SHARPENING THE KNIVES FOR CANCER THERAPY

Japan continues to lead the way in radiotherapy, with one university taking it in an entirely new surgical direction.

"Understanding the complex mechanisms of carcinogenesis and saving the lives of cancer patients are the things that first attracted me to oncology," says Takashi Nakano from Gunma University in Japan. The institution has been at the forefront of medical research using heavy ions since it conducted its first carbon beam therapy clinical trial in 2009. Now it is beginning to investigate surgical applications for its pioneering cancer therapy tool, particularly for treating cancers in delicate locations, such as those in the brain and in close proximity to the spinal cord.

Traditional radiotherapy directs a beam of radiation through a patient's body, damaging both cancer cells and healthy tissues alike. The therapy takes advantage of the fact that healthy cells possess mechanisms of repair, whereas cancer cells usually have only weak mechanisms. Unfortunately, even with our ability to resist cellular damage, radiotherapy still carries the risk of significant adverse effects, including skin damage, pain, fatigue, and fertility issues. Sometimes it fails to kill the cancer.

A GROUND-BREAKING TREATMENT

Clinical trials of carbon ion therapy began in Japan in 1994 and overcame some of the drawbacks of traditional radiotherapy. The technique's main advantage is that it can be manipulated to deposit its energy at a specific point (called a 'Bragg peak') in 3D space, allowing for selective irradiation of a tumor while imparting very few ill effects on the surrounding healthy tissues.

"HEAVY ION THERAPY EVEN SHOWS EFFICACY AGAINST CANCERS TRADITIONALLY THOUGHT TO BE RADIATION-RESISTANT"

"In addition, as carbon ions have two to three times stronger cell-killing power compared to conventional X-rays, heavy ion therapy is a biologically innovative, non-invasive treatment that shows efficacy against cancers traditionally thought to be radiation-resistant," explains Nakano, who is the director of Gunma University's research programme for heavy ion therapy. "And it causes less damage to surrounding tissue and can dramatically decrease the number of therapy sessions needed to induce remission."

Nakano says he found his particular research passion at the intersection of oncology and heavy ion beam research.

"The staggering impact this can have on cancer patients' quality of life is what attracted me to heavy ion therapy."

A CENTRE FOR EXCELLENCE

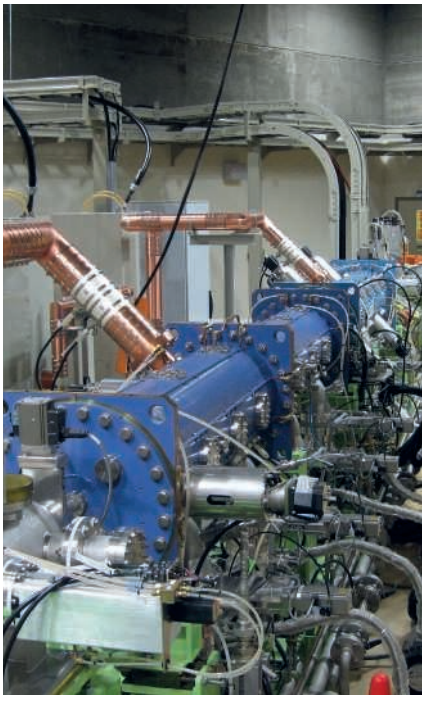
It is evident that Gunma University recognizes the value of Nakano's work. Their Heavy Ion Medical Center is the first academic facility of its kind in Japan, and the university actively solicits support and partnerships from government bodies and research institutes across Japan. Nakano adds: "We also collaborate with the vendor of our treatment machine — Mitsubishi Electric — to integrate existing technologies and develop the most beneficial tool we can."

