THERANOSTICS IN NUCLEAR MEDICINE: INTEGRATING DIAGNOSTIC PRECISION AND PERSONALIZED THERAPY

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Abstract

Theranostics in nuclear medicine is an innovative approach that integrates molecular diagnosis and targeted therapy through the use of specific radiopharmaceuticals, enabling greater precision in disease characterization and more individualized treatment. This study is a descriptive literature review aimed at analyzing the application of theranostics in nuclear medicine, with emphasis on its foundations, main radiopharmaceuticals, clinical indications, benefits, and prospects for personalized medicine. The methodology was based on an analysis of scientific publications concerning the use of theranostic pairs, particularly in prostate cancer and neuroendocrine tumors, with consideration given to molecular imaging methods and radionuclide therapies. The results demonstrate that this approach enables the prior identification of molecular target expression, the selection of patients with a greater likelihood of therapeutic response, the delivery of radionuclides to tumor cells, and the monitoring of treatment effectiveness. The integration of diagnosis and therapy was also found to have the potential to improve therapeutic precision and reduce unnecessary exposure of healthy tissues. It is concluded that theranostics represents a major advance in contemporary nuclear medicine, contributing to more individualized treatments and strengthening precision medicine.

Keywords: Nuclear Medicine, Personalized Therapy, Precision Medicine, Radiopharmaceuticals, Theranostics.

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INTRODUCTION

Nuclear medicine has significantly expanded its role in healthcare, particularly in oncology, by enabling the assessment of biological and molecular processes that cannot always be identified solely through anatomical changes. In this context, theranostics has gained prominence by combining, within a single clinical strategy, two stages traditionally addressed separately: diagnosis and therapy. The term is derived from the combination of therapy and diagnostics and, in nuclear medicine, refers to the use of molecules directed at specific biological targets and labeled with radionuclides suitable for imaging or treatment. Thus, the target identified during the diagnostic stage can serve as a reference for selecting and directing therapy (Herrmann et al., 2020).

This possibility has changed how the role of radiopharmaceuticals in clinical practice is understood. Rather than using them exclusively to locate or characterize abnormalities, the theranostic approach allows information obtained from imaging studies to contribute directly to therapeutic decision-making. Könik et al. (2021) emphasize that integrating quantitative imaging with radionuclide therapy makes it possible to assess the distribution of radiopharmaceuticals in tumors and normal tissues, providing important information for individualized treatment planning. In this way, nuclear medicine is increasingly aligned with the principles of precision medicine, in which the biological characteristics of both the disease and the patient are considered when defining the course of treatment.

Although the use of radionuclides for both diagnosis and treatment is not a recent concept, advances made over the past several decades have substantially strengthened this field. The use of radioiodine in thyroid diseases is considered one of the best-known historical examples of this principle. Today, however, new molecules and biological targets have broadened the potential applications of theranostics, particularly in oncology. Among the strategies that have achieved the greatest clinical development are those directed at somatostatin receptors, which are present in certain neuroendocrine tumors, and at prostate-specific membrane antigen (PSMA), which is used in the management of prostate cancer (Solnes et al., 2020).

The rationale underlying these applications can be understood through the prior identification of a molecular target. In neuroendocrine tumors, for example, somatostatin receptor expression can be assessed using molecular imaging with specific radiopharmaceuticals. When sufficient target expression is demonstrated, radionuclide therapy directed at the same receptor may be considered. Similarly, in prostate cancer, PSMA-targeted molecular imaging can help identify patients who are more likely to benefit from radioligand therapies. This model contributes to treatment selection based on the characteristics demonstrated by the disease in each patient, rather than relying exclusively on the tumor's anatomical or histological classification (Virgolini et al., 2018).

Lutetium-177 is among the radionuclides that have gained prominence in this context and is used in therapies directed at different molecular targets. The expansion of therapies using ^177Lu combined with specific ligands represents one of the most significant examples of the incorporation of theranostics into contemporary oncology. In metastatic castration-resistant prostate cancer, for example, PSMA-targeted therapy has become an important area of clinical development. Sartor and Herrmann (2022) emphasize the growing importance of ^177Lu-PSMA-617 following the results of phase III clinical trials, thereby strengthening the role of theranostic strategies in the treatment of advanced prostate cancer.

