less ambiguous than the empirical SECT based stoichiometric method.

Methods and Materials

To investigate the accuracy of SPR estimation methods, experimental validation was performed on organic tissues. Measurements of the proton range were made with pristine pencil beams, and CT scans were acquired in SECT and DECT mode, as well as PCD-CT mode. Firstly, the SECT scans were evaluated with a clinical stoichiometric conversion curve, and the DECT scans were evaluated with commercial DECT software. The SECT and DECT scans were later re-evaluated with our own implementation of (other) SPR methods. No software is available for evaluation of SPR estimation based on PCD-CT scans and these were therefore evaluated with our own implementation of different SPR estimation methods. The accuracy of the methods was evaluated based on the root-mean-square error (RMSE) and the mean error, with main focus on the RMSE as too few tissues were examined to assume Gaussian distributed errors.

Results

It was found that DECT was superior to SECT, following the trend of other recent investigations. However, re-evaluation using another implementation of the stoichiometric curve, it was found that the SECT based SPR estimation error could be significantly reduced (Table 1). The mean errors stayed lower for the DECT based methods. The same tissues (a subset) were scanned with a PCD-CT scanner, acquired in four, two and one energy bin mode. For the one-bin images the stoichiometric method was applied, here the result was consistent with the second implementation for SECT (compare Table 1 and 2). Two different SPR methods developed for MECT and a DECT method were tested. The results for all the methods were comparable (Table 2).

Discussion

In the comparison of SECT and DECT (Table 1), the fitting of the second stoichiometric curve was not guided by the measurements of the organic tissues. This shows that when comparing any DECT or MECT based SPR method to the SECT based stoichiometric method an effort should be made to improve the stoichiometric curve to have a fair comparison. More importantly, it shows that SECT based SPR estimation as applied in most proton centers today can provide fairly good results, but the curve fit should be carefully considered. At best, it should be experimentally validated to ensure the connection points between the individual line sections are placed appropriately; generally, more than two line sections are needed. Moreover, it was found that the stoichiometric curve could also be improved by implementing different methods for estimating the CT numbers of the literature data for the reference human tissues (first step of the stoichiometric method). The standard stoichiometric method was based on an empirical parametrization of the linear photon attenuation coefficient, which is less accurate for high density tissues. The second method applied a CT number estimation was based on effective energies for the x-ray energy spectrum, which improved the accuracy (Table 3). DECT and PCD-CT provided low errors for the SPR estimation of the organic tissues, but it was found that two-bin PCD-CT images were sufficient, and a further increase of the number of energy bins was not needed. It has previously been shown that three or four CT numbers improved the accuracy above the results for DECT. However, for our experimental results this was not the case, which most likely can be explained by the favorable energy separation which can be obtained using two-bin PCD-CT scans. In conclusion, DECT, MECT and PCD-CT can improve the SPR accuracy compared to SECT. But until these CT techniques can be used in commercial treatment planning software, improvements of the SPR estimation can be obtained by carefully fitting the stoichiometric method, and optimization of the CT scanning protocols.

Table 1: SPR accuracy in experimental evaluation based on fourteen organic tissues for comparison of SECT vs DECT. The results are stated as root-mean-square errors (RMSE) and mean errors.

SPR methods – SECT vs DECT	RMSE (%)	Mean (%)
SECT version 1	2.8	-0.6
DECT method 1	1.3	-0.3
SECT version 2	0.8	-0.6
DECT method 2	0.9	0.2

Table 2: Results for SPR estimation based on PCD-CT compared to measured SPR for nine organic tissues.

SPR methods – PCD-CT	RMSE (%)	Mean (%)
4 energy bins, PCD method 1	1.0	0.3
4 energy bins, PCD method 2	0.8	-0.7
2 energy bins, PCD method 1	0.8	0.1
2 energy bins, DECT method	1.3	0.1
1 energy bin, SECT method	0.8	-0.1

Table 3: CT estimation accuracy. Results presented in the upper part of the table is based on the accuracy of the CT number estimation for tissue equivalent phantom materials. The lower part of the table present SPR accuracy for the stoichiometric method applying the two different CT number estimation methods, evaluated on the fourteen organic tissues.

CT number estimation	RMSE (%)	Mean (%)
X-ray attenuation parametrization	3.1	-1.2
Effective energies	0.2	0.0
SPR estimation	**RMSE (%)**	**Mean (%)**
X-ray attenuation parametrization	0.7	-0.2
Effective energies	0.5	-0.1

SP-0471 Treatment Planning and Verification with Proton CT and Proton Radiography to Reduce Range Uncertainties in Proton Therapy

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Abstract text

Proton CT was originally proposed as a low-dose imaging modality by physicist Allan M. Cormack, winner of the 1979 Nobel Prize in Physiology or Medicine. Cormack had in mind to use protons for diagnostic imaging instead of x-rays but was discouraged by the need for large accelerators, rotating gantries, and other expensive equipment, besides the difficulties imposed by multiple Coulomb scattering. The real value of pCT became apparent with the expansion of proton therapy; currently, there are 27 proton treatment centers operational in the United. States. Proton CT (pCT) provides artifact-free images of the true relative stopping power values of the patient tissues (not converted from x-ray CT HU), thus avoiding the uncertainties in HU-to-RSP conversions. The use of pCT in treatment planning would reduce distal margins added to clinical proton beams and allow the use of beam directions where the beam stops near critical organs at risk like brain stem and optic chiasm. In this presentation, the possible technological realizations of proton CT scanners, all still at the preclinical stage and ranging from single-particle tracking systems operating in list-mode data acquisition to simpler technology using equipment already in use in the clinic. Proton radiography can be used as a pre-treatment verification of water-equivalent range-checking tool for each treatment field. In addition, proton CT may be used for pretreatment volumetric imaging and treatment adaptation, thus closing the gap in image guidance with respect to photon therapy.

