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Current Brazilian scenario on quality control of small animal PET scanners

Cenário Brasileiro atual em controle de qualidade de equipamentos PET para pequenos animais

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Resumo

O objetivo deste trabalho foi atualizar o cenário brasileiro sobre o programa de garantia da qualidade dos sistemas de imagem de PET pré-clínicos. Um levantamento eletrônico foi elaborado e aplicado a todos os serviços brasileiros de imagem molecular pré-clínica que participaram da primeira reunião brasileira de usuários do microPET/SPECT/CT realizada na Universidade Federal do Rio de Janeiro. Seu principal objetivo foi conhecer o cenário atual sobre os desempenhos pré-clínicos dos tomógrafos PET e medidores de atividade disponíveis nos centros de pesquisa brasileiros. É importante dizer que este trabalho foi baseado em cenário anteriormente levantado e publicado por Gontijo *et al*. (2020) e é devido a mudanças no cenário atual. As respostas foram compiladas e estatística descritiva foi aplicada. Existem ainda seis centros de imagem molecular pré-clínicos no Brasil utilizando sete sistemas PET para animais de pequeno porte. Entre eles, cinco estão na região sudeste e um na região sul. A plataforma Triumph II com software LabPET ainda é predominante (usada em 4 serviços); o fabricante Albira é usado em 2 centros diferentes e Molecubes é usado em um centro que tem 2 sistemas disponíveis atualmente. Todos os serviços possuem conhecimento da publicação NEMA NU 4/2008 específica para sistemas PET de pequeno porte. No entanto, não há nenhum programa de garantia de qualidade para o tomógrafo PET implementado na maioria dos centros, mas é unânime sua importância no campo de pesquisa de imagem molecular pré-clínica.

Palavras-chave: PET pré-clínico; garantia da qualidade; NEMA NU 4-2008

Abstract

The aim of this work was to update the Brazilian scenario regarding the quality assurance program of preclinical PET imaging systems. An electronic survey (in Portuguese) was prepared and applied to all Brazilian preclinical molecular imaging services that participated in the first Brazilian microPET/SPECT/CT users meeting held at the Federal University of Rio de Janeiro. Its main goal was to know the current scenario of preclinical PET scanners and dose calibrator performances available at the Brazilian research centers. It is important to note that this work was based on a scenario previously proposed and published by Gontijo et al. (2020) due to changes in the current scenario. The answers were compiled, and descriptive statistic was applied. There are currently six preclinical molecular imaging centers in Brazil using seven PET systems for small animals. Among them, five are in the southeastern region and one in the south region. Triumph II platform with LabPET software is still predominant (used in 4 services); the Albira manufacturer is used in 2 different centers and Molecubes is used in a center that has 2 systems available. All services know of the NEMA NU 4/2008 publication specific to small animal PET systems. However, there is no quality assurance program for PET scanner implemented in most of the centers, although its importance is unanimous in the preclinical molecular imaging research field.

Keywords*: Preclinical PET; Quality Assurance; NEMA NU 4-2008*

1. Introduction

Preclinical positron emission tomography (PET) is an important molecular imaging modality of small animals such as rats and mice. This imaging technology can generate static and dynamic images to study biochemical, metabolic, and functional processes of organs and tissues (1). In the context of nuclear medicine, these systems are widely used for the development of new radiopharmaceuticals or in studies of new applications of traditional radiopharmaceuticals (2).

The National Electrical Manufactures Association (NEMA) produces technical documents regarding quality control procedures for various products, including medical equipment such as single-photon emission computed tomography (SPECT) and PET for human (clinical) and animals (preclinical). The NEMA NU 4/2008 publication presents all the methodological parameters and needs for the small-animal PET scanner quality control. According to the standard publication, PET performance should be evaluated by the following parameters (3):

I. Spatial Resolution.
II. Sensitivity.
III. Coincidence Events Rate.
IV. Image Quality.

In addition to the PET system another important equipment, the dose calibrator, is used daily in the laboratorial routine and requires continuous evaluation of its performance (4,5).

In Brazil, there are few preclinical PET scanners in use and to know where they are installed and how they are working is important to harmonize their use

in the research field (6), especially regarding their quality performance. Every imaging technology needs to be evaluated by a set of quality tests that confirms their performance or indicates the need for corrective maintenance (3, 7). Quality control (QC) is a set of safety and performance tests executed periodically to assess whether the radiation measuring device continues to meet the requirements of current national and international resolutions and the reference values established during acceptance test (4). QC is part of the quality assurance program that allows functional image acquisition for correct measurements and analysis.

In Brazil, there is no specific legislation that requires quality tests for PET imaging system or dose calibrators in preclinical imaging laboratories. National regulatory agencies do not yet have a publication to establish in detail all necessary tests for preclinical equipment. In addition, there is a lack of knowledge for some methodological aspects of small-animals PET (8).