Despite these promising results, the incorporation of theranostics also involves issues that must be carefully examined. Appropriate patient selection, the availability of radiopharmaceuticals and radionuclides, nuclear medicine service infrastructure, the training of multidisciplinary teams, the evaluation of treatment response, and the determination of therapeutic activity are important considerations for its safe and effective use. Challenges also remain regarding the standardization of protocols and follow-up criteria, particularly as new targets and radiopharmaceuticals are incorporated into clinical practice. Herrmann et al. (2020) note that the development of radiotheranostics requires not only scientific innovation but also appropriate organizational structures to support the sustainable incorporation of these technologies into healthcare systems.

In view of this context, the following question was established as the guiding research problem of this study: How does the integration of molecular diagnosis and targeted therapy provided by theranostics contribute to increasing diagnostic precision and promoting treatment personalization in nuclear medicine? This discussion is relevant because identifying the therapeutic target in advance can help select patients with a greater likelihood of benefiting from treatment while also enabling treatment response to be monitored. According to Solnes et al. (2020), advances in theranostics have the potential to significantly change the management of different malignancies by strengthening the relationship between molecular imaging, patient selection, and targeted therapies.

The general objective of this chapter is to analyze the application of theranostics in nuclear medicine and its contribution to the integration of diagnostic precision and personalized therapy. Specifically, it seeks to explain the foundations of the theranostic approach; describe the role of radiopharmaceuticals and the main radionuclides used in diagnosis and treatment; discuss relevant clinical applications, particularly in neuroendocrine tumors and prostate cancer; analyze the benefits of selecting patients through molecular imaging; and identify the challenges and prospects associated with the expansion of this strategy in precision medicine.

This study is justified by the growing importance of personalized medicine in the care of patients with complex diseases, particularly in oncology. Theranostics has one especially relevant characteristic: before a particular radionuclide therapy is administered, it is possible to investigate whether the molecular target is sufficiently present in that patient's disease. This association tends to support better-informed therapeutic decisions and may prevent unsuitable interventions in individuals whose target expression is insufficient. In addition, molecular imaging can be used to monitor radiopharmaceutical distribution and evaluate therapeutic response, expanding the possibilities for monitoring throughout treatment (Könik et al., 2021).

Studying theranostics therefore entails discussing an important change in the role of nuclear medicine itself. The field is no longer associated predominantly with diagnostic imaging and is assuming

an increasingly prominent position in the selection, delivery, and monitoring of targeted therapies. Advances involving targets such as somatostatin receptors and PSMA demonstrate that diagnosis and treatment can form part of a single strategy based on the molecular characteristics of the disease. At the same time, expansion to new targets and radionuclides indicates that theranostics is likely to remain one of the areas of greatest interest in the development of nuclear medicine and precision oncology in the coming years (Weber et al., 2020).

METHODOLOGY

This study is a descriptive and exploratory literature review with a qualitative approach, conducted to gather and discuss scientific knowledge related to theranostics as applied to nuclear medicine. This research design was selected because of the need to understand the foundations of the integration between molecular diagnosis and radionuclide therapy, as well as its main clinical applications, benefits, limitations, and prospects in the context of precision medicine.

According to Gil (2022), bibliographic research is based on previously published materials and allows researchers to analyze the various existing contributions concerning a particular problem. Accordingly, the methodological process was organized to provide a well-founded analysis of the literature without restricting the discussion to a single radiopharmaceutical, radionuclide, or type of malignancy.

RESEARCH TYPE AND DESIGN

This is a narrative literature review of a descriptive and exploratory nature. This type of review is appropriate when the aim is to present a broad understanding of a particular subject by integrating conceptual aspects and evidence produced by different types of studies. Unlike systematic reviews, narrative reviews allow for a more comprehensive discussion of the development and applications of a

field of knowledge and are particularly useful for subjects characterized by rapid technological development and diverse clinical approaches.

The research was descriptive because it sought to present the characteristics of theranostics, the mechanisms involved in the use of radiopharmaceuticals, and their main applications. Its exploratory component concerned the investigation of recent advances, limitations, and prospects associated with this approach. The qualitative analysis focused on interpreting and integrating information found in the literature while considering its contribution to understanding the relationship among diagnosis, patient selection, and personalized therapy.

SEARCH STRATEGY AND INFORMATION SOURCES

The literature search focused on the PubMed/MEDLINE, Scopus, Web of Science, and SciELO databases and was supplemented with technical documents and publications issued by recognized scientific organizations in the field of nuclear medicine. Priority was given to peer-reviewed scientific articles, reviews, clinical trials, and consensus documents concerning the clinical use of theranostics.

