For more information, please contact us:

Research Center for Charged Particle Therapy Hospital
Phone: +81-(0)43-284-8852

Advanced Radiological Sciences
The World Leader in Radiotherapy for Solid Cancers

Effective Cure for Intractable Cancers
Short-Term Treatment
High Quality of Life

National Institute of Radiological Sciences, Japan

From central Tokyo, Tokyo-Haneda Airport
<by train> Take the JR Sobu line to Inage station. Walk for 10 minutes to NIRS, or take the bus for Sanno-cho from Inage station to Houiken-mae/NIRS’s main gate.
<by car> About 1.8 km to NIRS from Anagawa IC on Keiyo Highway.

From Tokyo-Narita Airport
<by train> Take the JR Sobu line in rapid service to Inage station. Walk for 10 minutes to NIRS, or take the bus for Sanno-cho from Inage station to Houiken-mae/NIRS’s main gate.
<by car> About 5.5 km from Chiba-kita IC on Higashi-Kanto Expressway.

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National Institute of Radiological Sciences, Japan
http://www.nirs.go.jp

(Heavy Ion Medical Accelerator in Chiba)
**Principles and Advantages**

**Carbon Ion Beam • Physical and Biological Features**

Advantages of Carbon Ion Radiotherapy: Cure for intractable cancers, short-term treatment, high quality of life.
Curing cancers not curable by surgery nor conventional radiation.

As you can see in the figure on the right, X-rays are not suitable for the treatment of cancers located in a deep region of the body because their effect is gradually decreasing with depth. In comparison, heavy ions are suitable for the treatment of these cancers because they affect cells only weakly until they reach the tumor, and demonstrate an enormous effect at the moment they stop in the tumor.

**National Institute of Radiological Sciences (NIRS) constructed the first original machine in the world specialized for heavy ion radiotherapy named HIMAC (Heavy Ion Medical Accelerator in Chiba).**

HIMAC has achieved remarkable results in clinical trials and advanced medicine.

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**Cancer, The First Cause of Death**

The ultimate solution for treatment is radiotherapy.

The numbers of patients with cancer, and of deaths resulting from cancer are increasing recently. In 2006, the number of people who died of cancer in Japan amounted to 330,000, which is 33% of the total deaths of the year.

**What Is the Radiotherapy?**

Radiotherapy = cure without surgery: neither painful, hot, nor scary, and no traces left.

Radiotherapy is not a treatment by killing cells with the heat generated by radiation, but a sophisticated method of killing cancer cells with radiation, by making microscopic cuts within the molecules of DNA (deoxyribonucleic acid) in a cell nucleus, and of preventing further cell division.

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**Therapies for Cancers**

<table>
<thead>
<tr>
<th>Therapy</th>
<th>Surgery</th>
<th>Radiotherapy</th>
<th>Chemotherapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case</td>
<td>early cancer to moderately advanced cancer, local cancer (not diverged nor scattered)</td>
<td>early cancer to local advanced cancer, local cancer</td>
<td>Leukemia or cancers diffused in the whole body</td>
</tr>
<tr>
<td>Advantage</td>
<td>High curability, minimum loss of form or function, minimum burden during the treatment</td>
<td>In some cases, life prolonging effect is remarkable</td>
<td></td>
</tr>
<tr>
<td>Advantage</td>
<td>It may cause serious loss of form or function, unsuitable for elderly patients or patients with physical weaknesses</td>
<td>limited side effects left</td>
<td>In general, side effects are strong, Not all patients can complete treatment</td>
</tr>
</tbody>
</table>

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**Principles and Advantages**

**Carbon Ion Radiotherapy**

Cure for cancers which used to be incurable.
Enjoying your life.

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**What is a heavy ion beam?**

Carbon ion beam: beam of such ions as carbon(C), neon(Ne), silicon(Si) or argon(Ar), etc., flying at extraordinarily high speed.

NIRS is using a heavy ion (carbon ion) beam for cancer treatment.

**Other radiations**

Proton beam: beam of protons (nuclei of hydrogen) flying at an extraordinarily high speed.
Photon beam: a beam of photons, particles of light.

They fly at the speed of light. X-rays and gamma-rays are photon beams at high energy.

