Current Status and Future Direction of Proton Beam Therapy

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### Comparison of status of particle therapy - USA vs. Japan -

<table>
<thead>
<tr>
<th></th>
<th>Number of Particle Therapy Facilities (2008→2011)</th>
<th>Number of New Patients (2008-2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>6 → 8</td>
<td>9,057</td>
</tr>
<tr>
<td>USA</td>
<td>6 → 9</td>
<td>16,358</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Number of Radiation Therapy Facilities</th>
<th>Number of New Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan (2005)※1</td>
<td>735</td>
<td>162,000 (estimate)</td>
</tr>
<tr>
<td>USAA (2004)※2</td>
<td>2,010</td>
<td>700,000 (estimate)</td>
</tr>
</tbody>
</table>

※1: Data from JASTRO, ※2: Data from ASTRO
## Particle therapy in Japan

<table>
<thead>
<tr>
<th>Years</th>
<th>No of Institution (Radiation Therapy)</th>
<th>Number of New Patients</th>
<th>No of Institution (Particle Therapy)</th>
<th>Number of New Patients</th>
<th>% of New patients (Particle therapy/All patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>700</td>
<td>149,793</td>
<td>6</td>
<td>657</td>
<td>0.44</td>
</tr>
<tr>
<td>2005</td>
<td>712</td>
<td>156,318</td>
<td>6</td>
<td>1,240</td>
<td>0.79</td>
</tr>
<tr>
<td>2007</td>
<td>721</td>
<td>170,229</td>
<td>6</td>
<td>1,643</td>
<td>0.97</td>
</tr>
<tr>
<td>2009</td>
<td>726</td>
<td>182,390</td>
<td>7</td>
<td>2,038</td>
<td>1.12</td>
</tr>
</tbody>
</table>

- Radiation therapy is an important treatment modality for curable localized cancer.
- Applicable even to elderly patients who are not suited for surgery and any type of cancer.

# Developed countries: 60% of all cancer patient

  # Japan: 25%→40% (Rapidly increasing)

- Particle therapy is more sophisticated and advanced form of radiation therapy.
Dose Distribution (X-ray) vs. Dose Distribution (Protons)

- **X-ray**
  - Dose Distribution:
  - Cancer cells
  - Normal cells
  - Bragg Peak formation

- **Proton**
  - Dose Distribution:
  - Cancer cells

- **Neutron**
  - Dose Distribution:
  - Normal cells
  - Cancer cells

- **Carbon**
  - Dose Distribution:
  - Bragg Peak formation

**Tumor**
Advantage of proton beam therapy

Non-invasive and highly confined irradiation tool.

- Improvement of local control and curability
- Preserve organ function of treated area, leading to high QOL after treatment
- Reduction of treatment-related toxicities
- Proton beam therapy can be used as combination form with chemotherapy as well as single modality.
- It can be applicable for locally advanced cancer
- Wide indication
Indications

- Brain tumor
- Skull base
- Head and Neck cancer
- Lung cancer
- Esophageal cancer
- Metastatic lung cancer
- Mediastinal tumors
- Bone and Soft tissues
- Pediatric tumors
- Malignant lymphoma
- Prostate cancer
- Rectal cancer
- Bladder cancer
- Hepatocellular cancer
- Pancreatic cancer
- Metastatic liver cancer
Changes in the Number of Patients treated with particle therapy
- 1979 ~ 2012 -

Number of New Patients

Proton
- Prostate cancer: 30%
- HCC: 19%
- Head and Neck: 14%
- Others: 14%
- GI: 5%
- CNS: 3%
- Pancreas: 3%

Carbon
- Prostate cancer: 22%
- HCC: 12%
- Lung cancer: 11%
- Others: 10%
- CNS: 14%
- Head and Neck: 14%
- GI: 12%
- Pancreas: 11%
- Bone and Soft tissue: 3%
- Others: 3%
Comparison of Dose distribution of Proton beam therapy and photon beam

Reduction of excessive dose to normal lungs

Lung cancer

Liver cancer
Proton beam therapy for Pediatric cancer

Late treatment-related morbidities

- Bone growth retardation
- Cataract
- Neuro-cognitive dysfunction
- Impairment of endocrine, gonadal function
- Pulmonary fibrosis
- Second malignant neoplasms

Excessive dose to normal tissues or healthy organs

Proton beam therapy has a positive impact on reduction of occurrence of long-term treatment-related morbidities compared with photon RT through reduction of dose to normal tissues.
Proton therapy facility in National Cancer Center Hospital East

- Contracted with the Sumitomo heavy Industry in 1996
- Clinical treatment was started in 1998
- 2nd hospital-based proton therapy facility in the world

# the 1st hospital-based proton therapy facility was opened at Loma Linda Medical Center in 1990
Scattering Method

Bolus

Collimator

Scattering Method
Respiratory Gating
Pencil beam scanning offers the best flexibility for shaping the dose distribution.

- Improvement of dose conformality compared with scattering method.
- Intensity modulation are possible.
• High precision technology overcoming current drawbacks of radiation therapy.

❖ World-leading innovative technologies and clinical experience in Japan

❖ Compact treatment system → Improve cost effectiveness

• Establishment of effectiveness of proton beam therapy enables us to realized effective solution for cancer treatment in aging society.

• Continuous development of cutting edge technology of particle therapy would result in improve the role of Japan in the international particle radiotherapy community and encouraging Japanese radiotherapy equipment industries.