To locate publications, descriptors and terms related to the subject were used in Portuguese and English, including “teranóstica,” “theranostics,” “medicina nuclear,” “nuclear medicine,” “radiofármacos,” “radiopharmaceuticals,” “radionuclide therapy,” “molecular imaging,” “precision medicine,” “personalized medicine,” “PSMA,” and “neuroendocrine tumors.” The terms were used both individually and in combination to address the general foundations and specific applications of theranostics.

The search also included publications concerning diagnostic and therapeutic pairs used in clinical practice, particularly those targeting prostate-specific membrane antigen, or PSMA, and somatostatin receptors. These two applications received particular attention because they are important examples of the consolidation of the theranostic approach in contemporary oncology (Herrmann et al., 2020; Solnes et al., 2020).

INCLUSION AND EXCLUSION CRITERIA

Scientific articles, reviews, and clinical studies published preferably between 2015 and 2026 in Portuguese or English were considered eligible if they were directly related to the use of theranostics in nuclear medicine. Publications predating this period were retained when considered relevant to the historical or conceptual contextualization of the subject.

The inclusion criteria encompassed studies addressing the foundations of theranostics; the use of radiopharmaceuticals for diagnosis and therapy; molecular imaging applied to patient selection; radionuclide therapy; neuroendocrine tumors; prostate cancer and PSMA; dosimetry; therapeutic response assessment; safety; limitations; and prospects for personalized nuclear medicine.

Publications that were not directly related to the study objective, duplicate studies, texts containing insufficient information to support the discussion, and studies that addressed diagnostic techniques exclusively without establishing a relationship with the theranostic principle were excluded.

SELECTION AND ORGANIZATION OF THE MATERIAL

Following the initial search, titles and abstracts were reviewed to identify the publications most closely aligned with the established objectives. The available full texts of potentially relevant studies were examined, with particular attention to the research purpose, study population, radiopharmaceuticals used, molecular target, imaging modality, therapeutic radionuclide, clinical outcomes, adverse effects, and conclusions presented by the authors.

To organize the information, an analysis matrix was adopted that included the author and year of publication, study design, clinical application, molecular target, radiopharmaceutical or radionuclide used, key findings, and contribution to theranostics. This procedure made it possible to compare different publications and identify recurring themes in the literature.

The analysis was not intended to perform a meta-analysis or calculate a pooled effect because the study was designed as a narrative review. The bibliographic sample therefore consisted of the set of

publications selected after the eligibility criteria had been applied, based on their relevance to answering the research problem and meeting the proposed objectives.

DATA ANALYSIS AND DISCUSSION

The extracted information underwent qualitative analysis and was organized according to thematic similarities. The discussion was structured around four main themes: the foundations of theranostics and its relationship with precision medicine; radiopharmaceuticals and theranostic pairs; applications in neuroendocrine tumors and prostate cancer; and the benefits, limitations, and prospects of personalized radionuclide therapy.

The interpretation of the studies considered that theranostics is not limited to combining an examination with a treatment but involves identifying a molecular target capable of guiding patient selection and subsequent therapeutic intervention. Herrmann et al. (2020) emphasize that radiotheranostics occupies an important position in the expansion of personalized medicine, particularly because information obtained through molecular imaging can be used to direct specific treatments.

In the field of neuroendocrine tumors, evidence concerning the identification of somatostatin receptors and targeted radionuclide therapy was analyzed. For prostate cancer, the analysis focused primarily on PSMA-based applications, as PSMA expression can be assessed by molecular imaging and subsequently exploited for therapeutic purposes. This strategy became particularly relevant with the development of lutetium-177-labeled radioligands, which expanded therapeutic possibilities for patients with advanced disease (Sartor; Herrmann, 2022).

The discussion also considered the results of major clinical trials. In the VISION trial, Sartor et al. (2021) demonstrated the clinical benefits of treatment with ^177Lu-PSMA-617 in addition to standard care in selected patients with metastatic castration-resistant prostate cancer. In neuroendocrine tumors, Strosberg et al. (2017), in the NETTER-1 trial, demonstrated significant results for therapy with ^177Lu-DOTATATE in patients with advanced midgut neuroendocrine tumors.