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**Difference between X-ray and carbon ion beam treatments**

**Cancer treatment by conventional radiation**

The conventional radiation (photon beam) has the strongest effect in shallow regions of the body and its effect is gradually decreasing with depth: In addition, it does not stop at a finite depth but is penetrating furthermore. Therefore, it causes damage to normal tissue before and after the tumor.

**Cancer treatment by carbon ion beam**

Carbon ions stop at the exact depth given by the injection energy. In addition, they have the advantage that enormous effects on killing cells is shown only at the point where they stop. Therefore, one can concentrate the damage to cancer cells by adjusting the stopping point for them.

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**Physical features of a carbon ion beam**

- The depth where the ion stops is exactly predetermined.
- The effect becomes enormous only when the ion stops.

**Biological features of a carbon ion beam**

- The effect is stronger than X-rays for the same dose.

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**Death Rate (per 100,000 of population)**

The number of patients with cancer, and of deaths the number of people who died of cancer in Japan amounted to 330,000, which is 33% of the total deaths of the year.

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**Annual change of partial death rates by cause in Japan**

Reference: Demographic data of Japan (Ministry of Health, Japan)

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HIMAC, the first machine for heavy ion radiotherapy in the world

HIMAC is the first machine in the world specially constructed for researches on heavy ion radiotherapy. The mission of HIMAC is to verify the effectiveness and safety of carbon ion radiotherapy and to develop new medical technologies. HIMAC consists of various instruments shown below.

① ECR Ion Source
This type of ion source produces highly charged ions.

② RFO Linac
Linear accelerator for low speed ions. Length: 7.3m / up to 4% of the light speed.

③ Alvarez Linac
Linear accelerator for medium speed ions. Length: 24m / up to 11% of the light speed.

④ Bending Magnet of Synchrotron
These alternating current electromagnets form the orbit of ions.

⑤ RF Cavity
Radio frequency gradually accelerates ions up to 84% of the light speed.

⑥ Irradiation Instruments
For example, a multi-leaf collimator forms the irradiation field of an ion beam adjusted to the shape of the cross section of a tumor.

⑦ Treatment Room
HIMAC has three treatment rooms. Treatment Room A: Vertical beam Treatment Room B: Vertical and horizontal beams Treatment Room C: Horizontal beam

Gunma University has constructed as the first standard machine of carbon ion radiotherapy and the treatment started since March, 2010. NIRS supports fully this project. For the future spread all over the world, NIRS is also leading in developing such human resources as carbon ion radiological oncologists, radiological technologists, medical physicists, etc.

Research on Down Sizing for the Standard Type of Facility

The research facility HIMAC, is a big machine with a huge area as big as a football court. However, the area can be reduced to one third by specializing the energy of carbon ion beam to cancer treatment, and by using the newest technology for each part of the machine. Construction and operation costs can be reduced too.

Research and Development of Next Generation Irradiation System

【Development of Three-dimensional Beam Scanning Irradiation system】

• In order to reduce damages to normal cells, this aims at realizing higher precision irradiation of the tumor which changes its form and size every moment.

• For clinical study, we have started the treatment since 17 May 2011.

【Development of Rotating Gantry】

• In comparison with the irradiation from a fixed port, this will greatly reduce the burden of a patient in positioning and treatment time, because the direction of irradiation can be freely selected.

Instruments for Carbon Ion Radiotherapy

History of Carbon Ion Radiotherapy

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<tbody>
<tr>
<td>• NIRS was established</td>
<td>• National project of HIMAC started under the first 10-year comprehensive strategy against cancer by the Japanes government</td>
<td>• Basic design of HIMAC started</td>
<td>• Construction of HIMAC started</td>
<td>• Construction of HIMAC was accomplished</td>
<td>• Research Center for Charged Particle Therapy was established</td>
<td>• Clinical trial of carbon ion radiotherapy started</td>
<td>• Research Center for Charged Particle Therapy was established</td>
<td>• Total number of treated patients exceeded 1000</td>
<td>• Carbon ion radiotherapy was approved as advanced medicine by the Ministry of Health, Labor and Welfare</td>
<td>• Total number of treated patients exceeded 4000</td>
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</tbody>
</table>
**Frequently Asked Questions**

### Fundamental Features

**Q1. What is the most important difference of carbon ion radiotherapy from proton radiotherapy?**

**A1** Carbon ion radiotherapy shows greater effect in attacking tumor for the same dose. As a result, it can remarkably reduce the number of sessions for treatment. For radioresistant cancers such as osteosarcoma, carbon ion radiotherapy is especially powerful because of its higher dose convergence and biological effectiveness compared with X-ray or proton beam.

