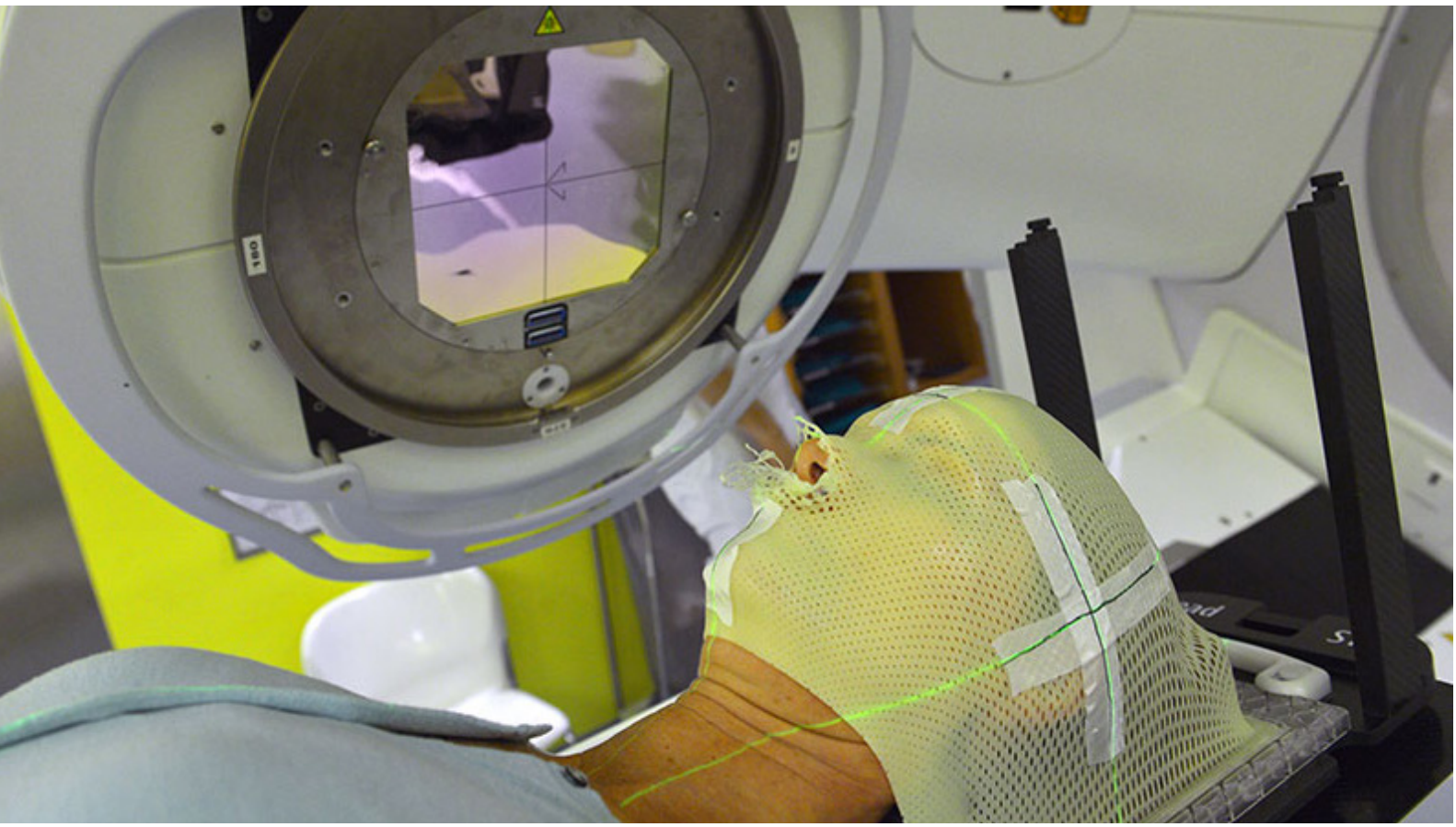
Cancer, nuclear medicine, radiation therapy and biology

An overview

By Nicole Jawerth



A radiotherapy mask keeps a patient's head still to ensure radiation consistently and accurately hits the precise target area during treatment.
(Photo: D. Calma/IAEA)

Cancers once considered unmanageable and fatal can now be diagnosed earlier and treated more effectively using nuclear medicine and radiation therapy, giving patients a better quality of life and, for many, a significant possibility of being cured. These developments can be attributed to advances in research and innovations in technology, which are becoming increasingly accessible.

