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# Dosimetry estimation of SPECT/CT for iodine 123-labeled metaiodobenzylguanidine in children

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## Abstract

**Purpose:** To evaluate the additional radiation exposure in terms of effective dose incurred by patients in the CT (computed tomography) portion of $^{123}$I-MIBG (123II-metaiodobenzylguanidine) study with SPECT/CT (Single photon emission computed tomography associated to computed tomography) in some pediatric patients of our department. **Methods:** Data from 123II-MIBG scans comprising 50 children were presented in this study. The contribution of total effective dose imparted by the nuclear tracer and patient's age was calculated. Effective dose from the CT portion of the examination is also estimated.SPECT acquisitions were performed with a dual-headed SPECT unit with an integrated 2-slice CT scanner (Symbia T E-Cam, Siemens Medical Systems, Erlangen, Germany). The CT acquisition were performed using a tube current modulation system (Care Dose 4D). Parameters used were: tube current of 30 - 60 mAs, slice thickness of 3-5 mm, and tube voltage of 110 kV. **Results:** Our results show that SPECT dosimetry depends on administered activity and patient's age and weight. For CT scan, effective dose is affected by tube current (mA), tube potential (kVp), rotation speed, pitch, slice thickness, patient mass, and the exact volume of the patient that is being imaged. **Conclusion:** For children, 123II-MIBG study with SPECT/CT should be performed using the lowest available voltage and current. A sensible choice of these two parameters used can significantly reduce radiation dose, without any compromise in the quality of the diagnostic information.

**Keywords:** 123II-Metaiodobenzylguanidine; SPECT-CT- Pediatric; Dosimetry

## Introduction

Metaiodobenzylguanidine (MIBG) is used for scintigraphic imaging of the adrenomedullary tumors pheochromocytoma and neuroblastoma in children. The use of I23I-l for labeling takes advantage of the better physical properties of I23I for imaging, allows higher activities to be administered with favorable radiation dosimetry and greater photon flux resulting in higher count, higher quality planar images and permits the performance of the single photon computed tomography (SPECT).[1-3] Single photon emission computed tomography associated to X-ray computed tomography (SPECT/CT) is a nuclear medicine tomographic imaging technique which improves diagnostic accuracy for particular clinical indications due to the possible attenuation and/or scatter correction of the SPECT functional images and the availability of helpful anatomic information.[4]

Also, the interpretation of scintigraphic images can be confounded by physiological uptake, which can be better identified with SPECT/CT. However, it results in a significant increase of patient dose. In fact, according to literature data SPECT/CT compared to SPECT alone causes more radiation to the patient which is not sufficient to cause deterministic effects.[2, 4, 5, 6] For SPECT effective dose depends on administered activity and patient's age. The average radiopharmaceutical effective dose varies from tens to thousands of mSv for some nuclear medicine exams.[4] However, the introduction of CT in nuclear diagnostic process results in a significant increase of the patient dose. In general, effective dose (E) for CT examinations can be higher than most other diagnostic imaging modalities[6]. Some authors have questioned the need to reduce doses particularly in children.[7-8]

Understanding radiation dosimetry and its potential for deleterious health effects, having knowledge of the magnitude of the effective dose and the dose to specific organs from SPECT and CT, and considering the role of CT in the context of SPECT/CT will allow the reader to reduce the radiation dose to the patient without compromising the quality of the patient's care.[9] In this article, we will present the dosimetry associated with pediatric SPECT/CT for iodine 123-labeled metaiodobenzylguanidine, in terms of effective dose, in some pediatric patients of our department. Factors affecting the radiation dose associated with SPECT, using 123II-MIBG in children will be described. The dosimetry associated with

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the CT component will be also noted.

## Methods and Materials

Data from 123II-MIBG scans comprising 50 children aged between 1 and 10 years, were presented in this study. The contribution of total effective dose imparted by the nuclear tracer and patient's age was calculated. Effective dose from the CT portion of the examination is also estimated.

SPECT acquisitions were performed with a dual-headed SPECT unit with an integrated 2-slice CT scanner (Symbia T E-Cam, Siemens Medical Systems, Erlangen, Germany). The CT acquisition were performed using a tube current modulation system (Care Dose 4D). Parameters used were: tube current of 30 - 60 mAs, slice thickness of 3-5 mm, and tube voltage of 110 kV.