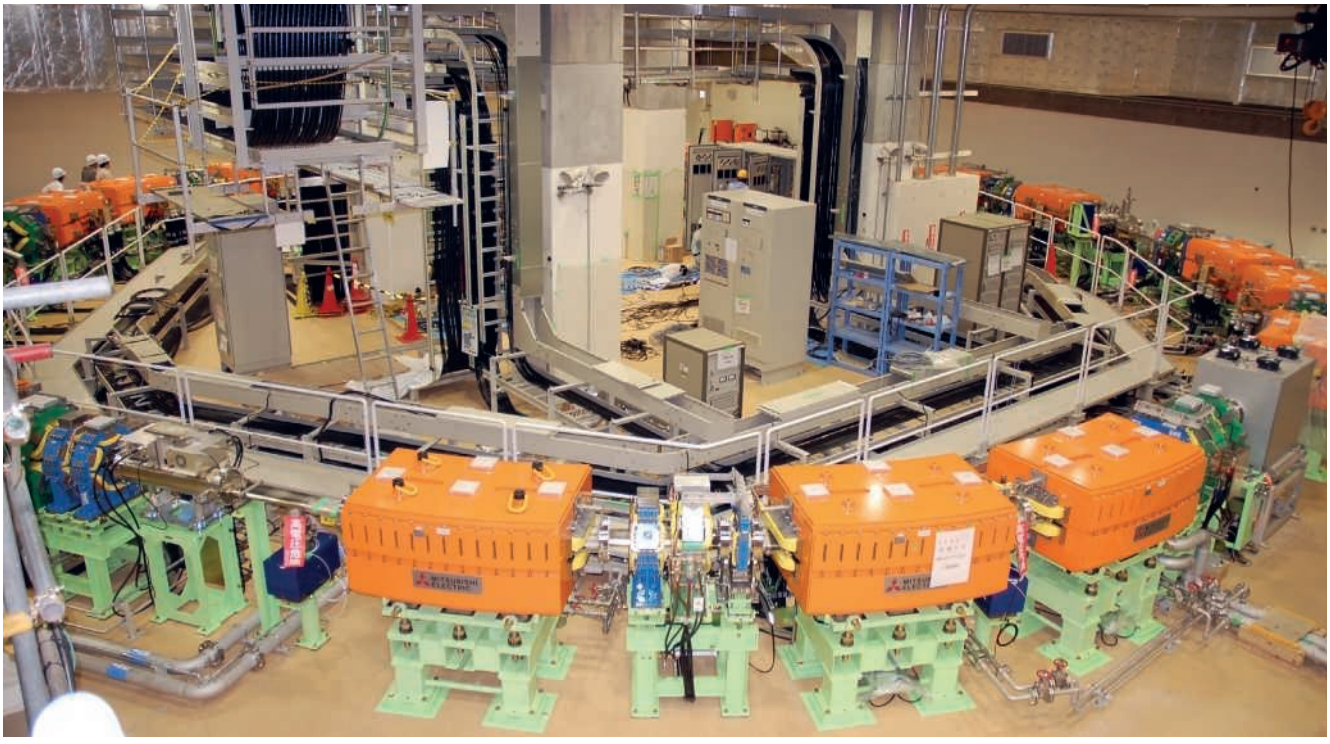
Gunma is now adapting their carbon beam as a tool for the treatment of malignant and benign diseases that require sub-millimetre precision: "We're developing a high-precision heavy-ion microsurgery system that will take full advantage of the sharp focus potential of carbon ions," says Nakano. "This technique is nowhere to be found in the world, and we have already acquired patents to cover the principal elements of the method."

Gunma's proposed microsurgery beamline can be targeted with an accuracy within a fraction of a millimetre. The therapy focuses the carbon beam to a diameter of 1 mm to 3 mm and can deliver therapeutic levels of radiation in just a few seconds. Due to the high rate of irradiation, the system images the patient in real-time and only allows the beam to fire when the patient is in the correct position, eliminating the risk of accidental damage to healthy tissues.

Today, there are other heavy-ion research centres in existence across the world — such as those in Germany, Italy and China — but none match Gunma's proposed microsurgery facility in terms of sheer precision and breadth of application potential. The centre is set to offer clinical trials by 2020. Alongside the existing applications in cancer,

(UPPER LEFT) EXTERIOR OF GUNMA UNIVERSITY HEAVY ION MEDICAL CENTER (GHMC) (UPPER RIGHT) INJECTOR OF CARBON-ION BEAM, WHICH ACCELERATES CARBON IONS (C^{4+}) UP TO ENERGY OF 4 MEV/U (MEGA ELECTRON VOLT PER NUCLEON). (LOWER) SYNCHROTRON WHICH ACCELERATES CARBON IONS (C^{6+}) UP TO ENERGY OF 400 MEV/U AT MAXIMUM. SUBSEQUENTLY, EXTRACTED CARBON-ION BEAM IS TRANSPORTED INTO TREATMENT ROOMS.





it is hoped that the therapy will also find uses in the treatment of less life-threatening diseases, such as age-related macular degeneration (a disorder of the eye that can cause central blindness in the elderly) and blood vessel lesions. "There are no similar facilities to treat diseases like these with such accuracy. We hope to be the first," says Nakano.

TAKING THE FIGHT TO CANCER

Looking to the future, Nakano has much to offer. A particular aspiration of his is trialling heavy ion carbon beam therapy alongside courses of immunotherapy, a technique that boosts the body's natural defences in order to identify and halt cancer growth. "With this combination, carbon beam therapy could be used to eradicate local cancers, while an element of immunotherapy eliminates cancer that has spread to different parts of the body." ■

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