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QUALITY CONTROL IN SMALL ANIMAL PET SCANNERS: ANALYSIS OF THE BRAZILIAN SCENARIO IN 2024.

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ABSTRACT

Positron Emission Tomography (PET) is an important modality of molecular imaging, and its applications in small animals, especially rodents, have grown significantly in recent years. In the practice of studies using PET molecular imaging, it is essential to implement Quality Control Programs. Considering the constant technological advancement in the field, this study presents an update of the national scenario regarding small animal's PET scanners and activity meters in use in different Brazilian molecular imaging services. Additionally, the aim is to investigate the quality assurance programs involving small animal PET imaging. It is worth noting that this study was based on previous research conducted by Gontijo *et al.* (2020 and 2022) and covered changes that occurred in the scenario from 2022 onwards. An electronic survey was sent to Brazilian molecular imaging services that participated in the first and/or second national meeting of micro PET/SPECT/CT users, held in 2015 and 2023, respectively. The survey responses were compiled and subjected to descriptive statistical analysis. This study revealed a new small animal PET molecular imaging service in the country. Thus, it was possible to ascertain that there are currently seven molecular imaging services dedicated to small animals in Brazil, operating a total of eight PET scanners, one of which is still in the initial testing phase. Of the seven services, five are located in the southeast region, one in the south region, and one in the northeast region. The majority (four units) of the small animals PET scanners installed in Brazil are from the Gamma Medical (GE) manufacturer, Triumph® platform. The Bruker manufacturer, Albira platform, is found in two services. Additionally, there is one scanner from the Molecube manufacturer, β-Cube platform, and another from the Milabs manufacturer, U-PET/CT platform. The results also showed that, although all services demonstrate interest in quality assurance and agree on its importance, the existence of a quality assurance program for small animals PET scanners is not yet common in Brazil.

1. INTRODUCTION

Preclinical positron emission tomography (PET) is essential in molecular imaging, as it is applied to small animals such as rats and mice. This technique allows the acquisition of both static and dynamic images and enables a detailed analysis of functional, biochemical, and metabolic processes in organs and tissues [1].

Through the use of preclinical PET in small animals, it is possible to develop advanced radiopharmaceuticals and identify new options for treatments with conventional radiopharmaceuticals, making it essential in nuclear medicine research centers [2].

Working in conjunction with PET equipment, the dose calibrator is a fundamental tool employed daily in the routine of a laboratory to monitor the activity of radioisotopes used in research with small animals. It allows for precise quantification of radioactivity, ensuring the correct activity for imaging studies, which is essential for obtaining reliable and reproducible results.

Additionally, it enhances safety by controlling radiation exposure levels for both researchers and animals [3].

In the routine of molecular imaging laboratories, quality control involves safety and performance tests that are conducted periodically to ensure that equipment continues to meet the requirements of current national and international regulations, as well as the reference values established during acceptance testing. This control is part of the quality assurance program and enables the acquisition of functional images for accurate measurements and analysis [3].

In relation to the activimeter, tests to assess its performance are described in the manufacturer's manual and in the national standard CNEN 3.05 for clinical nuclear medicine services. The standard regulates clinical nuclear medicine services in Brazil, establishing criteria for evaluating device performance in clinical research laboratories. In this context, it is possible to use the same criteria for routine use in preclinical laboratories, such as those for research with small animals. Performance tests are conducted periodically and include factors such as: (I) Repeatability; (II) Zero adjustment; (III) Background radiation; (IV) Linearity tests; (V) High voltage tests; (VI) Accuracy and precision; (VII) Geometry tests [3, 4].

The National Electrical Manufacturers Association (NEMA) produces technical documents that encompass quality control procedures for various products, including medical equipment such as Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET), both for human (clinical) and animal (preclinical) use. The document NEMA NU 4/2008 outlines methodological criteria and requirements for the quality control of preclinical PET scanners. According to this publication, equipment performance is evaluated based on the following points: (I) Spatial Resolution; (II) Sensitivity; (III) Coincidence Event Rate; (IV) Image Quality [5].

It should be emphasized that this publication has been discontinued, but it continues to be used as a reference for standardization criteria due to the lack of specific regulations replacing it for preclinical PET scanners. It is essential that all preclinical PET equipment undergo regular quality tests to assess their performance or identify the need for corrective maintenance [5, 6].

National regulatory agencies have not developed a publication establishing which tests are necessary to assess the proper functioning of this equipment. For this reason, there is a need to improve knowledge regarding the methodological processes of using preclinical PET in Brazil [7].

Currently, there are seven research centers in Brazil that use preclinical PET scanners, identified by their participation in the first and/or second national meeting of micro PET/SPECT/CT users, held in 2015 and 2023, respectively. Despite this, it is important to map their locations, learn more about their routines and applications in research, and be able to assess their quality performance [8].

