Context

Carbon ion therapy is a spinoff from proton beam therapy. Proton therapy, like carbon ion technology, can be used to treat a broad spectrum of cancers and is intended to incur fewer adverse effects than traditional radiation treatments by more precisely targeting tumour cells with higher doses of radiation while minimizing damage to adjacent normal tissues. But, unlike proton therapy, carbon ion therapy can cause damage to cancer cells in such a way that they cannot repair themselves.

Carbon ion beam centres are growing in number. However, the progression of this technology has been limited by its expense. Indeed, the American facility at the University of Michigan, which is currently under construction, is estimated to cost about US$280 million.

Some innovative synchrotron designs currently in development could reduce the price of carbon ion (and proton) therapy. Progress made in Japan to reduce the number of required treatment sessions could potentially curb costs sufficiently to allow much wider international application. However, these are some years away from being proven and even further from being developed into clinically useful technologies.

A carbon ion facility will typically include a dedicated and highly specialized synchrotron (a machine similar to the particle accelerator), a beam transport system, a beam delivery system, isocentric gantries, and a patient alignment and imaging system, all under the operation of a facility-control system. Computed tomography scans, magnetic resonance imaging, and positron emission tomography, along with conventional X-rays, can be used to visualize the patient.

Objective

The purpose of this review is to provide information regarding the extent of use of carbon ion therapy across Canada. The following questions will be addressed:

- Are there any Canadian assessments of carbon ion radiotherapy?
- Is the technique approved for use or reimbursement in Canada?
- Are there any centres under construction in other countries that can deliver carbon ion radiotherapy?

Findings

- There are no Canadian health technology assessments pertaining to carbon ion therapy. However, a number of systematic reviews from other countries have been identified and are listed in the appendix, along with some links to general reviews.
- Carbon ion therapy has not been approved for use in Canada. There are a few proposals that have been developed in Canada for proton therapy, but they are not funded.
- Carbon ion therapy was pioneered in Japan in 1994 using a Canadian-designed double heavy ion medical accelerator synchrotron. In 1997, a facility in Germany undertook research in carbon ion radiation therapy for the management of cancer.

Clinically promising results at these facilities encouraged other research centres to study carbon ion therapies. In 2002, Japan set up a second site; and in 2006, China set up its first carbon ion therapy research centre.
Another German facility will start proton and carbon ion therapy in 2009.\(^4\) Eight synchrotrons are currently under construction — one each in the US,\(^1\) Japan,\(^4\) Austria,\(^3\) and Italy.\(^4\) Two additional German\(^4\) and French proposals are also underway.\(^3\) Table 1 below provides additional details on the location of these sites and their dates of operation.

<table>
<thead>
<tr>
<th>Country</th>
<th>Facility</th>
<th>Production start date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>National Institute of Radiological Sciences</td>
<td>1994</td>
</tr>
<tr>
<td>Germany</td>
<td>Gesellschaft für Schwerionenforschung</td>
<td>1997</td>
</tr>
<tr>
<td>Japan</td>
<td>Hyogo Ion Beam Medical Center</td>
<td>2002</td>
</tr>
<tr>
<td>China</td>
<td>Institute of Modern Physics</td>
<td>2006</td>
</tr>
<tr>
<td>Germany</td>
<td>Heidelberg Ion Beam Centre</td>
<td>2009</td>
</tr>
<tr>
<td>Germany</td>
<td>Rhone Klinikum</td>
<td>2010 (anticipated)</td>
</tr>
<tr>
<td>Italy</td>
<td>CNAO</td>
<td>2010 (anticipated)</td>
</tr>
<tr>
<td>Germany</td>
<td>University Klinikum &amp; NRoCK</td>
<td>2012 (anticipated)</td>
</tr>
<tr>
<td>France</td>
<td>ARCADE</td>
<td>2012 (anticipated)</td>
</tr>
<tr>
<td>USA</td>
<td>University of Michigan Health System</td>
<td>2013 (anticipated)</td>
</tr>
<tr>
<td>France</td>
<td>ETOILE</td>
<td>2014 (anticipated)</td>
</tr>
<tr>
<td>Austria</td>
<td>Med-AUSTRON</td>
<td>2014 (anticipated)</td>
</tr>
</tbody>
</table>

Knowledge Gaps

Results of this report are based on a limited literature search. As such, the comprehensiveness of this report cannot be guaranteed. This report is based on information gathered as of October 2009 and may not reflect the most current information.

Conclusion

Carbon ion therapy has not been approved for use in Canada, and there are no known Canadian assessments that have been conducted. There are four international facilities conducting carbon ion research; two of these are in Japan; and Germany and China also have facilities. Germany is expected to have a second facility in operation in 2009 and two others in 2010 and 2012. Italy is anticipating its first facility in 2010. France is expecting to open two facilities — one in 2012 and another in 2014. The US is anticipating the opening of its first facility in 2013, and Austria is opening a facility in 2014.

References

Appendix

Systematic reviews / HTAs


A systematic literature review of the clinical and cost-effectiveness of hadron therapy in cancer. Radiother Oncol. 2007 May;83(2):110-22


General interest


Current status of radiotherapy with proton and light ion beams. Cancer. 2007 Apr 1;109(7):1227-38
http://www3.interscience.wiley.com/cgi-bin/fulltext/114129774/PDFSTART