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TECHNOLOGICAL SUPPORT FOR PROTON THERAPY

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Abstract
The paper reviews the main parts of proton therapy: cyclotron, beam transport system, and irradiation unit with a radiation head. Several advantages of proton therapy, which is an alternative to surgical procedures.

Keywords: Proton therapy, cyclotron, head, dose, cancer, tumor, chordoma, transportation, collimator, clinic, surgery.

Introduction

Proton therapy is at least as effective as conventional radiation therapy, but with fewer side effects. In some cases, proton therapy is not only the best, but also the only option. It has been proven to successfully treat or control many types of cancer when used correctly. Success after radiation therapy depends on the type and stage of cancer treated. For some cancers, such as chordomas, brain tumors, or liver cancer, control rates with proton therapy can reach 85–90% [1].

Proton beam therapy (PBT) is an advanced form of radiation therapy that delivers radiation therapy using accelerated proton beams rather than X-rays. The proton beam delivers some radiation to healthy tissues that reach the tumor, but very little radiation beyond the edge of the tumor being treated. This means that PBT can treat cancer just as effectively, but delivers less radiation to other healthy parts of the body that surround the tumor. The development of proton technology as a cancer treatment option began in the 1940s. The idea of using protons in medical treatment was first proposed in 1946 by physicist Robert R. Wilson, Ph.D. The first attempts to use proton radiation to treat patients began in the 1950s at nuclear physics research centers, but the use was limited to a few areas of the body. In the late 1970s, advances in imaging, coupled with the development of sophisticated computers and improved accelerator and treatment delivery technologies, made proton therapy more viable for routine medical applications such as cancer treatment. It has only been possible in recent years to develop proton beam facilities in conjunction with existing medical centres. Initially, proton therapy machines were designed so that the narrow beam of protons emerging from the nozzle was then widened (scattered) and shaped to match the shape of the tumour by custom-made accessories (collimators and compensators) that had to be fitted to the nozzle. This was called passively scattered proton therapy (PSPT). Earlier machines also only had x-ray beams placed perpendicular to each other to provide image guidance, and so only bony anatomy could really be examined [2-10].

Additionally, most older machines were fixed and required the patient to be turned or positioned differently so that the beam could be aimed at the tumour from different angles. However, this has now given way to Pencil Beam Scanning Proton Therapy (PBSPT), which is much more versatile and eliminates the bulky and time-consuming paraphernalia required to deliver the treatment. Additionally, the use of on-board image guidance and rotating gantries has made the delivery of proton therapy much more streamlined and comfortable for both the patient and the therapist. This, in turn, has made proton therapy accessible to many more people around the world. Pencil Beam Scanning and IMPT are the latest technologies in proton therapy. With a proton beam just millimetres wide, these advanced forms of proton therapy combine precision and efficiency, offering an unrivalled ability to treat a patient's tumour and minimise the impact on the patient's quality of life – during and after treatment. They rely on sophisticated treatment planning systems and an intricate array of magnets to target a narrow proton beam, essentially "painting" the radiation dose layer by layer.

Pencil beam is very effective at treating the most complex tumors, such as prostate, brain, eye, and childhood cancers, while leaving healthy tissue and other critical areas intact. IMPT is best used to deliver a powerful, precise dose of protons to complex or concave tumors that may be adjacent to the spinal cord or embedded in the head and neck or base of the skull, including the sinuses, mouth, salivary glands, tongue, tonsils, and larynx. Proton therapy will be most beneficial for:

• Pediatric patients

• Those with tumors very close to critical structures

• Those receiving radiation for the second or third time

• Those who are expected to survive longer after radiation and who are at risk of developing a second cancer during their lifetime.

• Those with congenital conditions that predispose them to excessive toxicity or a higher risk of developing a second malignancy after radiation.

However, these are not the only patients who may benefit from proton therapy. Your radiation oncologist will discuss with you in detail the benefits of proton therapy for your specific cancer type and location.

Proton therapy has many benefits, including:

• Precisely targets tumors and cancer cells with a minimal output dose.

• Reduces overall toxicity.

•Reduces the likelihood and/or severity of short-term and long-term side effects on surrounding healthy tissue and organs (e.g., reduces the likelihood of secondary tumors caused by treatment).

• Delivers the optimal dose of radiation to the tumor precisely.

• Can be used to treat recurrent tumors, even in patients who have already received radiation therapy.

• Improves quality of life during and after treatment.

• Increases long-term progression-free survival in some tumor types.

The main advantages of this technology are the targeted delivery of the radiation dose to the tumor target and a significant reduction in the radiation load of personnel. The technological support for proton therapy consists of the following main parts: a cyclotron, a beam transport system, an irradiation unit with a radiation head (Fig. a–c).