**Q2. What cases the carbon ion radiotherapy can be applied at NIRS?**

**A2**

**Cases Advanced Medicine is applicable**
- head and neck cancers
  - nose, paranasal sinus, salivary gland
  - 4-week treatment
- lung cancers (non-small-cell cancers)
  - local advanced cancer
  - 3~4-week treatment
- liver cancers
  - within 1-week treatment
- prostate cancer
  - 4~5-week treatment
- bone and soft tissue sarcoma
  - surgery not applicable cases
  - 4-week treatment
- rectal cancer (postoperative recurrence)
  - surgery not applicable cases
  - 4-week treatment
- malignant melanoma (choroid*)
  - 4-week treatment

**Cases Clinical Trial still applicable**
- lung cancers (non-small-cell cancers)
  - stage I
  - 1-week treatment
- uterine cancers
- brain tumors
- pancreas cancer
- esophageal cancer
- liver metastasis of colon cancer

**Q3. What are the cases the treatment at NIRS is not applicable?**

**A3**

- In case of metastasis
  - In principle, carbon ion radiotherapy is not applicable to metastasis to the lung etc., far from the primary region (distant metastasis). In the case of wide spread metastases in the whole body, carbon ion radiotherapy is not applicable for individual metastases either.

- In case of post-radiotherapy
  - At present it is not know what side effect will occur when we add carbon ion radiotherapy to region where any radiotherapy was applied before, even just once. In most of those cases carbon ion radiotherapy can not be applied.

- In case of cancers in bag-shaped hollow organs or the cases for which the therapies have been established by other methods
  - stomach cancer, colon cancer (primary), breast cancer, ovarian cancer etc.

**Q4. What data prove this therapy is really effective from your clinical results?**

**A4** The rate the size of tumor reduces or its growth stops by treatment, is called the local control rate, an index for the effectiveness of treatment. Our carbon ion radiotherapy obtained fairly high values of the 3-year local control rate; more than 90% for non-small-cell lung cancers, 80%–90% for liver cancers, and almost 100% for prostate cancer, for example. We can therefore conclude that the carbon ion radiotherapy is reasonably effective.

**Q5. How much is the patient's expense in the system of the "Advanced Medicine"?**

**A5**

- Hospitalization is necessary for our carbon ion radiotherapy.
  - The expense for treatment in this system is 3,140,000 yen. This part is not covered by the national-health insurance.
  - The national-health insurance mostly covers expenses for diagnosis, examination, prescription, inspection, and hospitalization, common to other treatment.
  - Some of the cases are categorized into Clinical Trials for medical research. In those cases, treatment is free.

**Q6. Will the national insurance be applied to carbon ion radiotherapy in near future?**

**A6**

- For the application of the national insurance, the effectiveness and safety of the therapy must be approved first. NIRS obtained the approval as Advanced Medicine in October 2003. This requirement has been satisfied.
  - Possibility for upgrade from the Advanced Medicine to the general application of national insurance is discussed and advised at the Advanced Medicine Expert Committee under the Central Council of Social Insurance and Medicine of the Japanese government, held every two years. In addition to the effectiveness and safety as an Advanced Medicine, the Expert Committee comprehensively judges its spread, efficiency and technological accomplishment. Its spread must be realized to assure equal opportunity of treatment for patients from all over the country.
  - In the case of carbon ion radiotherapy, clinical facilities are not yet developed enough in the whole country. For the application of national insurance, medical institutions for Advanced Medicine should be established throughout the whole country.
  - When Advanced Medicine has met all the above conditions, the Expert Committee will advise its possibility for application of national insurance. After approval by the Central Council of Social Insurance and Medicine, national insurance will be applied to the carbon ion radiotherapy generally over the country, resulting in the great reduction of the patient's share of medical cost.