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Original Report

Practice patterns of photon and proton pediatric image guided radiation treatment: Results from an International Pediatric Research Consortium

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Abstract

Purpose: Image guided radiation therapy (IGRT) has become common practice for both photon and proton radiation therapy, but there is little consensus regarding its application in the pediatric population. We evaluated clinical patterns of pediatric IGRT practice through an international pediatrics consortium comprised of institutions using either photon or proton radiation therapy.

Methods and materials: Seven international institutions with dedicated pediatric expertise completed a 53-item survey evaluating patterns of IGRT use in definitive radiation therapy for patients ≤21 years old. Two institutions use proton therapy for children and all others use IG photon therapy. Descriptive statistics including frequencies of IGRT use and means and standard deviations for planning target volume (PTV) margins by institution and treatment site were calculated.

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Conflicts of interest: None.

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Results: Approximately 750 pediatric patients were treated annually across the 7 institutions. IGRT was used in tumors of the central nervous system (98%), abdomen or pelvis (73%), head and neck (100%), lung (83%), and liver (69%). Photon institutions used kV cone beam computed tomography and kV- and MV-based planar imaging for IGRT, and all proton institutions used kV-based planar imaging; 57% of photon institutions used a specialized pediatric protocol for IGRT that delivers lower dose than standard adult protocols. Immobilization techniques varied by treatment site and institution. IGRT was utilized daily in 45% and weekly in 35% of cases. The PTV margin with use of IGRT ranged from 2 cm to 1 cm across treatment sites and institution.

Conclusions: Use of IGRT in children was prevalent at all consortium institutions. There was treatment site-specific variability in IGRT use and technique across institutions, although practices varied less at proton facilities. Despite use of IGRT, there was no consensus of optimum PTV margin by treatment site. Given the desire to restrict any additional radiation exposure in children to instances where the exposure is associated with measureable benefit, prospective studies are warranted to optimize IGRT protocols by modality and treatment site.

Introduction

Image guided radiation treatment (IGRT) has become common practice for multiple tumor types in the adult population and is frequently used in management of the pediatric population as well. Although there is no consensus definition, IGRT generally refers to frequent, serial imaging performed in the treatment room prior to delivery of radiation therapy, affording improved localization of the target and normal structures.[1-3] Such pretreatment IGRT allows for more precise and accurate radiation delivery, permitting for reduction in treatment margins and subsequent dose escalation strategies,[4,5] which have been associated with improved local control.[6,7] Moreover, serial IGRT can identify changes in target and normal tissue volumes over the course of radiation therapy, allowing for the possibility of adaptive radiation regimens.[8,9]

Methods for image guidance include planar and volumetric imaging as well as localization and tracking of internal or surface markers.[1,10] Commonly employed planar strategies include megavoltage (MV) images derived from the treatment x-ray beam (known as portal imaging) and kilovoltage (kV) images from x-ray devices in the treatment room. Planar radiographs can also be continuously acquired to allow for real-time fluoroscopic monitoring. Yet MV- and kV-based planar imaging often lack adequate contrast for soft tissue delineation; as such, these images are generally directed at surrogate bony landmarks or fiducials as opposed to the actual treatment target. Consequently, deformation in target volumes or movement of the target may go undetected. Conversely, volumetric imaging strategies such as cone beam computed tomography (CBCT) can offer a means for 3-dimensional target localization with adequate soft tissue and bone resolutions for many treatment sites.[11] Yet, repeated pretreatment CT scans are associated with increased treatment time, monetary cost, and radiation dose of up to approximately 3 cGy per CBCT scan.[11,12]

These limitations may be especially important to consider when choosing optimal IGRT regimens in the pediatric population, for whom there is particular concern for potential late effects related to both cumulative radiation dose and distribution of radiation dose.[13-15] Moreover, the increased time required to complete IGRT protocols may reduce the older pediatric patient's tolerance for maintaining the treatment position or lengthen the younger patient's time under anesthesia.

There is a paucity of studies in the literature examining the use of IGRT in the pediatric population, with no consensus guidelines for its appropriate application. Thus, to better understand the range of IGRT practices currently employed, this study evaluates clinical patterns of pediatric IGRT use through an international pediatrics consortium comprised of institutions using either photon or proton radiation therapy.

Methods and materials

Consortium participants

Pediatric radiation oncologists at 9 international institutions recognized for having dedicated pediatric expertise were selected to participate in a research consortium evaluating patterns of IGRT practice in the treatment of patients ≤ 21 years old. For definitive pediatric IGRT cases, 5 sites deliver photon IMRT alone, 1 site uses proton therapy alone, and 1 site utilizes both proton and photon therapy. Image guidance strategies employed at photon institutions within the consortium include in-room kV- and MV- planar imaging and kV-CBCT; all proton therapy was performed with kV-planar IGRT.