Effective Health Care

Particle Beam Radiation Therapies for Cancer

A Summary for Policymakers

Particle beam radiation therapy (PBRT) is an alternative to other types of radiation therapies for treating cancer. This summary reviews the different types of PBRT, their potential advantages and disadvantages, and their current uses. At present, there is very limited evidence comparing the safety and effectiveness of PBRT with other types of radiation therapies for people with cancer. Therefore, it is not possible to draw conclusions about the comparative safety and effectiveness of PBRT at this time.

Policy Issue

PBRT has theoretical advantages that might make it safer or more effective than other types of radiation therapy for treating certain cancers. However, PBRT facilities are not available in many areas and are expensive to build and operate. Moreover, there is limited clinical evidence that directly compares PBRT with other types of radiation therapy. Policymakers must weigh several considerations when deciding whether to invest in or use PBRT. This summary outlines the theoretical pros and cons of PBRT and provides a profile of the costs and current uses of this technology.

Bottom Line

- Most studies of PBRT have looked at its use in treating tumors that are inoperable or adjacent to critical body parts, such as tumors of the eye, head, neck, and spine.
- Over 60,000 people worldwide have been treated with PBRT since the 1970s.
- There are at least 30 operating PBRT facilities in the world; 7 are in the United States.
- The current cost of building a PBRT facility in the United States ranges from $20 million to $175 million, depending on the size and scope of the facility.
- Evidence about the effectiveness and harms of PBRT compared with other cancer treatments is lacking.

SOURCE The source material for this summary is a Technical Brief, *Particle Beam Radiation Therapies for Cancer* (2009). The Technical Brief was prepared by the Tufts Medical Center Evidence-based Practice Center. The Agency for Healthcare Research and Quality (AHRQ) funded the Technical Brief and this summary. This summary was developed using feedback from policymakers who reviewed preliminary drafts. The full Technical Brief is available at **www.effectivehealthcare.ahrq.gov**.

Agency for Healthcare Research and Quality
Advancing Excellence in Health Care • www.ahrq.gov

September 2009

Radiation Therapy

Radiation therapy kills cancer cells by delivering high-energy beams to cancer tissue. The effectiveness and safety of radiation therapy are limited by the fact that adjacent healthy tissue is also exposed to radiation. This exposure can damage healthy tissue or cause secondary tumors.

Photon Beam Radiation Therapy

Most radiation treatments use photon (electromagnetic or light) beams. Methods, such as intensity modulated radiation therapy and photon-based stereotactic radiosurgery, have been developed to target photon beams to the tumor area in order to maximize their effect on cancer tissue and minimize their effect on healthy tissue. However, the maximum radiation dose that can be delivered with photon beam therapy is limited because of its effect on healthy tissue.

PBRT

Particle beam radiation therapy uses charged elemental particles instead of photons. Most forms (87 percent) of PBRT use protons (hydrogen ions). Other charged particles, such as carbon ions and helium ions, are less commonly used (7 percent and 3 percent, respectively).

Particle beams and photon beams have different physical properties and deliver their energy to tissues in different ways. Particle beams disperse their energy closer to the targeted tissue than do photon beams.

Potential Pros and Cons of PBRT

- PBRT can deliver higher radiation doses to cancer cells with less exposure to surrounding tissues than conventional photon beam radiation. Theoretically, this greater precision may be particularly useful for treating:
  - Cancers in children.
  - Tumors in tight spaces or that are otherwise difficult to remove.
  - Tumors adjacent to critical body parts, such as the brain.
- It is not known whether the higher precision of PBRT actually translates to better clinical outcomes than other types of radiation therapy for people with many common cancers.
- The potential harms of photon beam radiation therapy and PBRT using protons are thought to be related only to the amount of radiation delivered and the tissues affected, not to the type of radiation used (photon beams or protons).
  - For other charged particles (e.g., carbon ions), the tissue damage caused by a given dose of radiation may be less predictable than it is for photon beams and protons.
- Potential disadvantages of PBRT are its high cost and limited availability.

Facilities and Costs

- PBRT is currently delivered at large facilities with expensive, technologically sophisticated equipment, including cyclotrons, systems to direct and focus particle beams, and robotic patient positioning systems.
- The current cost of building a standard PBRT facility in the United States is, on average, $175 million. These facilities have as many as five treatment rooms.
- There are at least 30 operating PBRT facilities worldwide; 7 are in the United States. All seven use technology cleared by the Food and Drug Administration (FDA).
- Smaller, single-room PBRT facilities (using proton beams only) are being developed.
  - The estimated cost of these smaller facilities is $20 million each.
  - Single-room technology has not yet been cleared by the FDA.
  - The first single-room PBRT facility is scheduled to open in late 2009 in St. Louis, MO.
  - In contrast to larger PBRT facilities, single-room facilities treat only one patient at a time.
- There are currently no accreditation standards for PBRT facilities.

Experience With PBRT

- Over 60,000 people worldwide have undergone treatment with PBRT.
- PBRT has been used to treat many different types of cancer, including cancers in the eye, brain, head, neck, and prostate.
- PBRT has been used alone, as boost therapy on top of photon beam radiation therapy, and in combination with other interventions.
- Irreversible and life-threatening harms have been reported among people receiving PBRT. In most cases, it was not clear whether those harms were caused by PBRT or by other treatments that the people were receiving at the same time.
- While there are over 200 published articles reporting the experience of cancer patients treated with PBRT since the early 1970s, evidence about the effectiveness and harms of PBRT compared with other cancer treatments is lacking.
  - Very few studies directly compare PBRT with photon beam radiation or other cancer treatments.
  - Studies to date have been highly variable in terms of study design, populations studied, cancers treated, and other therapies administered.

Standard PBRT Facilities

AHRQ's Series of Technical Briefs

In 2009, AHRQ launched a new series of scientific reports known as Technical Briefs. A Technical Brief is a quick-turnaround report on an emerging clinical intervention. It provides an overview of key issues related to the intervention, such as:

- Current indications.
- Relevant patient populations.
- Outcomes measured.
- Contextual factors that may affect decisionmaking.
- Variations of the intervention.
- Commercial state of the technology and its Food and Drug Administration (FDA) status.
- Current availability and use.

Technical Briefs generally focus on interventions for which there are limited published data and too few completed protocol-driven studies to support definitive conclusions. The emphasis of the Technical Briefs is on providing an early objective description of the state of science, a potential framework for assessing the new interventions, and information on future research needs.

Technical Briefs generally include a scan of the scope and methodologies used in published studies. The scan includes a synthesis and critical appraisal of variables such as patient selection criteria, study design issues, comparators used, and outcomes measured.

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Particle Beam Radiation Therapies for Cancer: A Summary for Policymakers,
AHRQ Pub. No. 09-EHC019-2

AHRQ created the John M. Eisenberg Center to make research useful for decisionmakers. This summary was prepared by Somnath Saha, M.D., Rachelle Nicolai, B.A., Martha Schechtel, R.N., Susan Severance, M.P.H., and David Hickam, M.D., of Oregon Health & Science University.

AHRQ Pub. No. 09-EHC019-2
September 2009