Radiotherapy and Oncology xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Original article

Practice patterns of image guided particle therapy in Europe: A 2016 survey of the European Particle Therapy Network (EPTN)

Alessandra Bolsi [a,1], Marta Peroni [a,1], Dante Amelio [b], Alexandru Dasu [c], Markus Stock [d], Iuliana Toma-Dasu [e], Petra Witt Nyström [c,f], Aswin Hoffmann [g,h,i,*]

[a] Centre for Proton Therapy, Paul Scherrer Institute, Villigen, Switzerland; [b] Proton Therapy Centre Azienda Provinciale per I Servizi Sanitari (APSS) Trento, Italy; [c] The Skandion Clinic, Uppsala, Sweden; [d] MedAustron Ion Therapy Center, Wiener Neustadt, Austria; [e] Medical Radiation Physics, Stockholm University and Karolinska Institutet, Sweden; [f] Danish Centre for Particle Therapy, Aarhus, Denmark; [g] Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany; [h] Institute of Radiooncology – OncoRay, Dresden, Germany; [i] OncoRay – National Centre for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Germany

ARTICLE INFO

Article history:
Received 28 January 2018
Accepted 10 March 2018
Available online xxxx

Keywords:
Particle therapy
Image guidance
Survey

ABSTRACT

Background and purpose: Image guidance is critical in achieving accurate and precise radiation delivery in particle therapy, even more than in photon therapy. However, equipment, quality assurance procedures and clinical workflows for image-guided particle therapy (IGPT) may vary substantially between centres due to a lack of standardization. A survey was conducted to evaluate the current practice of IGPT in European particle therapy centres.

Material and methods: In 2016, a questionnaire was distributed among 19 particle therapy centres in 12 European countries. The questionnaire consisted of 30 open and 37 closed questions related to image guidance in the general clinical workflow, for moving targets, current research activities and future perspectives of IGPT.

Results: All centres completed the questionnaire. The IGPT methods used by the 10 treating centres varied substantially. The 9 non-treating centres were in the process to introduce IGPT. Most centres have developed their own IGPT strategies, being tightly connected to their specific technical implementation and dose delivery methods.

Conclusions: Insight into the current clinical practice of IGPT in European particle therapy centres was obtained. A variety in IGPT practices and procedures was confirmed, which underlines the need for harmonisation of practice parameters and consensus guidelines.

A recent report from IAEA stresses that radiation therapy is effective and safe only as long as it is "*complemented by supporting accessories and trained staff*" [1]. One of the most important "*supporting accessories*" as defined by IAEA is imaging. Image Guided Particle Therapy (IGPT), similarly to Image Guided Radiation Therapy (IGRT) using megavoltage photons, represents a key concept in the particle therapy workflow [2,3]. But the translation of recent imaging concepts and technologies, such as cone-beam computed tomography (CBCT) and immobilization techniques from photon therapy to particle therapy has not always been straightforward. Hence, IGPT lags behind image guidance in photon therapy.

In radiation therapy, 'image guidance' is a general term ensuring the visualization and quantification of geometric uncertainties caused by the treatment setup or changing anatomy of the patient prior to or during a treatment fraction. For particle therapy, a detailed understanding of intra- and inter-fractional changes is essential for determining internal treatment margins and optimizing beam parameters in order to achieve greater accuracy and precision of radiation delivery. Moreover, the imaging requirements for the treatment of moving targets using particles are more stringent than for photons, as it is not only important to monitor positional changes of the tumour and/or normal tissues relative to the isocentre, but also morphological changes in the beam path need to be checked. Small positional variations can moreover lead to a significantly larger dose degradation in particle therapy than in photon therapy. This degradation might not always be compensated for by a correction of the isocentre, but may require treatment plan adaptation.

* Corresponding author at: Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Fetscherstraße 74, 01307 Dresden, Germany.

E-mail address: aswin.hoffmann@uniklinikum-dresden.de (A. Hoffmann).

[1] Both authors contributed equally to this work.

https://doi.org/10.1016/j.radonc.2018.03.017
0167-8140/

Particle therapy specific challenges can result in a difficult translation of IGRT achievements to IGPT. First of all, up to the point in which no vendor was present on the market, most centres have developed their own strategies for image guidance, tightly connected to their technical implementation and delivery methods. Hence, clinical procedures, equipment, and quality assurance (QA) processes for IGPT can vary substantially between centres.

So far, these aspects have not been systematically analysed across particle therapy centres. Given the lack of standardized procedures for IGPT, the need to cooperate among centres and exchange knowledge as an integral part of modern radiation therapy has been acknowledged as being of importance to bring particle therapy forward.

Given the increasing number of running and planned particle therapy facilities [4], a working group on Image Guidance in Particle Therapy within the framework of ESTRO's European Particle Therapy Network (EPTN) task force was established in 2015 [5]. The goal of this working group is to collect insight into ongoing clinical practice, to identify bottlenecks and challenges of current IGPT procedures and to drive the harmonization through practice parameters and guidelines based on expert opinions, literature and formal consensus between the European centres. Moreover, an inventory of current research topics in IGPT will be provided, with the intent of facilitating translation of innovative results into clinical practice.