But cancer remains a disease that is on the rise globally, having claimed the lives of 9.6 million people in 2018, a number that is expected to increase, with an estimated 16.3 million deaths predicted worldwide in 2040.

Cancer occurs when cells in the body grow and divide abnormally and uncontrollably, often forming clusters called tumours. Tumours can be diagnosed using small amounts of radiation and then treated with higher doses. Confirmation of the type of tumour, as well as of its size, location and extent of spread, is essential to selecting the appropriate treatment approach, such as surgery, radiotherapy, chemotherapy or immunotherapy, that is used either alone or in combination. When radiotherapy is appropriate, it is necessary to select the dose required carefully and to deliver it to the tumour with accurately calibrated equipment to maximize the effectiveness of the process while minimizing harm. The science of measuring, calculating and assessing absorbed doses of radiation is called dosimetry (see page 14).

Nuclear medicine

Nuclear medicine is a branch of medicine that involves the use of radiopharmaceuticals to diagnose and, in some cases, treat diseases such as cancer.

Radiopharmaceuticals are selected based on the location and type of cancer to be evaluated, and whether they are to be used for diagnosis, treatment or both. The radiopharmaceutical is then injected, inhaled or ingested into a patient's body. Once inside the body, it seeks out and then gathers near or inside the cancer cells, allowing for the evaluation of the tumour location or the delivery of the targeted radiation. Over a known period of time, the radiopharmaceutical loses its radioactivity.

For diagnosis, a radiopharmaceutical with very small amounts of radioactive material, termed a 'tracer,' is introduced into the body. Once it has collected in or near the cancer cells, a specialized camera is used to detect the radiation that is released, which is then used to create precise images of what is happening in the patient's body. These images help the healthcare team to understand the patient's condition and plan treatment. Images may be taken throughout the cancer care process to monitor the disease and adjust care accordingly.

For treatment, radiopharmaceuticals with higher amounts of radioactive material are selected. The tracer accumulates and delivers the radiation to the cancer cells, where the radiation damages and kills them.

In some cases, radiopharmaceuticals are used for both diagnosis and treatment. This is called theranostics and is one of the latest advances in cancer diagnosis and treatment (see page 8).

Radiation therapy

Radiation therapy, or radiotherapy, is carried out by a team of experts in radiation oncology, medical physics and radiation therapy technology who are trained to target ionizing radiation at cancer cells. Depending on the type and location of the cancer, the team may use external sources of radiation, such as cobalt-60, from a machine that emits radiation, or a linear accelerator that delivers photon radiation using electricity. They may also place radiation sources directly next to or inside of the tumour, which is known as brachytherapy. One of the latest advances in radiotherapy is image guided brachytherapy (see page 10).

Radiotherapy involves carefully selecting doses of radiation that are strong enough to effectively damage DNA in the cancer cells, while minimizing harm to healthy cells. Cancer cells often cannot repair damage to their DNA after small doses of radiation as efficiently as any normal healthy cells that are in the treatment area. To take advantage of this biological difference between cancerous and healthy cells, a course of radiotherapy may be divided into multiple small doses over several weeks, giving the best chance of destroying the tumour with the fewest side effects. Understanding the parameters for determining the best treatment regimen in individual situations is part of the science called radiobiology.

Over 14 million people worldwide are diagnosed with cancer each year. Around half of all cancer patients receive radiotherapy at some point during their treatment, and it is often used in combination with other methods, such as surgery and chemotherapy.

The IAEA has worked for over 60 years to promote the use of and advances in radiation medicine in controlling cancer. It supports countries worldwide in developing and maintaining their national cancer care services by training and educating professionals, equipping facilities and facilitating the transfer of scientific know-how between experts (see page 22). The IAEA also assists with planning, setting up and reviewing national cancer control plans, including resource mobilization for projects (see page 18).

Radiopharmaceuticals are medical drugs containing radioactive material and can be used for diagnosis or treatment purposes.
(Photo: S. Slavchev/IAEA)