SpotOn+

Center for Proton Therapy :: Paul Scherrer Institut :: #7_12/2015

Dear Colleagues

In this December SpotOn edition, we report the Quality of Life (QoL) outcome of toddlers treated with pencil beam scanning proton therapy. Most of these young children had brain tumors and cross-sectional and longitudinal QoL data were collected using a proxy-assessment. In the former assessment, toddlers in the PSI cohort had had not surprisingly a significant decrease of QoL in all domains except in emotional functioning before the initiation of PT, when compared to the normal reference group. Interestingly, in the latter assessment, all QoL scores increased substantially after PT. Girls, especially those with brain tumors receiving sequential chemotherapy presented incremental QoL scores that were more marked during follow-up. These data are of paramount importance, as few data is available on QoL in children treated with proton therapy. The assessment of QoL after treatment for children with cancer has become an integral part in many studies and every effort should be deployed to collect these critical data. We also report the results of a planning study for H&N patients treated with PT and a SIB delivery paradigm. The mean decrease of the delivered dose to the organ at risk in direct vicinity of the target volume (brainstem) is approximately 14%. In the light of these results, we deliver currently PT with 1.8 GyRBE to the PTV and 2.36 GyRBE to the GTV concomitantly for selected H&N patients. Finally, the safety concept of the integration of the control systems of our new Gantry (Gantry 3) into our general IT architecture is detailed by Dr Fernandez. Importantly, this new platform will enable CPT to save some resources, as it will allow automatizing the performance measurements of the safety system whilst assuring maximum patient's safety. As mentioned earlier in the previous issue, the Gantry 3 has been fully installed at PSI and is currently commissioned.

Finally, I am happy to report that another landmark has been reached at PSI: We treated 1'105 patients with the Optis 2 delivery system, which was an upgrade of the previous delivery system (i.e. Optis 1) that treated 5'500 patients with eye tumors since 1984. In the next edition, we will report the results of an international survey performed by PSI for the treatment of eye tumors. Stay tuned for some additional news in our next issue. I take the opportunity to wish you a Merry 'Xmas and Happy New Year.

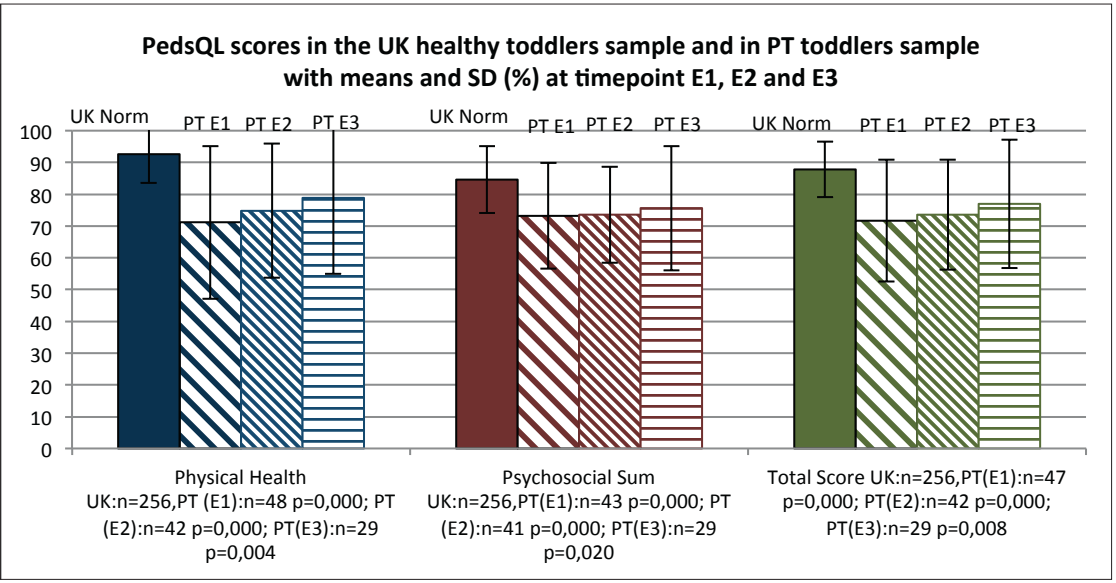
Yours sincerely,
Prof. Damien Charles Weber,
Chairman of CPT