SP-0472 Accounting for organ motion in proton therapy at the planning stage

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Abstract not received

Symposium: Care, communication and new technology in brain radiotherapy

SP-0473 Stereotactic radiosurgery for brain metastases: treating multiple lesions

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Abstract text
Stereotactic radiosurgery (SRS) has become an increasingly utilised treatment option in the initial management of patients with brain metastases. Its efficacy has been well demonstrated with a local control rate of >75% at 1 year with minimal treatment related toxicity. Novel plan optimisation and treatment delivery platforms for linear accelerator-based SRS techniques have shown that single isocentre SRS for multiple targets can be efficiently delivered without increasing the dose to organs at risk. Evolving radiation therapy and imaging technology has increased interest in SRS for hypofractionated stereotactic radiotherapy (HFSRT) for large metastases and for lesions close to organs at risk (e.g. the brainstem).
The aim of this presentation is to review and discuss results of selected SRS studies in light of technological advances and the emerging clinical needs. The session will include discussion on the optimal technique for delivery, including; different treatment platforms and technologies, treatment planning methods, methods of dose prescribing and calculation of appropriate margins. New and emerging evidence will be presented with an overview of future areas of interest.

SP-0474 Linac isocentric accuracy and its influence on treatment margins

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Abstract text
The majority of linear accelerators used for radiotherapy is isocentric. Their design is such that the three major rotation axes, for rotation of collimator, gantry and table, pass through one point, the isocenter. Several factors hinder the ideal situation of an isocenter having a fixed position in space. As a result the location of the tumor with respect to the beam's central axis is displaced due to gantry, table or collimator rotation. The isocentric accuracy is an important parameter in stereotactic treatment, as it is a major determinant of the treatment accuracy.
Measurement of isocentric accuracy is part of the quality assurance program. Ideally, it should be carried out quickly, and, considering the requirements on accuracy, have high spatial resolution.
We developed a procedure to measure isocentric accuracy, based on the Winston-Lutz test. To quantify isocentric accuracy due to gantry rotation (no table rotation) a ball bearing was imaged at various gantry and collimator angles. The accuracy of the procedure was established and found to be better than 10 µm. Several system quality parameters could be derived from these measurements, such as:
-Lateral vs. longitudinal excursion of isocenter due to gantry rotation
- EPID tilt
- Field size
- Position of beam focus, and the influence of beam steering
- MLC symmetry
The influence of inaccuracies of table rotation are mainly due to differences in location of collimator rotation axis vs. table rotation axis, as a function of table rotation angle. A simple procedure to measure this distance is discussed. The consequences of such an inaccuracy are variations in coincidence of the beam central axis and the target position in the patient. These should be accounted for by including its effect in the treatment margins that are applied. A procedure to calculate the contribution to treatment margins is given and discussed using results of our linacs.

SP-0475 Communication care and side effect - brain radiotherapy - What`s the role of the RTT?

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Abstract text
Abstract Estro April 2019 Presender: Hanne Simonsen, Department of Oncology, Aarhus University Hospital, Denmark. Topic category: Cancer care. Key words: Patient care, side effects and communication. Presentation preference: Oral, I am an invited speaker. Title: Individual network meetings in cancer care -From young people with cancer to adults with brain tumours Purpose/objective: The aim of the network meetings is to facilitate the involvement of a supportive social network around the patient and relatives. A malignant brain tumour often includes cognitive impairment. This affects both patients and families. Compared to other cancer patients, studies show that they are significantly in more need of social support and help for everyday activities. A network focused approach offering individual network meetings with and for young people with cancer has shown to facilitate the involvement of a social network around the patient and the family, with can assist them in keeping their world together. Methods: A participatory action research design was employed to develop and implement a researched based service that would promote and encourage a supportive social network for patients with primary brain tumours and their families. Patients and close relatives preferences and attitudes towards an offer of a network meeting were explored. The study involved parallel processes of interviews with patients and usually their spouses, education and interaction between the researcher and a group of ten clinical nurses. Results: Based on the findings the individual network meeting for patients with brain tumours has been shaped to fit their needs and wishes and are now fully implemented in the clinic.A group of nurses has been trained in planning and leading network meetings and acts as implementation agents. Early presentation of individualised network meetings is welcomed as an opportunity and accepted by about 40 % of the patients and relatives. Conclusion: Network meetings are feasible in clinical practice. They are highly valued by patients, who has participated and their social network. The interactive approach in action research has supported the implementation of the complex service - a service whith has potential in other nursing areas. The presentation will focus on preparing and conducting network meetings.

Poster Viewing : Poster viewing 9: Applied dosimetry

PV-0476 Effect of updated ICRU90 data on Monte Carlo kQ calculations: results from the Australian PSDL

M. Hanlon[1], C. Oliver[1], T. Bailey[1], J. Lye[2], D. Butler[1]