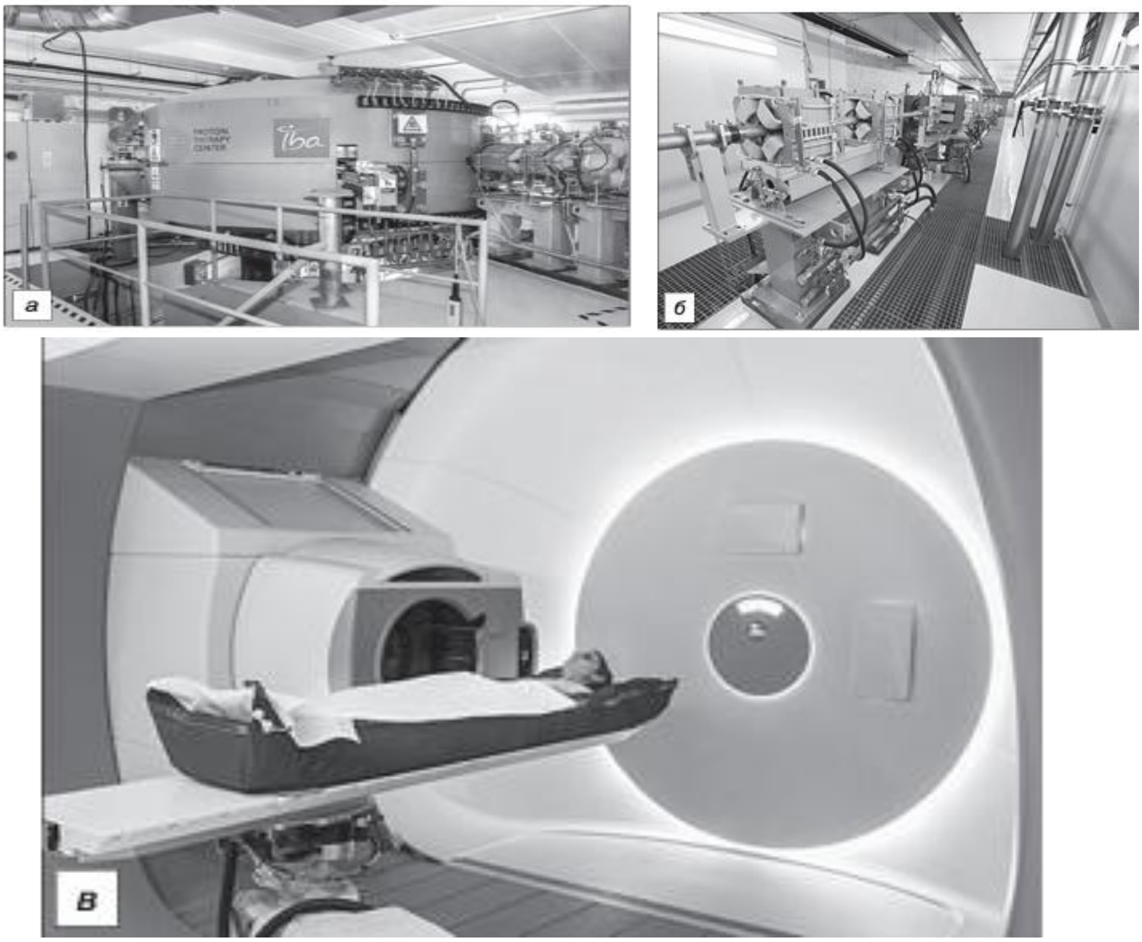

Fig. Photographs of the cyclotron (a), the proton beam transport system (b), and the rotating gantry irradiation unit with a robotic table (c) in the "Oncology Proton Therapy Center".

The source of protons is hydrogen. To separate protons from electrons, protons are accelerated by an electromagnetic field (in the case of IBA technology to an energy of 233 MeV). Protons that have acquired the required energy in the cyclotron enter the beam transport system. Their energy is regulated in equipment called a degrader (in which protons are slowed down by passing through a certain layer of carbon), and the beam is then distributed by the transport system to individual irradiation rooms. The irradiation rooms contain radiation heads - nozzles, in which a proton beam is formed, and then scanning magnets direct it to individual points - tumor targets [10-20].

These heads can be fixed (then it is necessary to change the patient's position relative to the head) or rotating (gantry technology - the patient's position remains unchanged). Proton emitters are currently equipped with a robotic table, which ensures optimal penetration of the beam into the patient's body.