Radio-Oncology News

Proxy assessed-Quality of life among toddlers with cancer treated with proton therapy

Background and Methods

Assessment of Quality of Life (QoL) in standard therapies for childhood cancer has become an integral part in many studies. Little is known about QoL in patients treated with proton beam therapy (PT). The aim of the presented study is a comprehensive evaluation (both cross-sectional and longitudinal) of QoL in a cohort of childhood cancer patients (toddlers, age 2 to 4 years) treated with spot-scanning PT at the Paul Scherrer Institute PSI during the years 2005 – 2014. The *PedsQL* toddler version was used [1] for QoL Proxy-assessment. This validated questionnaire, which is completed by parents or other guardians, includes 20 items on four scales (Physical Functioning, Emotional Functioning, Nursery and Social Functioning) and three summary scores (physical health, psychosocial health and total score). After baseline examination before start of PT patients/parents were followed up by postal mail to assess the QoL. Data from a sample of UK healthy toddlers (N = 256) were available for comparison purpose [2].



Results

49 toddler cancer patients (2–4 years) without relapse or progress at follow-up assessments who received focal proton therapy with a total dose of at least 40 Gy (RBE) and with completed baseline and at least one follow-up evaluation could be included in the statistical analyses. Patients were on average 2.7 years old and 60 % were male. About 60 % of patients had a brain tumor and were irradiated with a median dose of 54 GyRBE. QoL data were available for 49 patients at baseline (E1), for 43 patients at two months (E2), for 29 patients at one year (E3) and for 15 patients at two years (E4) after PT. When compared to the norm population, toddlers with cancer had a significant lower QoL in all domains except in emotional functioning before the initiation of PT. The difference also holds true after PT, however the QoL of cancer patients improves over time. The mean scores of both groups get closer and become more comparable (see figure).

Conclusion

Although QoL of toddlers with cancer is significantly decreased when compared to normative data, PT has no impact on the QoL of these very young patients. One year after therapy, QoL increased significantly in all domains.

Picture for illustration purpose of the project, painted and kindly provided by a 5-year old patient treated at PSI.

The presented data are part of an ongoing, prospective collaboration project between PSI and the QoL working group at University of Münster in Germany led by Dr. G. Calaminus.

[1] Varni JW, Seid M, Kurtin PS. *PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations.* Med Care 2001;39:800-812

[2] Buck D, Clarke MP, Powell C, et al. *Use of the PedsQL in childhood intermittent exotropia: estimates of feasibility, internal consistency reliability and parent-child agreement.* Qual Life Res 2012;21:727-736.

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Medical-Physics News

A clinical protocol for Simultaneous Integrated Boost for proton treatment of Head and Neck carcinoma

Background

Delivering proton therapy with a Pencil Beam Scanning technique allows the exploitation of dose escalation to the Gross Tumor Volume (GTV), simultaneously delivering a conventional dose to a larger elective target volume (PTV1) and to the Organs at Risks (OARs) included into it. This technique is called Simultaneous Integrated Boost (SIB). The advantages are a better tumor control due to the higher dose per fraction delivered to the GTV, and a shorter duration of the radiotherapy course for the patient. The challenge with the SIB technique is to achieve the desired dose gradient between the two targets avoiding an over-boosting of the fraction of PTV1 outside the GTV. The goal of our planning study was to find the optimization parameters that could guarantee this result and to implement them into a clinical protocol.

