Pediatric Radiopharmaceutical Administered Doses:

Harmonization of the 2007 EANM Paediatric Dosage Card and the 2010 North American Consensus Guidelines

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**Introduction**

In 2006 the EANM published a new version of their paediatric dosage card for 39 radiopharmaceuticals [[1](#_ENREF_1)]. In 2008 an amendment with respect to the use of FDG has been introduced [[2](#_ENREF_2)]. In addition, an on-line dosage calculator was released by the EANM (<http://www.eanm.org/publications/dosage_calculator.php?navId=285>). In 2012, as an offspring of a recent project of the European Union ([www.peddose.net](http://www.peddose.net)), an application for iPhone/iPad (iApp) was created for facilitating the activity calculation.

(<http://itunes.apple.com/us/app/peddose/id492680472?mt=8>).

In 2010 members of the SNMMI, SPR and ACR, with support from the Image Gently Campaign, developed the North American consensus guidelines, which recommended a set of administered activities for use in pediatric nuclear medicine in North America [[3](#_ENREF_3)]. The North American consensus guidelines suggest that the EANM paediatric dosage card may also be used for most of the selected radiopharmaceuticals.

During the EANM congress in 2012 a working group representing both groups was established to harmonize the guidelines published by the EANM and SNMMI.

The purpose of this work is to identify differences in dose recommendations between the EANM and North American guidelines, and to suggest changes for harmonizing the respective recommendations.

**Suggested changes**

The following tables list recommended administered activity values and effective doses, and are provided for comparison of: (1) the EANM dosage card, (2) the North American guideline and (3) suggestions for revising the EANM dosage card.

1. **Renal Cortical Scintigraphy**

Remark: As reported in a recent review on biokinetics and dosimetry of commonly used radiopharmaceuticals in diagnostic nuclear medicine [[4](#_ENREF_4)] the data on 99mTc-Dimercaptosuccinic Acid (DMSA) were collected more than 20 years ago and have never been updated. Particularly, the data on the effective dose given in ICRP publication 80 [[5](#_ENREF_5)] rely on those data sets. Therefore, there may be a larger error associated with the effective dose of 99mTc-DMSA as compared to other radiopharmaceuticals.

In 2011, Sgouros et al published a paper on an approach for balancing diagnostic image quality with cancer risk for 99mTc-DMSA [[6](#_ENREF_6)]. The authors used pharmacokinetic modeling and a pediatric series of non-uniform phantoms for simulating 99mTc-dimercaptosuccinic acid SPECT images. Images were generated for several different administered activities and for several lesions with different target-to-background activity concentration ratios; the phantoms were also used to calculate organ S values for 99mTc. An analysis of the diagnostic quality of images with different modeled administered activities (i.e., count densities) for anthropomorphic reference phantoms representing two 10-year-old girls with equal weights but different body morphometry was performed. Using BEIR VII age- and sex-specific risk factors, the authors converted absorbed doses to excess risk of cancer incidence and used them to directly assess the risk of the procedure. This study illustrates the implementation of a rigorous approach for balancing the benefits of adequate image quality against the radiation risks and also demonstrates that weight-based adjustment to the administered activity might be suboptimal.

Presently, this methodology cannot be applied directly to the case of renal cortical scans in pediatric nuclear medicine; this method, however, has a great potential for influencing future updates of the respective recommendations.

EANM: A reassessment of the data on the effective dose given in ICRP publication 80 [[5](#_ENREF_5)] reveals that a change of the effective dose would lie between class A and class B, as provided by the paediatric dosage card. To assure that the diagnostic quality was preserved a decision was made previously, for the 2007 EANM paediatric dosage card, to assign the class A values to this radiopharmaceutical; this resulted in higher activities to be administered as compared to the corresponding class B values. The North American Consensus Guideline, however, asserts that lower activity values for a given weight do not result in reduced diagnostic quality. Therefore, the following changes to the EANM paediatric dosage card are suggested in order to harmonize both sets of guidelines:

1. Assign class B to DMSA
2. Change the baseline activity to 6.8 MBq
3. Change the Minimum recommended activity to 18.5 MBq.