Fig. 1 shows the geographic distribution of Brazilian preclinical molecular imaging research centers. Currently, in 2024, there is one more center than in the previous survey conducted in 2022 [9].

Among these centers, one is in the South region, one in the Northeast region, and the remaining five are in the Southeast region. There are no PET scanners for small animals available in the other regions.

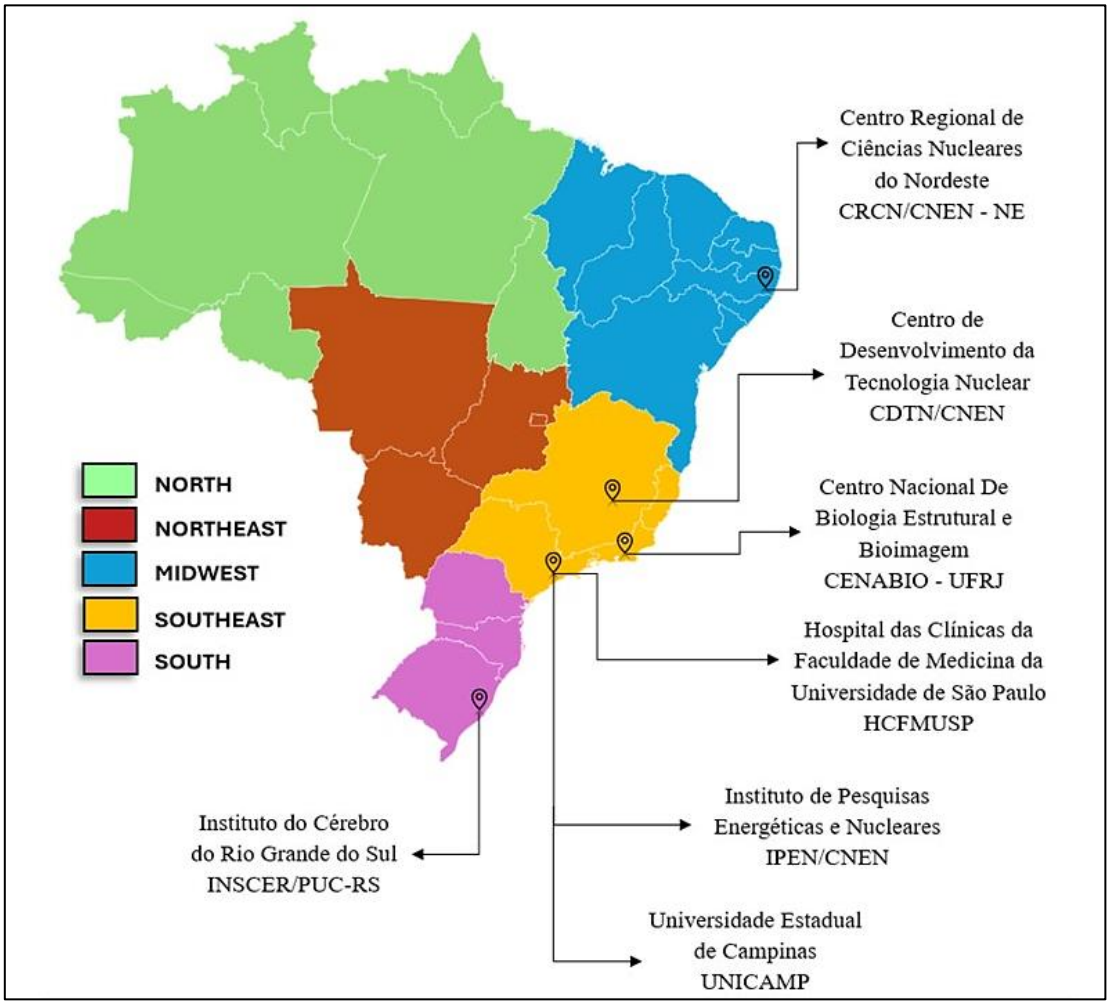

Fig. 1. Geographic Distribution of Brazilian Preclinical Molecular Imaging Research Centers in 2024.

The objective of this work was to update the Brazilian scenario regarding the quality assurance program of preclinical PET imaging systems used in research centers. It is important to emphasize that this study is an update of the research previously conducted by Gontijo et al. (2020 and 2022) [7, 9] and aims to verify the changes or lack thereof in the Brazilian scenario regarding the use and management of quality in preclinical PET scanners used in research centers.

2. METODOLOGY

An electronic survey was developed and applied to users of preclinical PET scanners. The survey access link was sent via email to all responsible individuals from Brazilian molecular imaging centers.

The research included specific topics on preclinical PET systems and their quality assurance programs, as illustrated in Fig. 2.

