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Radio-Theranostics: New Era in Molecular Imaging and Radiotracer in Bangladesh

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The term theranostics is a combination of two words, therapeutics and diagnostics. Theranostic agents are paired agents, one an imaging agent to see the lesion and the other a companion therapeutic agent that treats the same lesions. The most relevant application of theranostics is in nuclear medicine, where it is called radio-theranostics. Paired radionuclides attached to a common probe are used first for imaging the tumor with a specific PET scan and then treating the same using a therapeutic radionuclide attached to the same probe (1). Theranostics in nuclear medicine offer several advantages over traditional cancer treatments. Nuclear Medicine (NM) offers a comprehensive, systemic approach to cancer treatment, targeting both primary and metastatic lesions with fewer side effects.

Theranostics in NM have shown promising results in the treatment of neuroendocrine tumors (NETs). The first step in theranostics for NETs is the diagnosis and staging of the disease using a radiolabeled somatostatin analog and PET/CT imaging. After the identification of the tumor, the same radiolabeled somatostatin analog can be used as a therapeutic agent (2). The radiopharmaceutical delivers radiation directly to the tumor cells, which destroys them while sparing surrounding healthy tissue. This is known as peptide receptor radionuclide therapy (PRRT). It is likely that theranostics in nuclear medicine will become an increasingly important tool in the fight against cancer, offering personalized, targeted treatment options that improve patient outcomes.

The earliest and best-known element in theranostics is radioactive iodine. Beginning in the 1940s, this amazing radionuclide has revolutionized the treatment of hyperthyroidism and differentiated thyroid carcinoma (DTC) all over the world (3). The foundation of therapeutic nuclear medicine in Bangladesh was also laid around radioactive iodine. Radioactive iodine therapy (RAIT) for thyroid cancer was first launched at the National Institute of Nuclear Medicine and Allied Sciences (NINMAS), and since then, RAIT became an indispensable nuclear medicine practice for the management of DTC and primary hyperthyroidism in NINMAS (4) and other 21 Institutes of Nuclear Medicine and Allied Sciences (INMAS) in the country. Another radionuclide that was used for therapy was ^{32}P (Phsosphorus-32) with a physical half-life of 14.3 days for the treatment of myeloproliferative diseases, such as polycythemia vera and essential thrombocythaemia.

Strontium-90 (^{90}Sr) applicator is another kind of therapy offered for the treatment of pterygium, a benign ocular condition. ^{89}Sr therapy, as the intravenous injection of strontium chloride, was also introduced for the treatment of bone pain resulting from osteoblastic metastases.

Positron Emission Tomography and computed tomography (PET-CT) is a gold standard imaging method for the diagnosis and management of cancer. The prominent radioisotopes used to diagnose malignant cells in PET-CT are ^{11}C (Carbon-11), ^{13}N (Nitrogen-13), 15O (Oxygen-15), and ^{18}F (Fluorine-18). ^{18}F (fluorine) is the most commonly used because of its half-life of around 110 minutes, which is greater than 11C (twenty minutes), ^{13}N (ten minutes), and ^{15}O (two minutes). Under the ownership of the Bangladesh Atomic Energy Commission (BAEC), a medium-energy (18/9 MeV, IBA) cyclotron was installed in the oncology building (Block F) of Bangabandhu Sheikh Mujib Medical University (BSMMU). [^{18}F] FDG, [^{18}F] NaF, [^{18}F] FMISO, [^{11}C]Methionine and [^{13}N] NH3 are produced in the cyclotron facility of NINMAS.

Prostate-specific membrane antigen (PSMA) is an attractive target for molecular imaging of prostate cancer and several other solid tumors because of its overexpression in prostate carcinoma and tumor neovasculature, respectively (5). In recent years, the ^{68}Ga-PSMA-labeled PSMA conjugate (PSMA-11) has successfully been used for lesion detection as well as for improving primary staging in prostate cancer patients. In accordance with the theragnostic concept, ^{68}Ga-PSMA-11 PET/CT can be used for therapeutic response assessment with ^{177}Lu-PSMA-617 in patients with prostate cancer. However, the cyclotron of NINMAS doesn't have the facilities to produce ^{68}Ga presently. Using the existing set-up, scientists of NINMAS and BAEC have synthesized [^{18}F] PSMA-1007. The successful synthesis and quality control assessment of [^{18}F] PSMA-1007 at NINMAS marks the new beginning of prostate-specific radiotracer development in Bangladesh.

Regarding the production of ^{177}Lu-PSMA-617, the 3 MW Triga Mark II research reactor of BAEC doesn't have the capacity to produce ^{177}-Lu. However, BAEC has already implemented an annual development-funded survey project for establishing a high-power multipurpose research reactor (HPMRR). Based on the findings of the survey project, BAEC and the Ministry of Science and Technology (MOST) have already initiated work to set up an HPMRR at the Atomic Energy Research Establishment (AERE), Savar. NINMAS is also working on a project to initiate cyclotron-based ^{68}Ga by using liquid targets, as well as procure a germanium-68 and gallium-68 generator and a non-carrier-added ^{177}Lu.

In this era of precision-based personalized medicine in oncology, theranostic is the ultimate example of targeted, personalized diagnostic and treatment. Continuous research in the field of theranostics will lead to the development of more novel and improved radio-theranostic agents. Interdisciplinary efforts are needed to overcome structural, financial, and educational challenges to the advancement of theranostics in regular nuclear medicine practice in Bangladesh.

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