Thus, the aim of this work was to update the Brazilian scenario regarding the quality assurance program of preclinical PET imaging systems.

2. Materials and Methods

An electronic survey (in Portuguese) was prepared and applied to preclinical PET users. Its main goal was to know the current scenario of preclinical PET scanners available in Brazilian research centers as well as their performance. The electronic survey contained specific topics on preclinical PET systems and their quality assurance programs. Table 1 presents the topics covered in the survey.

Table 1 - Topics covered in the electronic survey

Topics covered			
i)	Preclinical PET systems	Quantity and type (manufacturer and model)	
ii)	Quality assurance program (QAP)	PET systems	Dose calibrator
	Quality control tests	NEMA NU 4/2008 publication [3]	National regulation [4]
	Materials and methods	Specific phantoms and sources required	Sources required

Source: Gontijo *et al* (2022).

In addition to the topics in Table 1, it was asked whether there is an interest in the implementation of a quality assurance program.

The electronic research was sent by e-mail to all Brazilian molecular imaging preclinical centers that participated on the first microPET/SPECT/CT Users meeting held at the Federal University of Rio de Janeiro in 2015. It is important to note that this study is an update of the survey previously conducted by Gontijo *et al*. (2020) due to changes in the current scenario involving quantity available preclinical PET scanners in use. The answers were compiled in Microsoft Excel and descriptive statistics were computed for further analyses.

3. Results and Discussions

Table 2 presents the results of the first topic covered in the electronic survey.

Table 2 - Preclinical PET systems (quantity and type) used in Brazilian research centers

Center	Institution	Imaging System
1	IPEN/CNEN, SP	Albira Trimodality PET/SPECT/CT
2	HCFMUSP, SP	Triumph® II LabPET 8 Trimodality PET/SPECT/CT Molecube Q8
3	UNICAMP, SP	Trimodality PET/SPECT/CT
4	UFRJ, RJ	Triumph® II LabPET 8 Trimodality PET/SPECT/CT
5	CDTN/CNEN, MG	Triumph® II LabPET Solo 4
6	PUC-RS, RS	Triumph® II LabPET 4 Bimodality PETCT

CDTN: Centro de Desenvolvimento da Tecnologia Nuclear; CNEN: Comissão Nacional de Energia Nuclear; HCFMUSP: Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo; IPEN: Instituto de Pesquisas Energéticas; PUC-RS: Pontifícia Universidade Católica do Rio Grande do Sul; RJ: Rio de Janeiro; RS: Rio Grande do Sul; SP: São Paulo; UFRJ: Universidade Federal do Rio de Janeiro; UNICAMP: Universidade de Campinas;
Source: Gontijo *et al* (2022).