This report describes the results of the first IGPT survey by the EPTN in European particle therapy centres. The aim was to assess differences between centres in terms of IGPT usage for treatment preparation, treatment planning, and treatment delivery in the clinical workflow. Furthermore, the most urgent developments needed to improve IGPT were identified, as well as the current and planned IGPT research activities.

Materials and methods

In 2015, contact persons interested to participate in the IGPT working group were identified within 19 participating European particle therapy centres from 12 European countries. In February 2016, these centres were asked to complete a questionnaire on the current status and future perspectives of IGPT. The questionnaire was divided into three sections: (1) IGPT in clinical practice, (2) IGPT for moving targets, and (3) IGPT research activities and future perspectives. The first section included imaging aspects for patient immobilization, treatment simulation and planning, setup verification, treatment evaluation and adaptation. The second section included motion mitigation techniques, 4D imaging acquisition techniques, procedures for on-line target localisation and repositioning as well as image registration/matching procedures. In the third section, centres were asked to express their needs for the most desirable developments in IGPT, to indicate their focus on IGPT research, and to rank 7 pre-defined possible IGPT research topics.

Results

In total, all of the 19 European particle centres responded to the questionnaire by providing complete or partial information, depending on the topic and the specific centres' experience.

The majority of the centres ($n = 10$; 53%) were treating patients with proton therapy, in most of the cases predominantly static tumours. Only 2 centres were also treating patients with carbon ions. In the following, we refer to these centres as *treating centres*. At the time of the survey, 5 centres were under construction, and 4 were in the planning phase. In the following, these sites are referred to as *non-treating centres*. Characteristics of the centres' facility specifications are summarized in Fig. 1.

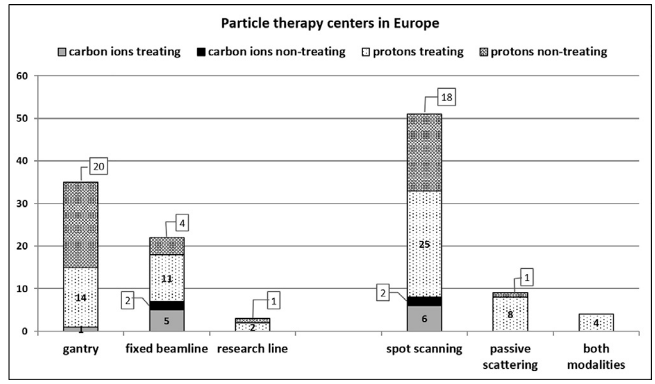

Fig. 1. Number of treatment rooms in European particle therapy centres.

Patient immobilization

The practice with respect to immobilisation tools for brain/CNS as well as for head-and-neck treatments is rather consistent between the various centres. Four non-treating centres did not respond to this part of the questionnaire. The other 15 centres use thermoplastic masks, together with suitable frames for immobilisation and accurate positioning reproducibility. Although not specified by all centres, 3-point masks are generally used for brain treatments and 5-point masks for head-and-neck treatments. The use of head cushions varies between centres with customized head supports used in 7/15 centres, while 5/15 others use standard cushions and 3/15 did not specify. In total 8/15 centres use base of skull head frames, with 6/10 being treating centres, while for the other centres the type of frames or inserts was not specified. Bite blocks are used only by two of the treating centres as an alternative or additionally to the masks.

The questionnaire highlighted varied practices with respect to patient immobilisation for thorax treatments. Most of the non-treating centres did not answer these questions. Five of the treating centres and one non-treating centre use individual vacuum or resin-based cushions and mattresses for patient fixation, while 5 centres use dedicated plates (e.g. breast board, head rest, arm rest) or inserts. Two centres also use thermoplastic masks for patient fixation.

For pelvis treatments, 8 out of 19 centres (will) use a vacuum cushion for prone positioning, while 4 centres are using it in combination with mask. Additionally, 5 centres are using a hip, knee or feet fixation for supine positioning, while a belly board is used by one centre. Moreover, 13 centres do not use fiducial markers for the pelvic/abdominal region, do not treat these patients or did not answer. Four treating and 2 non-treating centres use implanted fiducial markers for positioning. Three of those use gold markers of different sizes (0.28×10 mm, 0.75×5 mm, 1×3 mm) and one uses polymer markers. Dose perturbation due to implanted fiducials was evaluated in 5/6 centres using measurements (e.g. radiochromic films), or based on the results from literature. The water equivalent path length was assessed in one centre and 4 others stated that it has been included in the range uncertainty.

The use of a biodegradable rectum spacer is limited to one out of the 4 centres treating prostate tumours, while two were using a water-filled rectum balloon. For the other two centres planning to treat prostate tumours the organ immobilisation was still under investigation.