1) How many imaging devices does the center-laboratory have for small animal molecular imaging?
☐ None ☐01 ☐02 ☐03 ☐ Others

2) What are the model(s) and manufacturer(s) of the equipment? Please cite individually if there is more than one.

3) Is there a Quality Assurance Program implemented for the Small Animal PET equipment?
☐ Yes ☐No

- ***If the answer to the previous question is "no" is there interest in implementing it?***

4) Do the system users know the publication NEMA NU 4-2008 [Performance Measurements of Small Animal Positron Emission Tomographs]?
☐ Yes ☐No

- ***If the answer to the previous question is "yes" do they have NEMA - specific simulators (and/or point source) for small animals? Which ones?***

5) Regarding the activimeter (activity meter), are quality control tests performed periodically?
☐ Yes ☐No

6) Does the preclinical Molecular Imaging laboratory (PET and/or SPECT) have a specific professional responsible for performing quality control tests? If so, what is their educational background? Do they have certification as a Radiation Protection Supervisor by CNEN (RPS)?

Fig. 2. List of questions from the electronic survey.

The obtained answers were transferred to Excel, and descriptive statistics were applied for the necessary analyses.

3. RESULTS

All preclinical molecular imaging centers responded to the electronic survey, except for one. Tab. 1 presents the results related to Brazilian preclinical imaging centers which responded the survey.

Tab. 1. Data provided by research centers regarding PET scanners for small animals

RESEARCH CENTER	IMAGING SYSTEM	MANUFACTURER
IPEN/CNEN, SP	Albira Trimodality PET/SPECT/CT	Bruker
HCFMUSP, SP	β-Cube Q8	Molecube
UFRJ, RJ	Triumph® II LabPET 8 Trimodality PET/SPECT/CT	Gamma Medical (GE)
CDTN/CNEN, MG	Triumph® II LabPET Solo 4	Gamma Medical (GE)
PUC-RS, RS	Triumph® II LabPET 4 Bimodality PETCT	Gamma Medical (GE)
CRCN/CNEN-NE, PE	U-PET/SPECT/CT	MIlabs

Most of the equipment available in Brazil consists of hybrid modalities, with computed tomography (CT) and/or SPECT integrated. The Triumph® II platform with LabPET software is predominant, used in 3 centers; the Albira system, the β-Cube and the U-PET system are each used in one center.

Tab. 2 shows the results regarding the quality assurance programs adopted or not adopted at each center. The centers have been kept anonymous to preserve their internal routines.

Tab. 2. Quality assurance program (tests and materials) adopted at the centers

QUESTIONS	**CENTERS***						
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**
Quality assurance program implemented	Yes	No	No	No	No	No	**
Interest in a quality assurance program?	Yes	Yes	No	Yes	Yes♦	Yes	**
Tests on activimeter	Yes	Yes	No	Yes	No	Yes	**
Do system users know the NEMA publication?	Yes	Yes	No	Yes	Yes	Yes	**
Does the facility have simulators and sources?	Yes	Yes	No	Yes	No	**	**
Does the facility have a professional with RPS♦♦ certification?	Yes	Yes	No	No	No	Yes	**

*Centers not identified to maintain the confidentiality of responses.
**Information not provided.
♦ Quality management program in the analysis phase for implementation in the laboratory, according to the answer provided in the survey.
♦♦ Radiation Protection Supervisor certified by CNEN.

The results reveal that, in the 2024 Brazilian scenario, there are seven preclinical molecular imaging centers in operation, of which only one has an implemented quality assurance program, including tests for the PET scanner for small animals and tests for the activimeter.

It is noted that, although only one center has implemented the quality assurance program, four of the remaining six centers have shown interest in adopting it, one has no interest, and one did not respond to the survey. It can be observed that most centers have users who are familiar with the NEMA NU – 04/2008 publication, but not all of them use its phantoms and/or sources.

This study revealed the PET systems for small animals currently available in Brazil and provided information on the feasibility of assessing the performance of these imaging systems.

In addition, the study highlights the importance of conducting quality control tests regularly and demonstrate the potential for implementing a national quality assurance program for small animal PET systems, given its importance and the lack of regulation for such programs in Brazil.

4. CONCLUSION

In Brazil, there are seven preclinical PET systems installed across seven research centers, with the majority located in the Southeast region. Only one research center has implemented the complete quality assurance program for the PET scanner, including specific simulators and point sources, in accordance with the recommendations of the NEMA NU 4/2008 publication.

Although most centers have not yet implemented a quality assurance program, the majority of those responsible for preclinical molecular imaging centers recognizes its importance. One of the centers is even in the process of implementing the program.

In summary, PET for small animals plays a crucial role in bridging basic research, clinical research, preclinical studies, and clinical applications. This study updates the scenario regarding the adoption (or lack thereof) of quality assurance programs for preclinical PET systems in Brazil and represents another step toward supporting the proposal for national standardization of quality assurance programs.

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