Due to the very precise distribution of doses to the tumor focus, proton irradiation is very sensitive to the accuracy of execution. In this regard, it is necessary to use IGRT technology. Usually, an orthogonal RTG projection is used with a correction of the patient's position in accordance with the position of bone structures or in accordance with the position of contrast markers implanted in the tumor focus

In 2011, more than 80 thousand patients were registered who underwent proton irradiation. Before that, in the first decades, clinical experience with proton therapy was limited to tumor diseases of the brain and eyes. The reason for this was the low prevalence of proton therapy and the lack of gantry technology, which excluded irradiation from optimal angles. Over time, tumors of the prostate gland and neoplastic processes in children were added to the indications. With the increasing number of clinics specializing in proton therapy, the range of indications also expanded significantly. Now, most of the world's proton centers have begun treating pancreatic, lung and esophageal cancer. In principle, it can be said that most lesions can be treated more effectively with proton therapy than with photon therapy. The main problems with the wider use of proton irradiation are its low prevalence and high cost. In addition, the question of the effectiveness of treatment for some types of pathology remains. It should be noted that with the use of the same doses and similar radiobiological effectiveness of irradiation, one cannot expect better clinical results in terms of local control or overall survival. The only parameter that can be improved in such a situation is the toxicity of therapy. This outlines the direction in which proton therapy can develop - dose escalation, or the use of alternative fractional modes in order to improve local control and survival. This also indicates that randomized clinical trials, in which the only condition would be the physical nature of the radiation, do not make much sense in terms of the results of cancer treatment. The leading criterion may be the assessment of treatment toxicity.

It is paradoxical that the indications for proton therapy are not justified by data obtained in the course of randomized trials (melanoma of the eye, chordoma and chondrosarcoma of the skull base, pediatric radiotherapy). Treatment is prescribed primarily based on the results of dosimetric studies or our own empirical experience. Tumor localizations that are difficult to irradiate (pancreatic cancer, esophagus, lung cancer), the lack of randomized data is often considered an obstacle to the use of proton therapy.

A new indication for proton therapy is malignant lymphomas. As in children, the curability of lymphoma is high. Very often we are talking about young patients, where the presence of late toxicities of radiotherapy is decisive. From a dosimetry point of view, the load on healthy tissues is significantly lower when using proton radiotherapy. It can also be assumed that the probability of adverse effects, especially secondary complications such as cardiotoxicity and pulmonary complications, is significantly reduced. The most effective treatment is currently considered the administration of radiotherapy to the residual tumor after chemotherapy.

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Conclusion:

At the physical level, it is undeniable that proton therapy has much better parameters than most technologies available for photon irradiation. At the level of clinical results, there are only reasonable assumptions about the advantages of proton therapy, and its use is fully accepted only for some diagnoses. Proton therapy expands the possibilities of radiation oncology, offers treatment for currently incurable tumors, and in some indications is an alternative to surgical procedures, and its importance will continue to grow.

References:

1. Кубеш Й. Клиническое применение протонной радиотерапии при лечении опухолевых заболеваний // Российский онкологический журнал, № 5, 2014, С.4-10.

2. Amichetti M., Amelio D., Cianchetti *M.* A systematic review of proton therapy in the treatment of chondrosarcoma of the skull base. *Neurosurg. Rev.* 2010; 33: 155–65.

3. Mahadevan A., Miksad R., Goldstein M. et al. Induction gem- citabine and stereotactic body radiotherapy for locally advanced nonmetastatic pancreas cancer. *Int. J. Radiat. Oncol. Biol. Phys.* 2011; 81: 615–22.

4. Zietman A. L., Desilvio M. L., Slater J. D. Comparison of conventional-dose vshigh-dose conformal radiation therapy in clinically localized adenocarcinoma of the prostate: a random-ized controlled trial. *J.A.M.A.* 2005; 294: 1233–9.

5. Elmurotova D.B., Nishonova N.R., Kulueva F.G., Uzoqova G.S., Xo'jamberdiyeva J.N., Jo'rayeva Sh.A. Mashaits: islamic interpretation of the greek philosophical heritage // South Eastern European Journal of Public Health (SEEJPH), (ISSN: 2197-5248) V.XXV, S2, 2024, Posted:05-12-2024, P.516-522, https://www.seejph.com/index.php/seejph

6. Shodiev A.A., Mussaeva M.A., Nishonova N.R., Elmurotova D.B., Islamova D.X. Improving Structure and Superconductivity of Coated Cuprate Tapes by Irradiation with Electrons and Gamma-Rays // Nanotechnology Perceptions, ISSN 1660-6795, V.20, N.7 (2024), P. 209-126, https://nano-ntp.com/index.php/nano/article/view/3822

7. I. Mullojonov, Q.I. Narziqulova , V.G. Makhsudov , E.Ya. Ermetov, D.B. Elmurotova, M.I. Bazarbayev. Study of the appearing molar volume of electrolyte solutions and its application in health-biological processes // MedForum: Int. Conf. on Patient-Centered Approaches to Medical Intervention 2024, Dr. Tanima Bhattacharya et al. (eds) © 2024 Taylor & Francis Group, London, P.38-40.