NA: The guidelines will state additionally that the EANM Paediatric Dosage Card may also be used. In addition, the NA guidelines should be checked to determine if the maximum recommended activity can be set to 100 MBq.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Age:** | 1 year-old | 5 year-old | 10 year-old | 15 year-old | Adult |
| **Nominal weight (kg):** | 10 | 19 | 32 | 55 | 70 |
| **RENAL CORTICAL SCAN** |  |  |  |  |  |
| **99mTc-DMSA** | ICRP 80 [[5](#_ENREF_5)] |  |  |  |  |
| EANM Administered activity (MBq) | 33 | 48 | 64 | 87 | 100 |
| EANM Effective Dose (mSv) | 1.22 | 1.00 | 0.96 | 0.96 | 0.88 |
| *NA Administered activity (1.85 MBq/kg)* | *18* | *35* | *59* | *102* | *130* |
| *NA Effective Dose (mSv)* | *0.68* | *0.73* | *0.89* | *1.12* | *1.14* |
| EANM Administered activity (MBq) NEW | 18\* | 32 | 49 | 84 | 100 |
| EANM Effective Dose (mSv) NEW | 0.68 | 0.67 | 0.74 | 0.92 | 0.88 |

1. **Radionculide Cystography**

EANM: No changes suggested as it reflects present clinical practice in Europe.

NA: The guidelines need to be checked to determine if the lower EANM activity can be adopted or, if not, a statement will be issued that this activity value better reflects the current North American practice than the lower EANM value.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Age:** | 1 year-old | 5 year-old | 10 year-old | 15 year-old | Adult |
| **Nominal weight (kg):** | 10 | 19 | 32 | 55 | 70 |
| **RADIONUCLIDE CYSTOGRAPHY** |  |  |  |  |  |
| **99mTc sodium pertechnetate** | MIRD |  |  |  |  |
| EANM Administered activity (MBq) | 20\* | 20\* | 20\* | 20\* | -- |
| EANM Effective Dose (mSv) | 0.03 | 0.02 | 0.01 | 0.01 | -- |
| *NA Administered activity (MBq)* | *37\** | *37\** | *37\** | *37\** | *--* |
| *NA Effective Dose (mSv)* | *0.06* | *0.03* | *0.02* | *0.02* | *--* |

\* Minimum activity of the respective guideline

1. **Gastric Emptying / Reflux**

EANM: Presently no changes suggested.

NA: The guidelines need to be checked to determine if the weight-dependent EANM activity can be adopted or, if not, a statement will be issued that this activity value better reflects the current North American practice than the EANM value.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Age:** | 1 year-old | 5 year-old | 10 year-old | 15 year-old | Adult |
| **Nominal weight (kg):** | 10 | 19 | 32 | 55 | 70 |
| **GASTRIC EMPTYING / REFLUX (SOLID)** |  |  |  |  |  |
| **99mTc-labeled colloid** | ICRP 80 [[5](#_ENREF_5)] |  |  |  |  |
| EANM Administered activity (MBq) | 10\* | 13 | 20 | 33 | 40 |
| EANM Effective Dose (mSv) | 1.40 | 0.99 | 0.98 | 1.01 | 0.96 |
| *NA Administered activity (MBq)* | *9.25\** | *9.25\** | *18.5\** | *18.5\** | *18.5\** |
| *NA Effective Dose (mSv)* | *1.30* | *0.70* | *0.89* | *0.57* | *0.44* |
| **GASTRIC EMPTYING / REFLUX (LIQUID)** |  |  |  |  |  |
| **99mTc-labeled colloid** | ICRP 80 [[5](#_ENREF_5)] |  |  |  |  |
| EANM Administered activity (MBq) | 10\* | 13 | 20 | 33 | 40 |
| EANM Effective Dose (mSv) | 1.40 | 0.99 | 0.98 | 1.01 | 0.96 |
| *NA Administered activity (MBq)* | *9.25\** | *9.25\** | *37.5\** | *37.5\** | *37.5\** |
| *NA Effective Dose (mSv)* | *1.30* | *0.70* | *1.78* | *1.14* | *0.88* |

\* Minimum/Maximum activity of the respective guideline

1. **Whole Body MIBG Scan (123I)**

EANM: For 123I MIBG the lower limit of the activity in the EANM Paediatric Dosage Card will be reduced from 80 MBq to 37 MBq as suggested by the North American Consensus Guidelines.