A joint analysis of this evidence made it possible to discuss how the prior identification of molecular targets can contribute to patient selection, guide treatment choice, and support the monitoring of treatment response. Aspects related to toxicity, dosimetry, radiopharmaceutical availability, required infrastructure, and the need for specialized teams were also considered. The aim was therefore to develop a balanced discussion addressing not only the benefits of theranostics but also the barriers that continue to hinder its broader incorporation into clinical practice.

ETHICAL CONSIDERATIONS

Because this literature review was based exclusively on information from scientific publications and documents available in the literature, it involved no direct participation by human subjects and no collection of individual or identifiable data. Submission to a Research Ethics Committee was therefore unnecessary. Nevertheless, the principles of academic integrity were observed by acknowledging the sources used and respecting the authorship of the scientific works on which the research was based.

RESULTS AND DISCUSSION

The literature analysis demonstrated that theranostics occupies an increasingly important position in nuclear medicine, particularly because it establishes a direct link between identifying molecular targets and selecting treatment. The studies analyzed indicate that this strategy is currently most firmly established in the management of neuroendocrine tumors and prostate cancer, although new applications are being investigated. Overall, the evidence reveals an important shift in the approach to patient care: molecular imaging no longer performs a diagnostic function alone but also provides information for patient selection, treatment planning, and outcome monitoring.

Solnes et al. (2020) regard theranostics as one of the fields reshaping nuclear medicine within precision medicine. According to the authors, the ability to identify particular tumor targets in advance and subsequently direct a therapeutic agent toward those same targets creates conditions for a more

individualized approach. This characteristic helps explain the growing interest in the field because not all patients with the same histological diagnosis exhibit identical molecular behavior or similar expression of the targets used by radiopharmaceuticals.

INTEGRATION OF DIAGNOSIS AND THERAPY

One of the key findings of the literature review was the importance of integrating the diagnostic and therapeutic phases. In the conventional approach, imaging examinations help locate and characterize the disease and determine its extent. In theranostics, however, the information obtained through molecular imaging also assists in assessing the presence of the target to which radionuclide therapy may subsequently be delivered.

This characteristic is particularly important because it enables a form of biological selection before treatment. Rather than considering only the presence of a particular malignancy, the aim is to determine whether its cells possess molecular characteristics compatible with the proposed therapeutic agent. Marin et al. (2020) emphasize that theranostics integrates imaging and treatment within precision oncology by using disease-specific molecular characteristics to guide the clinical approach.

In practice, this integration may involve the use of the same molecule, or molecules with similar biological behavior, combined with radionuclides intended for imaging or treatment. This rationale is present, for example, in systems targeting somatostatin receptors and PSMA. The review findings therefore indicate that the main conceptual contribution of theranostics lies not only in the availability of new radiopharmaceuticals but also in the ability to connect diagnosis, patient selection, treatment, and monitoring within a single care strategy.

Box 1

Key Features of the Theranostic Approach in Nuclear Medicine

Stage	Purpose	Clinical contribution
Molecular target identification	Determine the presence and distribution of the target	Assists in patient selection
Molecular imaging	Visualize radiopharmaceutical distribution	Characterizes the disease and its extent
Treatment selection	Assess the feasibility of targeted therapy	Promotes individualized treatment
Radionuclide therapy	Deliver radiation to the tissue expressing the target	Provides targeted therapeutic action
Post-therapy assessment	Monitor distribution and response	Assists in treatment monitoring

Source: Prepared by the authors based on Solnes et al. (2020) and Marin et al. (2020).

THERANOSTICS IN NEUROENDOCRINE TUMORS

Among the applications identified in the literature, neuroendocrine tumors represent one of the most firmly established examples of the clinical use of theranostics. Many of these malignancies express somatostatin receptors, a characteristic that can be exploited for both imaging and treatment.

The clinical relevance of this strategy was clearly demonstrated by the NETTER-1 trial. Strosberg et al. (2017) evaluated 229 patients with advanced, progressive, somatostatin receptor-positive midgut neuroendocrine tumors. A total of 116 patients treated with ^177Lu-DOTATATE were compared with 113 patients in the control group, who received high-dose long-acting repeatable octreotide (octreotide LAR). At 20 months, the estimated progression-free survival rate was 65.2% in the ^177Lu-DOTATATE group and 10.8% in the control group. The objective response rate also differed, reaching 18% in the ^177Lu-DOTATATE group and 3% in the control group.

