas	10 / 370	5.6	8.1
Tc-99m ECD (Neurolite)	20 / 740	5.7	7.3
Tc-99m MAA	4 / 148	1.6	2.4
Tc-99m MIBI	30 / 1110	10.0	13.3

Nuclear Medicine Radiation Dose Tool, Society of Nuclear Medicine website: *http://www.snmmi.org/ClinicalPractice/doseTool.aspx?ItemNumber=11216&navItemNumber=11218*

3.3.3. Post Exam Values

Prior to injection the activity will be calculated using the appropriate dose calibrator. All devices times will be updated and synchronized the morning of an exam. Each time (dose calibrator pre/post injection, camera start time) will be added to the Nuclear Medicine safety screening form (PC-SOP-IM-001) which will be scanned into the NMIS system and stored in the participant log.

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APPENDIX I

POD Training Record Form

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POD Title

Radiation Dose Estimates, Calculations and Tracking Methodology

POD Code

Ownership	Document type	Area	POD Number	Version
PC	POD	IM	003	03

Training Record

Full Name	
Institution	
Contact (email or phone number)	

Signature

Sign here and return to POD custodian

Date