NA: The guidelines will state additionally that the EANM Paediatric Dosage Card may also be used for all weight classes.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Age:** | 1 year-old | 5 year-old | 10 year-old | 15 year-old | Adult |
| **Nominal weight (kg):** | 10 | 19 | 32 | 55 | 70 |
| **WHOLE BODY MIBG SCAN** |  |  |  |  |  |
| **123I-MIBG** | ICRP 80 [[5](#_ENREF_5)] |  |  |  |  |
| EANM Administered activity (MBq) OLD | 80\* | 130 | 204 | 326 | 400 |
| EANM Effective Dose (mSv) | 5.4 | 4.8 | 5.3 | 5.5 | 5.2 |
| *NA Administered activity (5.2 MBq/kg)* | *51* | *99* | *166* | *286* | *364* |
| *NA Effective Dose (mSv)* | *3.5* | *3.7* | *4.3* | *4.9* | *4.7* |
| EANM Administered activity (MBq) NEW | 76 | 130 | 204 | 326 | 400 |
| EANM Effective Dose (mSv) | 5.1 | 4.8 | 5.3 | 5.5 | 5.2 |

\* Minimum Activity, NA: North American Consensus Guideline

1. **FDG-PET torso**

EANM: For FDG-PET a renaming is suggested for the EANM Dosage Card:

Instead of using “F-18 FDG (2D)” the wording “FDG-PET torso” is used. The suggested activity values remain unchanged.

NA: The minimum administered activity in the NA Consensus Guidelines will be set to 26 MBq.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Age:** | 1 year-old | 5 year-old | 10 year-old | 15 year-old | Adult |
| **Nominal weight (kg):** | 10 | 19 | 32 | 55 | 70 |
| **FDG-PET torso** |  |  |  |  |  |
| **18F-fluoro-deoxyglucose (FDG)** | ICRP 106[[7](#_ENREF_7)] |  |  |  |  |
| EANM Administered activity (MBq) | 70 | 120 | 189 | 302 | 370 |
| EANM Effective Dose (mSv) | 6.7 | 6.7 | 7.0 | 7.2 | 7.0 |
| *NA Administered activity (5.2 MBq/kg)* | *51* | *99* | *166* | *286* | *364* |
| *NA Effective Dose (mSv)* | *4.8* | *5.5* | *6.2* | *6.9* | *6.9* |

1. **FDG-PET brain**

EANM: For FDG-PET a renaming is suggested for the EANM Dosage Card:

Instead of using “F-18 FDG (3D), Recommended in Children” the wording “FDG-PET brain” is used. The activity values remain unchanged.

NA: The minimum administered activity in the NA Consensus Guidelines will be set to 14 MBq.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Age:** | 1 year-old | 5 year-old | 10 year-old | 15 year-old | Adult |
| **Nominal weight (kg):** | 10 | 19 | 32 | 55 | 70 |
| **FDG-PET brain** |  |  |  |  |  |
| **18F fluoro-deoxyglucose (FDG)** | ICRP 106 [[7](#_ENREF_7)] |  |  |  |  |
| EANM Administered activity (MBq) | 38 | 65 | 102 | 163 | 200 |
| EANM Effective Dose (mSv) | 3.5 | 3.8 | 3.8 | 3.9 | 3.8 |
| *NA Administered activity (3.7 MBq/kg)* | *37\** | *70* | *118* | *204* | *259* |
| *NA Effective Dose (mSv)* | *3.5* | *3.9* | *4.4* | *4.9* | *4.9* |

\* Minimum activity of the respective guideline

1. **[18F] sodium fluoride**

Remark:

After the publication of the EANM Dosage Card in 2008, newer data for this radiopharmaceutical became available (see the review by Eberlein et al. [[4](#_ENREF_4)]). The result is that lowering the activity values of F-18 sodium fluoride is possible (as compared to the original EANM Dosage Card) in a pediatric population without losing diagnostic information [[8](#_ENREF_8)]. Therefore, the suggested activity values of the EANM Dosage Card are reduced in order to match the NA values.

