Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Proposed Revisions to the Australian National Diagnostic Reference Levels for Nuclear Medicine

Background

National Diagnostic Reference Levels (DRLs) were last published for nuclear medicine in Australia in 2017. A Nuclear Medicine DRL Liaison Panel convened by ARPANSA recommends that these national DRLs be revised to reflect changes in nuclear medicine techniques and utilisation. The DRLs apply to procedures conducted on adult patients.

The liaison panel consisted of representatives of the nuclear medicine community in Australia[1] and was convened in December 2020 with the aim of revising Australia's national DRLs for nuclear medicine and positron emission tomography. The panel oversaw a survey open to all Australian nuclear medicine providers, with all facilities with a gamma- or PET camera registered with Medicare sent an invitation to participate. The survey asked facilities to provide both the doses prescribed for all protocols they offer, and the doses delivered to patients over a two-week period.

Results from the survey have been used to formulate the proposed national DRLs for procedures on adult patients listed in the following sections. In all cases, the DRLs have been based on the 75th percentile of the distribution of Facility Reference Levels (FRLs), where the FRLs are doses indicative of common practice on a particular scanner at a particular facility.

How FRLs were defined varied for different modalities. For general nuclear medicine, the prescribed activity was generally used[2]. A similar approach was used for PET, however facilities that based prescribed activity on patient weight (or a similar characteristic) were treated separately to those that delivered the same activity to all patients. For the CT component of SPECT/CT and PET/CT, an FRL was assigned to each scanner that conducted a particular scan type, with the value of the FRL being the median dose delivered.

The national DRLs should not be interpreted as recommended doses or as dose limits. Rather, they indicate the dose that three quarters of facilities that participated in the survey would consider sufficient (or excessive) to achieve diagnostic quality images for a particular scan. A facility that delivers a dose above the DRL should review why they require a dose higher than three quarters of their colleagues to conduct a particular scan.

[1] Representatives were nominated by the Australian and New Zealand Society of Nuclear Medicine, the Australasian Association of Nuclear Medicine Specialists, the Australian College of Physical Scientists and Engineers in Medicine, the Australian Diagnostic Imaging Association, the Diagnostic Imaging Accreditation Scheme Advisory Committee, and ARPANSA.

[2] In the cases of facilities that used weight or body-mass index (BMI) to inform the prescribed dose, the dose prescribed to an 80 kg or BMI = 28 kg/m^2 patient was used.

General Nuclear Medicine

There are currently DRLs defined for around 60 general nuclear medicine procedures. The proposed DRLs, shown in Table 1, instead focus on the most common procedures for adult patients in Australia.

The revised DRLs are generally the same or 10 – 20 MBq below the current DRLs. In most cases, the reduction is likely a result of the proposed DRLs being based on the reported prescribed activity for a given procedure, whereas the preceding DRLs were based on the activity reportedly administered to patients.

As is the current guidance, it is envisaged that facilities could complete a DRL comparison by simply comparing their prescribed activities to the DRLs. Facilities should also audit the activities delivered to patients to ensure that administered activities are close to the prescribed activity, however that could be conducted as part of a regular QC procedure rather than as part of the DRL comparison.

In situations where a facility uses a variable prescribed activity (be it based on patient weight, chest circumference or similar), the facility should collect data from a representative sample of patients and count the number of patients that received an activity below the DRL. If half or more of the patient sample received an activity below the DRL, then the facility can consider itself below the DRL.

Table 1 Proposed DRLs for administered activity in general nuclear medicine procedures for adults. Where not otherwise specified, the pharmaceutical contains ^{99m}Tc. Where available, the current DRL is shown for comparison.

Category	Scan		Pharmaceuticals	Proposed DRL (MBq)	Current DRL (MBq)
Cardiovascular	Gated blood pool scan		Pertechnetate, RBCs	1000	1030
	MPI 1-day*:	1st phase (rest)	Tetrofosmin, MIBI	350	1520
		2nd phase (stress)	Tetrofosmin, MIBI	1150	
	MPI 2-day:	1st phase	Tetrofosmin, MIBI	600	620
		2nd phase	Tetrofosmin, MIBI	600	620
Endocrine	Thyroid		Pertechnetate	200	215
	Parathyroid:	without subtraction	MIBI	800	900
		with subtraction	MIBI	900	900
		thyroid subtraction	Pertechnetate	220	220
Gastrointestinal	Gastric emptying (solid phase)		Colloid, DTPA	40	44
	Colonic transit		^{67}Ga Citrate	20	20
Genitourinary	MAG3 Renal scan		MAG3	300	305
	DMSA Renal scan		DMSA	200	200
	Renal Imaging DTPA (not GFR)		DTPA	500	500
Hepatobiliary	Hepatobiliary		HIDA, DISIDA, Mebrofenin	200	210
Infection	Infection		^{67}Ga Citrate	220	220
Lymphatic	Sentinel node (breast)†:	Same day surgery	Colloid	40	52
		Delayed	Colloid	80	-
	Sentinel node (melanoma)†		Colloid	52	52
Nervous system	Brain		ECD, HMPAO	800	750
Pulmonary	Lung perfusion		MAA	220	240
Skeletal	Bone scan		MDP, HDP	900	920

*While the DRL reflects the most common approach reported in Australia (rest prior to stress), facilities that conduct the stress phase first appear able to deliver considerably lower dose.

