

Seeing cancer cells, killing cancer cells

Theranostics for diagnostics and treatment

By Elisa Mattar and Nicole Jawerth

Using molecules to safely carry radioactive materials inside the human body is helping physicians get more accurate images of tumours and more effectively eliminate cancer cells. This method of combining therapeutic and diagnostic uses of radiopharmaceuticals is called theranostics. It's one of the latest advances in cancer care and one of several methods the IAEA is helping to bring to patients in countries worldwide through technology transfer and capacity building.

“Theranostics has the potential to change the idea of cancer treatment,” said Mohamad Haidar, Associate Professor of Clinical Radiology in the Department of Radiology at the American University of Beirut Medical Center in Lebanon. “It is a very efficient approach that allows you to see what you treat and treat what you see. The result is a better quality of life, improved life expectancy and minimal side effects compared to other treatments, like chemotherapy.”

While it has been used for more than 70 years for a few specific diseases, such as thyroid cancer, theranostics has only started to take off in the last few decades; advances in medicine and technology have led to the development of new radiopharmaceuticals and medical equipment, opening the door for theranostics to be used for fighting cancers of the prostate, liver, gastrointestinal system and nervous system, among others. This includes treatment of neuroendocrine tumours using a radiopharmaceutical called lutetium-177 (Lu-177)-DOTATATE (learn more about this on page 6).

Although theranostics offers the possibility to improve patient outcomes, it is not yet widely available; the method requires different skills and facilities from those readily available for other cancer care methods, such as radiotherapy, chemotherapy and surgery.

“Through IAEA support, countries across the world are setting up facilities and receiving training in nuclear medicine and radiotherapy and, when ready, safely transitioning to

personalized medicine and advanced methods such as theranostics and stereotactic body radiation therapy (SBRT),” said May Abdel-Wahab, Director of the IAEA’s Division of Human Health.

How theranostics works

In some ways, theranostics works like other medical drugs by interacting with protein molecules, which are called receptors, on the walls of cells. These receptors can bind with outside molecules, such as hormones and drugs, which activate the receptors and generate a biochemical or electric signal that tells the cell what to do, such as to stop producing the chemicals that signal pain to the brain.

Different molecules are attracted to different types of receptors. By knowing which molecules go with which receptors, medicines can be created that link the right molecules with, for example, pain-blocking chemicals that the molecules then carry to the right cell receptors to, say, stop a headache.

This is the same with radiopharmaceuticals; radioactive materials are linked to molecules that have been selected based on how they interact with the body when certain cancers are present. The molecules then carry the radioactive materials to the target tumour for diagnostic imaging or treatment. As the healthy cells do not have the same receptors as the target cells, the radiopharmaceuticals bypass them and do not damage them.

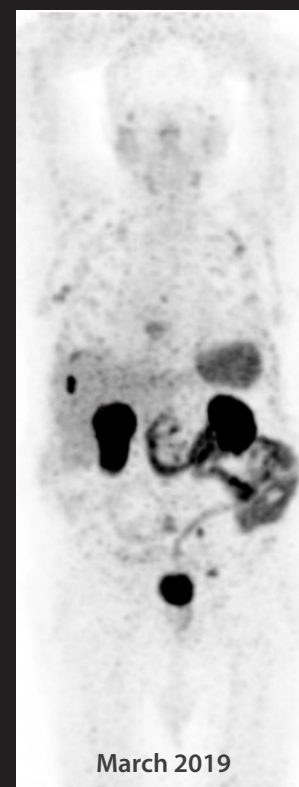
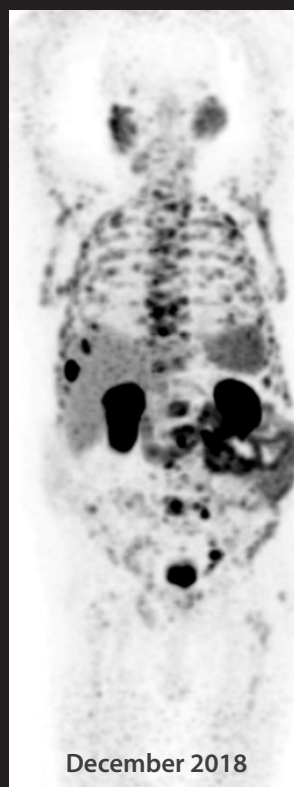
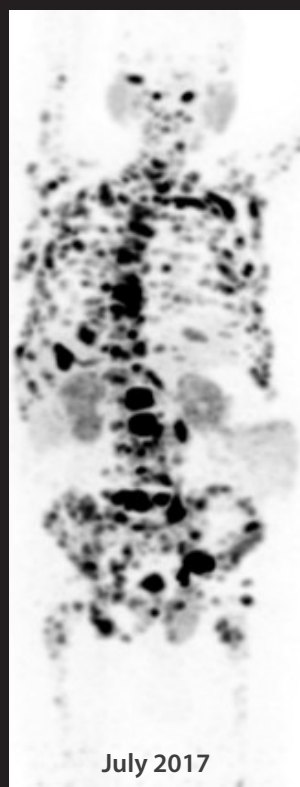
“With an approach that focuses on the specific needs of each patient, theranostics provides a transition from conventional medicine to personalized and precision medicine; the result is the selection of the right therapy for the right patient,” said Diana Paez, Head of the IAEA’s Nuclear Medicine and Diagnostic Imaging Section.

First you see, then you treat

For diagnostic imaging, radiopharmaceuticals with small amounts of radioactive material are either injected, ingested or inhaled, and

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then transported through the body to the target area. Once the drug gathers around or inside the target cells, the tiny amount of radiation emitted by the radiopharmaceutical is scanned and detected by a special camera. This then produces images of that area of the body.

Following the results of diagnostic imaging, the physician determines which course of treatment is best for the patient. If theranostics is suitable, a radiopharmaceutical is selected for that patient, and the exact amount of radiation needed for treatment is determined — the dose depends on the type and size of the tumour, as well as the patient's age and gender, the severity of the case and the organ targeted. Once the radiopharmaceutical collects around or inside the cancer cells, the radiation it emits damages and kills the cancer cells, while harm to the surrounding healthy cells is minimized. Patients usually have several treatment sessions, and further diagnostic images are taken to monitor progress.

“We have seen responses to theranostic treatment that were nearly impossible with other kinds of treatment,” Haidar said. While for now they are only treating a handful of patients each year, Haidar and his team of 15 specialists in Lebanon have already begun seeing significant results.

“For example, I had an 82-year-old patient with prostate cancer that had spread to the lymph nodes and bones, and after failed treatment using other methods, we switched to theranostics,” he said. “After two doses with lutetium-177 prostate-specific membrane antigen (PSMA), we saw a significant drop in tumour lesions, and then, after an additional dose with another radiopharmaceutical, actinium-255 PSMA, near complete remission.”

These are just preliminary findings, explained Haidar, and there is still much work to be done in the field of theranostics to more fully understand its impact and potential scope. He and his team plan to continue their work with the IAEA to advance their research, refine their skills and help train others in the region. The IAEA, through its technical cooperation programme, has provided training and donated equipment to Lebanon to support the development of its cancer care services.

“In the future, we could see an expansion of theranostics into use for breast and lung cancers,” he said. “If we can find a molecule that works specifically for these very common cancers, it could have a big impact on cancer survival rates and quality of life.”

Progress of theranostics on an 82-year-old patient with prostate cancer that spread to lymph nodes and bones. Condition at beginning of theranostics (very left) to near complete remission (very right).

(Photo: American University of Beirut Medical Center)