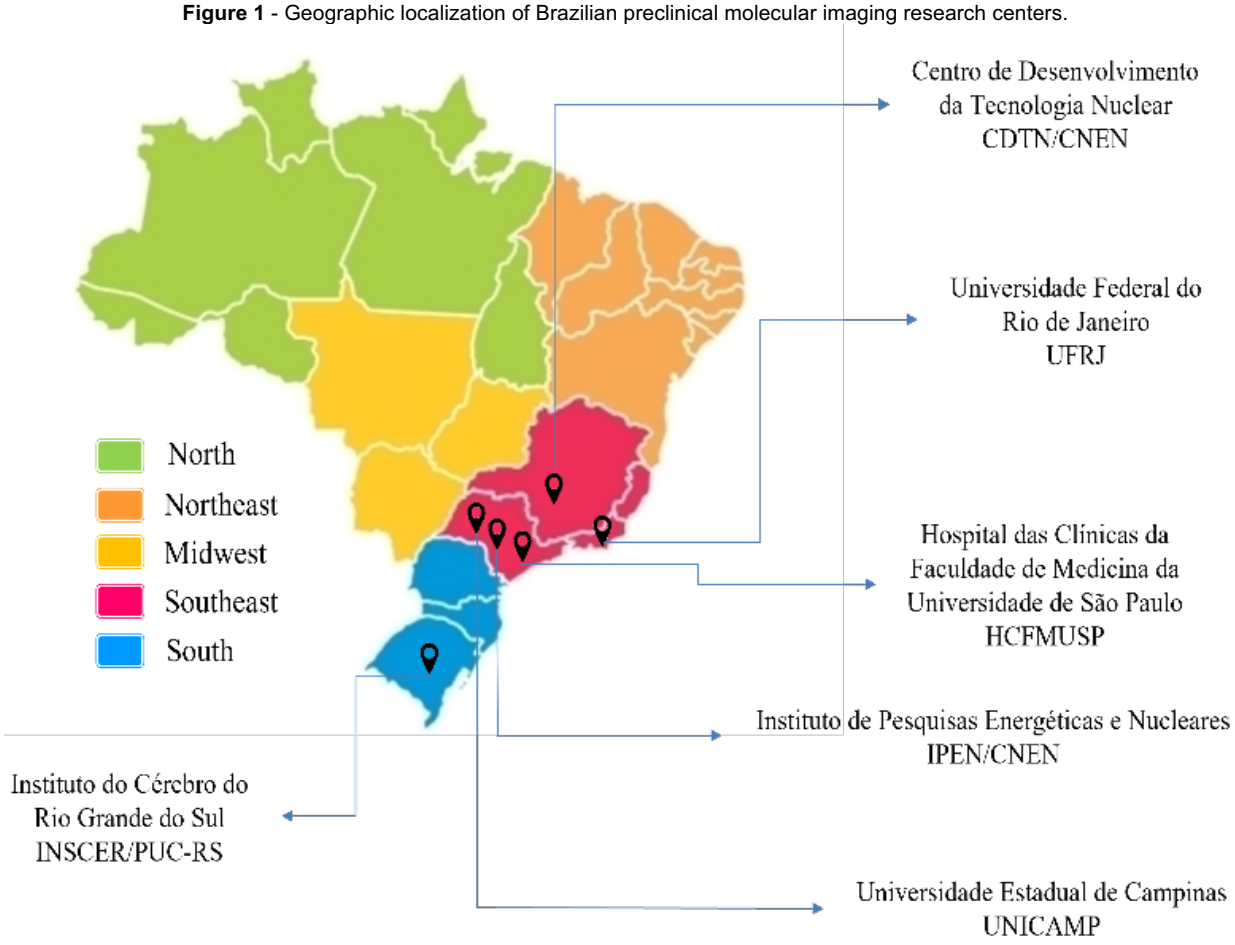
Figure 1 shows the geographic distribution of preclinical molecular imaging research centers in Brazil. There are six preclinical molecular imaging services using currently seven small-animal PET scanners. Among them, five centers are in the southeastern region and one in the south region. No scanner is available in the North, Northeast, or Midwest regions. All preclinical molecular imaging services replied to the electronic survey.

Most imaging technology available in Brazil has hybrid modalities, with computed tomography coupled (CT) and/or SPECT.

Triumph II platform with LabPET software is predominant (used in 4 services); the Albira manufacturer are used in 2 different centers and Molecubes is used in a center that has 2 systems available.

Table 3 shows part of the internal quality assurance procedures adopted in each center. Centers were not identified to preserve the internal routines.

Figure 1 - Geographic localization of Brazilian preclinical molecular imaging research centers.



Source: Gontijo et al. (2022)

Table 3 - Quality assurance Program (tests and materials) adopted in centers

Centers§	Phantoms (NEMA) and Sources	Quality Assurance Program (QAP) Implemented		Interest in QAP
		PET system	Dose calibrator	
i	No	No	Yes	Yes
ii	No	No	Yes	Yes
iii	Yes	Yes	Yes	Yes
iv	*	*	Yes	Yes
v	No	No	Yes	Yes
vi	No	No	Yes	Yes

§Centers not identified for confidentiality. *Information not provided.
Source: Gontijo *et al* (2022).

In addition to the answers presented in the table above, all services stated that they are familiar with NEMA NU 4-2008 and its performance evaluation methods specific to small animal PET scanner.

Considering the Brazilian scenario of six centers of molecular imaging preclinical only one has quality assurance program implemented (PET imaging system and dose calibrator). Tests to assess the performance of dose calibrators are described in the manufacturer's manual and in the CNEN standard 3.05 for clinical nuclear medicine services.

This study reveals the current small-animal PET systems available in Brazil, as well as information around feasibility of evaluating the performance of these imaging systems. In addition, this paper alerts all users for the importance of performing the quality control tests in their routines and allows strategies to propose a national program for small animal PET quality assurance.

5. Conclusion

There are seven preclinical PET devices installed in Brazil and most are concentrated in the southeast region. Only one center has 2 PET systems available. Only one research center has the totally quality assurance program implemented for the PET scanner including specific phantoms and point source as recommended by NEMA NU 4/2008 publication. There is no quality assurance program for the PET scanner in most of the centers, but its importance is unanimous in the preclinical molecular imaging research field.

In summary, small animal PET has an important role in bridging the gap between basic, preclinical, and clinical research and clinical application. Thus, the present study is an update of the scenario regarding the adoption (or not) of a quality assurance program in preclinical PET systems in Brazil and an initial step to corroborate a proposal for national standardization.

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