For each child the CT was acquired immediately after SPECT; the patient being kept in the same position to minimize offsets due to movement and allow proper registration on fused imaging. The contribution of total effective dose imparted by the nuclear tracers for each child was calculated by multiplying the average administered activity for all patients by the "effective dose per unit administered activity" conversion factors listed in the International Commission on Radiological Protection (ICRP) Publication 53 [7] and 80 [10-11]. The effective dose from the CT portion of the examination is estimated from the product of the dose length product (DLP) and a body-region-specific conversion factor, $k$ (mSv $mGy^{-1}$ $cm^{-1}$), which take into account the varying biological sensitivities of different organs as given in **Table 1**.[12]

DLP is a patient-specific value determined by the scan length and the acquisition parameters; it represents the total amount of radiation delivered in the acquisition. CT scan was acquired immediately following completion of the SPECT study with the child in the same position to minimize motion errors.

## Results

While for SPECT, dosimetry is dependent on administered activity and the patient's age and weight; for CT scan, there are many factors which affect dosimetry. Dose estimates (**Table 2**) are dependent on tube current (mA), tube potential (kVp), rotation speed, pitch, slice thickness, patient mass, and the exact volume of the patient that is being imaged. According to the literature data, for children, MIBG imaging can be performed using the lowest available voltage and current.

## Discussion

According to Gelfand [13] and Fahey [9], combined imaging results in a significant increase of the patient dose. Effective dose is directly dependent on administered activity and the patient's age for SPECT; whereas as described by Mhiri [14], for CT scan, it depends on tube current, tube potential, rotation speed, pitch, slice thickness, patient mass, and the exact volume of the patient that is being imaged. A sensible choice of these parameters used, can significantly reduce radiation dose, without any compromise in the quality of the diagnostic information, according to Piwowarska [15] and Larking [5]. The dose in the patient must be as low as compatible with the medical purpose. For Larkin [5] and Valentin [7], practice leading to a medical exposure must be clearly justified and protection against radiation must be optimized, particularly for children. Also, quality control procedures have to be defined because of the coupling between the two devices.[16]

**TABLE 1**: Factors for DPL/effective dose Conversion over various body regions and patient ages.[12]

| Region of body | Effective dose per DLP (mSv (mGy cm)-1) by age | | | |
|---|---|---|---|---|
| | < 1-year-old | 1-year-old | 5-year-old | 10-year-old |
| *Head and neck* | 0.013 | 0.0085 | 0.0057 | 0.0042 |
| *Head* | 0.011 | 0.0067 | 0.0040 | 0.0032 |
| *Neck* | 0.017 | 0.012 | 0.011 | 0.0079 |
| *Chest* | 0.039 | 0.026 | 0.018 | 0,013 |
| *Abdomen and pelvis* | 0.049 | 0.030 | 0.020 | 0.015 |
| *Trunk* | 0.044 | 0.028 | 0.019 | 0.014 |

**TABLE 2:** Effective doses (E) delivered by 123 I-MIBG SPECT-CT scintigraphy over patient ages and body regions.

| | SPECT portion | | CT portion | | | SPECT-CT examination | |
|---|---|---|---|---|---|---|---|
| | Average Ac* (MBq/kg) | Average E* (mSv) | Average E* (mSv) | E over regions (mSv) *Trunk* | *Abd* | Total E* (mSv) | % increase of E* by the inclusion of the CT |
| **1-year-old** | 6 | 3.4 | 1.72 | 1.44 | 1.98 | 5.12 | 50% |
| **5-year-old** | 5 | 4.4 | 1.24 | 1.20 | 1.34 | 5.64 | 28% |
| **10-year-old** | 5 | 4.1 | 1.36 | 1.24 | 1.51 | 5.46 | 33% |

*Ac = Activity; *E = Exposure


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## Conclusion

Compared to planer images, 123I-MIBG study with SPECT/CT increases significantly the number of lesions detected and allows better anatomic localization of neuroblastoma deposits and delineation of normal bowel activity. However, patient dose increases significantly also. Then, reducing the patient dose should be a constant preoccupation of prescribing physician, nuclear physician's and qualified personnel performing the act, particularly for child. Every effort should be made to adhere to the “As Low as Reasonably Achievable (ALARA)” principle and ensure that the patient is not subjected to unnecessarily high levels of radiation, still more at young age.

## Conflict of interest

The authors declare that they have no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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