Table 1

Key findings of the NETTER-1 trial

Indicator	^177Lu-DOTATATE	Control group
Number of patients	116	113
Estimated progression-free survival at 20 months	65,2%	10,8%
Objective response rate	18%	3%
Progression or death events in the primary analysis	23	68

Source: Prepared by the authors based on Strosberg et al. (2017).

These data are relevant because they demonstrate that the theranostic principle extends beyond the theoretical domain and produces measurable clinical effects. In the primary analysis, the study found a 79% reduction in the risk of disease progression or death in the treatment group compared with the control group. In this case, somatostatin receptor expression serves not only as a tumor characteristic identified through imaging but also as a factor that enables the therapy to be directed toward the target.

This result reinforces one of the central aspects identified in this review: the effectiveness of theranostics depends on the presence of a target that is sufficiently expressed by tumor cells and accessible to the radiopharmaceutical. Molecular imaging therefore helps identify in advance those patients for whom the therapy has a biological rationale.

APPLICATION IN PROSTATE CANCER AND PSMA TARGETING

Another relevant finding was the expansion of strategies targeting prostate-specific membrane antigen, or PSMA. The high expression of this protein in a substantial proportion of prostate cancer cells, particularly in certain advanced disease settings, has made PSMA an important target for developing agents used in both positron emission tomography/computed tomography (PET/CT) and radioligand therapies

The results of the VISION trial made a decisive contribution to consolidating this application. Sartor et al. (2021) investigated ^177Lu-PSMA-617 in previously treated patients with metastatic castration-resistant prostate cancer. In the population used for the imaging-based progression-free survival analysis, median progression-free survival was 8.7 months among patients who received ^177Lu-PSMA-617 in addition to standard care, compared with 3.4 months in the control group, corresponding to a hazard ratio for progression or death of 0.40.

Table 2

Summary of theranostic applications discussed in the literature

Clinical condition	Main target	Diagnostic application	Therapeutic application
Neuroendocrine tumors	Somatostatin receptors	Somatostatin receptor imaging	^177Lu-DOTATATE
Prostate cancer	PSMA	PSMA-targeted PET	^177Lu-PSMA-617
Differentiated thyroid diseases	Iodine metabolism/uptake	Radioiodine for functional assessment	^131I

Source: Prepared by the authors based on Solnes et al. (2020), Marin et al. (2020), Strosberg et al. (2017), and Sartor et al. (2021).

The case of PSMA also demonstrates why the diagnostic stage is essential. Target expression may vary among patients and among different lesions in the same individual. Consequently, a diagnosis of prostate cancer does not automatically mean that a patient has the characteristics required for a particular PSMA-targeted treatment. The experience from the VISION trial itself demonstrates the importance of imaging-based selection before therapy, reinforcing the genuinely personalized nature of the strategy.

CLINICAL BENEFITS AND CONTRIBUTION TO PERSONALIZED MEDICINE

The literature analyzed identified the key benefits of theranostics as more rigorous patient selection, the delivery of radiation to target-expressing tissue, the possibility of monitoring, and the closer integration of diagnosis and therapeutic decision-making. Collectively, these characteristics bring nuclear medicine closer to the concept of personalized medicine.

Therapeutic radiopharmaceuticals transport radionuclides to specific molecular structures. This does not mean that normal tissues are not exposed, because certain organs may also exhibit physiological uptake or participate in the elimination of these agents. For this reason, individualization should not be regarded as synonymous with toxicity-free treatment. The benefit lies in the possibility of achieving more specific biological targeting and selecting in advance those individuals who are more likely to exhibit adequate tumor uptake.

The results of the NETTER-1 and VISION trials provide concrete examples of this contribution. The former demonstrated a substantial benefit from ^177Lu-DOTATATE in selected patients with somatostatin receptor-positive neuroendocrine tumors, while the latter showed improvements in relevant outcomes with ^177Lu-PSMA-617 in selected patients with advanced prostate cancer.

SAFETY, LIMITATIONS, AND CHALLENGES

Despite favorable results, the studies also demonstrate that theranostics should not be understood as a risk-free approach or one that can be applied indiscriminately to all patients. In NETTER-1, for example, grade 3 or 4 hematologic adverse events, including neutropenia, thrombocytopenia, and lymphopenia, were reported in small proportions of patients treated with ^177Lu-DOTATATE. These results demonstrate the need for appropriate clinical and laboratory evaluation before and during treatment.