EANM: For F-18 sodium fluoride a renaming and a change of the administered activities is suggested for the EANM Dosage Card:

* The baseline value for the calculation of the activities to administer in the EANM Dosage Card is set to 10.5 MBq.
* Instead of using “F-18 Fluorine (3D), Recommended in Children” the wording is changed to “F-18 sodium fluoride”.
* The table “F-18 Fluorine (2D)” will be deleted.

NA: The minimum administered activity in the NA Consensus Guidelines will be set to 14 MBq. The guidelines will state additionally that the EANM Paediatric Dosage Card may also be used.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Age:** | 1 year-old | 5 year-old | 10 year-old | 15 year-old | Adult |
| **Nominal weight (kg):** | 10 | 19 | 32 | 55 | 70 |
| **18F- sodium fluoride** | ICRP 80[[5](#_ENREF_5)]/ Gelfand  [[8](#_ENREF_8)] |  |  |  |  |
| EANM Administered activity (MBq) OLD | 38 | 65 | 102 | 163 | 200 |
| EANM Effective Dose (mSv) | 5.7 | 4.9 | 4.7 | 4.7 | 4.8 |
| *NA Administered activity (2.22 MBq/kg)* | *22* | *42* | *71* | *122* | *155* |
| *NA Effective Dose (mSv)* | *3.3* | *3.2* | *3.3* | *3.6* | *3.7* |
| EANM Administered activity (MBq) NEW | 28 | 49 | 77 | 115 | 150 |
| EANM Effective Dose (mSv) NEW | 4.2 | 3.7 | 3.5 | 3.3 | 3.6 |

**References**

1. Lassmann M, Biassoni L, Monsieurs M, Franzius C, Jacobs F, Dosimetry E, et al. The new EANM paediatric dosage card. Eur J Nucl Med Mol Imaging. 2007;34:796-8.

2. Lassmann M, Biassoni L, Monsieurs M, Franzius C, Dosimetry E, Paediatrics C. The new EANM paediatric dosage card: additional notes with respect to F-18. Eur J Nucl Med Mol Imaging. 2008;35:1666-8.

3. Gelfand MJ, Parisi MT, Treves ST, Pediatric Nuclear Medicine Dose Reduction W. Pediatric radiopharmaceutical administered doses: 2010 North American consensus guidelines. J Nucl Med. 2011;52:318-22.

4. Eberlein U, Broer JH, Vandevoorde C, Santos P, Bardies M, Bacher K, et al. Biokinetics and dosimetry of commonly used radiopharmaceuticals in diagnostic nuclear medicine - a review. Eur J Nucl Med Mol Imaging. 2011;38:2269-81.

5. ICRP. Publication 80: Radiation dose to patients from radiopharmaceuticals: Addendum 2 to ICRP publication 53. Ann ICRP. 1998;28 (3).

6. Sgouros G, Frey EC, Bolch WE, Wayson MB, Abadia AF, Treves ST. An approach for balancing diagnostic image quality with cancer risk: application to pediatric diagnostic imaging of 99mTc-dimercaptosuccinic acid. J Nucl Med. 2011;52:1923-9.

7. ICRP. Publication 106: Radiation dose to patients from radiopharmaceuticals: Addendum 3 to ICRP Publication 53. Ann ICRP. 2008;38 (1-2).

8. Gelfand MJ. Dosimetry of FDG PET/CT and other molecular imaging applications in pediatric patients. Pediatr Radiol. 2009;39 Suppl 1:S46-56.