† Quoted DRL is for the total activity delivered, not per injection. The most common approach reported was 4 x 10 MBq injections for same day surgery.

CT component of SPECT/CT

The proposed DRLs for the CT component of SPECT/CT studies performed on adult patients are detailed in Table 2. The main change is the introduction of DRLs expressed in volume computed tomography dose index ($CTDI_{vol}$). It is hoped that this additional information will allow facilities to better interpret their DRL comparisons and provide an indication as to whether a high dose is a result of exposure settings or the length of the scans they conduct (using just the dose-length product (DLP) it is difficult to distinguish).

Data was collected for brain scans during the most recent survey, however, due to vagaries in how scanners report dose for head protocols, further analysis is required before a revised DRL can be issued. In the interim, the existing DRL will continue to be used.

DRL comparisons should be conducted by determining the median dose delivered to a representative sample of patients. This should be done separately for each scanner for all scans regularly conducted at that facility. It is generally left to the facility to decide exactly how the term "regularly" is defined.

Table 2 Proposed DRLs for the CT component of SPECT/CT scans for adults.

Category	Region	Proposed $CTDI_{vol}$ DRL (mGy)	Proposed DLP DRL (mGy.cm)	Existing DLP DRL (mGy.cm)
Cardiac	Chest (heart)	2.1	50	45
Lymphatic (breast ca.)	Chest	3.8	135	170
Neurological	Brain	-	255	255
Parathyroid	Neck/Chest	7.2	240	255
Pulmonary	Chest (lung)	4.6	150	120
Skeletal	Single width	4.8	200	240
	Double width	4.8	365	415

$CTDI_{vol}$ – volume computed tomography dose index
DLP – dose length product

Positron Emission Tomography

Five DRLs are proposed for PET studies performed on adult patients, shown in Table 3. The DRLs have been expressed as both a fixed activity and in terms of MBq/kg (except for brain FDG scans, where there were limited sites that used a weight-based variable prescribed activity). Expressing DRLs in terms of MBq/kg is the recommended approach of the International Commission on Radiological Protection (ICRP)[3] however, for all but whole body FDG scans, a sizeable portion of participating facilities reported prescribing a fixed activity, so a weight invariant DRL has also been proposed.

DRLs expressed in terms of patient weight are not suitable for all patients. It is proposed that the weight dependent DRLs only apply to patients weighing between 50 and 120 kg.

Facilities should compare their prescribed activities against the variable or fixed DRL depending on their own protocol. In cases where a variable prescribed activity is used that cannot be expressed in terms of MBq/kg, the facility should take a sample of patients and determine the proportion that were given an

[3] International Commission for Radiological Protection, publication 135 available from https://www.icrp.org/publication.asp?id=icrp%20publication%20135.

activity below either the fixed DRL or, preferably, the variable DRL. If half or more patients are below the DRL then the facility can consider its administered activities to be below the DRL.

Table 3. Proposed DRLs for administered activity in PET studies for adults.

Scan	Pharmaceutical	Proposed DRL		Current DRL MBq
		MBq/kg*	MBq	
Whole body†	^{18}F FDG	3.5	270	310
Parkinsonian/ Alzheimer's	^{18}F FDG	-	230	250
NETs	^{68}Ga DOTA-TATE	2.2	200	-
Prostate cancer	^{68}Ga PSMA	2.2	200	-
	^{18}F DCFPyL	3.7	270	-

* Variable DRLs only applicable for patients weighing between 50 and 120 kg.

† Includes scans conducted for oncology, infection, inflammation, vasculitis

CT component of PET/CT

The proposed DRLs for the CT component of PET/CT imaging performed on adult patients are shown in Table 4. As was the case for SPECT/CT, it is proposed to introduce DRLs expressed in volume computed tomography dose index ($CTDI_{vol}$). The other change proposed is to have separate DRLs based on the arm position of the patient being imaged.

The same issue that prevented a proposed revision to the SPECT/CT DRL for brain scans applies to the PET/CT brain scans. It is hoped that a revised DRL can be issued following additional analysis.

Table 4 Proposed DRLs for the CT component of PET/CT for adults.

Region	Arm position	Proposed $CTDI_{vol}$ DRL (mGy)	Proposed DLP DRL (mGy.cm)	Current DRL (mGy.cm)
Brain vertex to prox./mid thighs	Up	4.2	430	540
	Down	5.3	555	
Brain vertex to toes	Up	3.9	675	985
	Down	4.6	825	
Brain	Down	-	325	325

$CTDI_{vol}$ – volume computed tomography dose index

DLP – dose length product