8. M.I. Bazarbayev, B.T. Rakhimov, Sh.A. Isroilova, D.B. Elmurotova, D.I. Sayfullayeva. Enhancing biophysics problem-solving skills in medical students through a targeted three-step strategy // MedForum: Int. Conf. on Patient-Centered Approaches to Medical Intervention 2024, Dr. Tanima Bhattacharya et al. (eds) © 2024 Taylor & Francis Group, London, P.112-114.

9. М.И. Базарбаев., Д.Б. Элмуротова., Ш.К. Нематов., Ш.Ш. Азимов., Т.З. Даминов., А.Р. Махкамов. Современные подходы к гигиене рук медицинского персонала //The journal of humanities & natural sciences, Issue 8, V.1, 2024. P.208-217.

10. Elmurotova D.B., Odilova N.J., Jumanov Sh.E. Semmelweis against puberner fever in hungary // Western European Journal of Linguistics and Education, V.2, Iss1, January-2024 ISSN (E): 2942-190X, P.56-59, Germany. https://westerneuropeanstudies.com/index.php/2/article/view/255
11. Элмуротова Д.Б., Элмуратов Э.Б. Исследование и совершенствование техники и технологии по освоению скважин в сложных горно-геологических условиях на месторождениях Республики Узбекистан // Лучшие интеллектуальные исследования, Ч-13, Т.5, Январь-2024, С.11-23, Россия. http://web-journal.ru/index.php/journal/issue/view/89
12. Elmurotova D.B., Sayfullayeva D.I., Isroilova Sh.A. Terms of medical information system, World Bulletin of Public Health (WBPH), V.34, May, P.91-92, 2024 ISSN: 2749-3644, Berlin. https://www.scholarexpress.net
13. Elmurotova D.B, Majlimov F.B., Zuparov I.B., Kayumova K.S., Xudoyberdiyev B.A. A modern approach to hand hygiene in medicine // European Journal of Humanities and Educational Advancements (EJHEA), V.5 N.05, May 2024 ISSN: 2660-5589, P.51-53, Spain. https://www.scholarzest.com
14. Elmurotova D., Arzikulov F., Egamov S., Isroilov U. Organization of direct memory access // Intent Research Scientific Journal-(IRSJ), ISSN (E): 2980-4612, V.3, Is.10, October – 2024, P. 31-38., Philippines, https://intentresearch.org/index.php/irsj/article/view/345
15. Elmurotova D., Arzikulov F., Izzatullayev I., Olimov A., Abdurahmonov J. The role of remote diagnostics in medicine // World Bulletin of Public Health (WBPH), V.39, October 2024, ISSN:2749-3644, P.102-105. Germany, https://scholarexpress.net/index.php/wbph/article/view/4664
16. Elmurotova D., Fayziyeva N.A., Urmanbekova D.S., Bozorov E.H. Implementation of the method of teaching x-ray therapy in higher educational institutions // Web of Teachers: Inderscience Research, V.2, Issue 10, October-2024, ISSN (E):2938-379X, P.18-23. Spain. https://webofjournals.com/index.php/1/article/view/1868
17. Elmurotova D.B., Esanov Sh.Sh., Abduraxmonov S.A., Ulug'berdiyev A.Sh., Umarov J.S. Medical device reliability and measuring instrument specifications // Eurasian Journal of Engineering and Technology, EJET, V.34, October-7, 2024, ISSN: (E) 2795-7640, P.10-13, Belgium. https://geniusjournals.org/index.php/ejet
18. Shodiev A.A., Mussaeva M.A., Elmurotova D.B. Magnetic resistance and mobility of carriers of HTSC – YBCO tapes irradiated with 5 MeV electrons // Eurasian Journal of Physics, Chemistry and Mathematics, EJPCM, V.35, October-26, 2024, ISSN: 2795-7667, P.25-33, Belgium. https://geniusjournals.org/index.php/ejpcm/article/view/6393
19. Elmurotova D.B., Fayziyeva N.A., Odilova N.J. Properties of electron and neutron therapy // Web of Medicine: Journal of medicine, practice and nursing, V.2, Issue 10, October-2024, ISSN (E): 2938-3765, P.137-141, Spain.
20 Elmurotova D.B., Yoqubboyeva E.Z., Orifqulova M.F., Imanova L.N. Application of computer technologies in medicine // Western European Journal of Medicine and Medical Science, V.2, Issue 11, ISSN (E): 2942-1918, November-2024, P.1-12. Germany. https://westerneuropeanstudies.com/index.php/3.

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