Methods

We selected 7 patients, treated at PSI for different Head and Neck (H&N) carcinomas with two sequential series at 2 GyRBE. The first series up to 54 GyRBE to the PTV1, followed by a second series up to 72 GyRBE to the boost target volume, for a total of 36 treatment days. All cases have been re-planned using a SIB regimen of 1.8 GyRBE (up to 54 GyRBE) to PTV1 and 2.36 GyRBE (up to 70.8 GyRBE) to the GTV for a total of 30 fractions. Dose constraints to the OARs were kept as for the sequential approach. All plans were designed on the PSIPlan Treatment Planning System using Intensity Modulated Proton Therapy (IMPT) with non-coplanar fields. The prescription dose of 100 % corresponded to the average dose to PTV1, while the dose escalation to the GTV was achieved by applying a boosting factor based on the ratio of the two different prescribed dose levels (i.e. 54 GyRBE and 70.8 GyRBE). To guarantee dose homogeneity in the dose gradient region between PTV1 and the boost, the optimized SIB plans were normalized such that 54 GyRBE corresponded to the average dose to [PTV1-(Boost volume + 3 mm)]. This avoided over-dosages close to GTV being compensated by under-dosages at the PTV1 margin.

Results

When compared to the nominal sequential plan (see figure), the SIB approach resulted in a much lower mean dose to the ring area (average value for SIB: 55.2 + 1.0 GyRBE; average value for sequential: 64.1 + 3.6 GyRBE). This can be crucial in order to avoid excessive toxicities to OARs included in that area, given the increased dose per fraction. Therefore, planning H&N patients with SIB optimization resulted in dose distributions which guaranteed the targets coverage and conformity whilst keeping dose to OARs within tolerance. This approach could be transferred to the clinical operation and has already been applied to a first patient.

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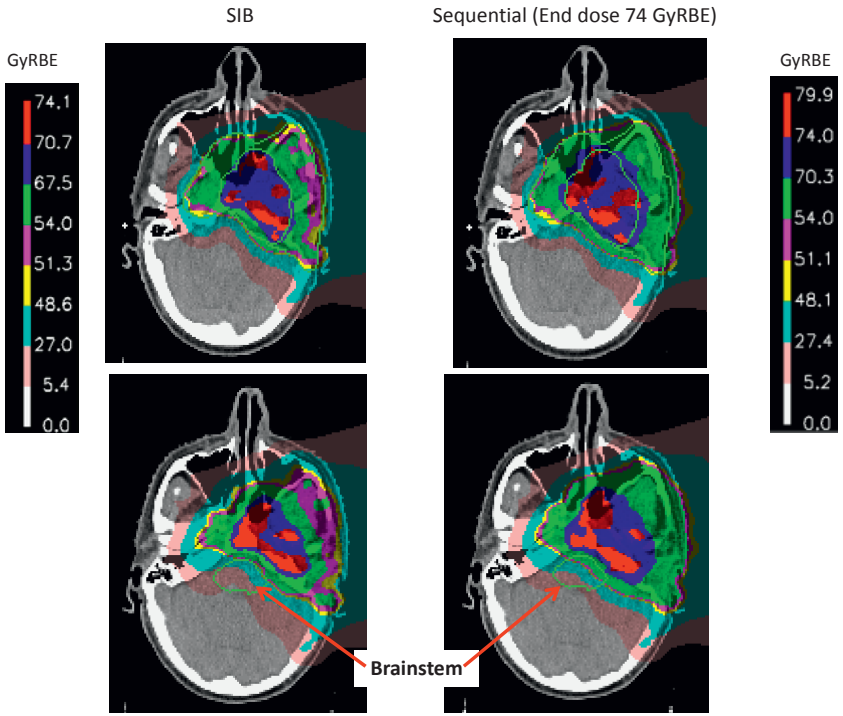

Comparison of dose distributions for the SIB and the sequential plans for a slice close to target's center. The upper raw highlights the PTV1 (outer contour) and the boost (inner contour) volumes; the lower raw highlights the brainstem. 54 GyRBE corresponds to the prescribed dose to PTV1-GTV for both plans. The green and the blue isodoses correspond to the 95 % and 100 % dose levels prescribed to the boost for both approaches, independently from the different end doses.

Physics News

Integration of Gantry 3 Safety Systems

PSI's new treatment room Gantry 3 is based on the Varian ProBeam product and is delivered with its own system for the safety of the patient and personnel. However, many of the control and safety elements of the PSI facility are located at the cyclotron and shared parts of the beamline and they are controlled by already existing systems. Therefore interfaces had to be built to integrate Gantry 3 controls.