Another challenge concerns tumor heterogeneity. A patient may have lesions with different levels of expression of a particular molecular target, which affects both image interpretation and the expected therapeutic response. This issue is particularly important in the case of PSMA because the absence or insufficient expression of the target in certain lesions may limit the effectiveness of targeted therapy.

Structural considerations must also be taken into account. Implementing theranostic programs requires the availability of radionuclides and radiopharmaceuticals, suitable infrastructure, radiation protection protocols, and trained professionals. Solnes et al. (2020) draw attention to the need to prepare nuclear medicine services and specialists to incorporate these therapies safely and effectively.

PROSPECTS FOR THERANOSTICS IN NUCLEAR MEDICINE

The findings analyzed suggest that the theranostic field is likely to continue expanding. The success achieved with somatostatin receptors and PSMA has stimulated research into other molecular targets, new ligands, and different radionuclides. Marin et al. (2020) describe the field as part of the

evolution of precision oncology, in which advances in molecular imaging and targeted therapies are expected to expand opportunities for more individualized treatment.

In this regard, the development of theranostics depends not only on discovering new radiopharmaceuticals. Improvements in dosimetry, biomarker identification, an understanding of tumor heterogeneity, and the establishment of more precise criteria for patient selection and follow-up are also important to the advancement of the field.

Overall, the results of this review indicate that the main contribution of theranostics lies in changing the relationship between diagnosis and treatment. The two processes are no longer entirely independent stages but instead constitute a sequence guided by the molecular behavior of the disease. The clinical results obtained with ^177Lu-DOTATATE and ^177Lu-PSMA-617 demonstrate the potential of this strategy, while limitations related to target expression, toxicity, infrastructure, and access indicate that its expansion must be accompanied by careful evaluation and the continuous production of scientific evidence. Theranostics is thus becoming established not only as a technological innovation but also as an approach capable of expanding the role of nuclear medicine in the development of more individualized treatments.

CONCLUSION

This study aimed to analyze the application of theranostics in nuclear medicine, considering its contribution to the integration of diagnostic precision and personalized therapy. The literature reviewed made it possible to understand the foundations of this approach, its main clinical applications, the role of radiopharmaceuticals and radionuclides, and the benefits and limitations associated with incorporating this model into precision medicine.

The results demonstrated that theranostics represents an important change in the use of nuclear medicine because it brings together stages that were traditionally conducted separately. The prior identification of molecular targets through imaging makes it possible not only to characterize the disease

but also to select patients whose characteristics are compatible with a particular radionuclide therapy. In this regard, neuroendocrine tumors and prostate cancer are relevant examples of the clinical application of this principle.

Among the evidence analyzed, particular attention was given to the results concerning ^177Lu-DOTATATE in somatostatin receptor-positive neuroendocrine tumors and ^177Lu-PSMA-617 in metastatic castration-resistant prostate cancer. These advances demonstrate that patient selection based on the molecular characteristics of the disease can promote more targeted treatments and contribute to better clinical outcomes. At the same time, the approach does not eliminate the possibility of adverse events and requires individualized assessment, clinical monitoring, and appropriate infrastructure.

Another aspect highlighted was that theranostics should not be understood merely as the combination of a diagnostic examination and a treatment. Its importance lies in establishing a care pathway in which the molecular information initially obtained contributes to therapeutic decision-making and can continue to be used to monitor response. Nuclear medicine therefore assumes a broader role in patient care by bringing diagnosis, treatment planning, and monitoring closer together.

As a contribution, this study gathers and organizes important knowledge concerning a rapidly expanding field, highlighting its clinical potential without overlooking challenges such as tumor heterogeneity, toxicity, dosimetry, radiopharmaceutical availability, specialized infrastructure, and unequal access to new technologies. The consolidation of theranostics will depend not only on the development of new agents but also on the capacity of healthcare services to incorporate them safely, on a sound evidentiary basis, and in an accessible manner.

It is therefore concluded that theranostics has the potential to strengthen personalized medicine by enabling certain therapeutic decisions to be guided by the molecular characteristics demonstrated in the individual patient. The results already observed in certain malignancies indicate that this integration can provide relevant clinical benefits, although some issues still require further clarification. Future research

should investigate new molecular targets and radionuclide combinations, improve individualized dosimetry strategies, and evaluate long-term outcomes, safety, quality of life, and cost-effectiveness.

Studies addressing access to and implementation of these technologies in different healthcare systems, including the Brazilian context, are also necessary so that scientific advances can be effectively incorporated into healthcare delivery.

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