The task of control and safety systems is to guarantee the correct application of the treatment plan and to ensure the patient's safety at all times. The control system determines the dose distribution in the patient (spot dose and position) by setting the corresponding actuators (beam on/off by the kicker magnet, position by scanning magnets, beam energy by degrader and beamline etc.). The safety system supervises the action of the control system by evaluating signals from different sensors (redundant dose monitors, hall probes etc.). Its logic decides when the treatment is deviating from the plan. It will then trigger the corresponding devices ("final elements") to reach the safe state (turn beam off, stop mechanical movement). The correct functioning of such an interlock is again supervised by the logic, and if necessary an escalation involving redundant final elements can be triggered.

The safety concept, as implemented in the already existing treatment rooms, comprises local (specific to one treatment room) and central (shared over the facility) components, each with their own sensors, logic and final elements. The integration of Gantry 3 follows this architecture as the safety interface takes a role similar to the local safety system and connects it to the central system in a highly reliable way. Besides passing the relevant signals between Gantry 3 and the central safety system it provides additional supervision and a local beam blocker as final element.

While reusing most of the technology from the existing treatment rooms, like redundant complementary cabling to allow detection of broken links, it was decided to program the logic on a state-of-the-art platform. The choice fell for the IFC1210 controller, developed jointly by PSI and the Swiss company IOXOS. It features a user programmable Virtex 6 FPGA chip. It contains the safety system logic which after system startup is totally autonomous. The 116 safety signals are then connected to the corresponding physical cables using either optical or electrical adapters. On board are further two CPUs (type PowerPC) running SMP Linux. They provide a standardized EPICS communication interface. This is used by the Graphical User Interface (GUI) which provides access to the safety logic and automated actions like logging and statistics.

Figure 1
The Safety System Interface for Gantry 3. The logic is on the controller at the top, signal conversion between Varian and PSI is handled by the two modules is in the center, cabling to/from sensors and final elements is at the bottom.

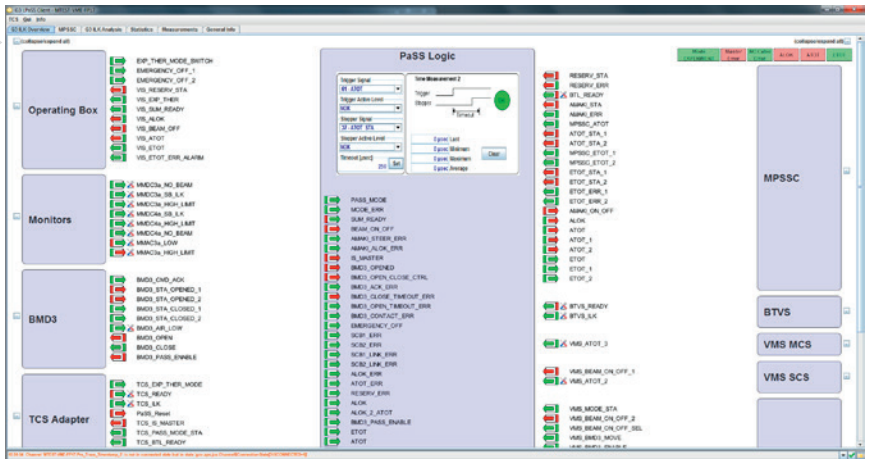

Figure 2 The Graphical User Interface displaying the status of input and output signals, and an example for a performance measurement.

For the development of the safety logic the same process as for the existing areas is followed. It comprises extensive verification and validation steps to ensure the correctness and integrity of the logic.

An additional benefit of the new platform is the possibility to automatize performance measurements of the safety system (the logic and the final elements). These measurements are required for the acceptance and the technical quality assurance of Gantry 3. It is expected to save 10 man days of work each year. The continuous monitoring will allow the prediction of failures by ageing of components and organize their replacement before delays in the clinical program would arise.

For any further information, please refer to CPT,
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Reference: Fernandez Carmona et al, *"Reusable Patient Safety System Framework for the Proton Therapy Centre at PSI"*, Pre-Press Release ICALEPCS 2015 Proceedings

Imprint

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