P1

ANALYSIS OF IMRT MODULES OF COMMERCIAL TREATMENT PLANNING SYSTEMS APPLIED TO BREAST TUMOUR MODEL

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Objective:
The evaluation of different commercial inverse treatment planning systems (TPS) for the irradiation of breast and internal mammary chain with IMRT.

Material and Methods:
Five patients treatet at our institute were planned using several TPS (Varian-Eclipse, Nucletron-OTP, CMS-Xio, Philips-Pinnacle, Elekta-Precise, Nomos-Corvus, Konrad and Hyperion) having applied the same planning goals and strategies. For all systems IMRT plans were designed for 6 MV photons beams and 80 leaves MLC. Quantitative analysis was carried out using dose volume histograms and derived quantities to ascertain differences among systems.

Results:
Good target coverage was achieved by most of the TPS in terms of V90 and V95 (target volume receiving at least 90 and 95% of the prescribed dose). Regarding organs at risk: not all TPS were able to reach the goal of no more than 15 Gy as mean dose to the omolateral lung. Also the contralateral breast, intended as healthy tissue to be particularly spared, in some cases was irradiated in a too large extent.

Conclusion:
Despite of the particular difficult shape and position with respect to organs at risk of the target volume including the whole breast and the internal mammary chain, different TPS are able to calculate acceptable treatment plans in terms of both PTV and organs at risk.

P2

ROUTINE CHECK OF P-32 SOURCE WIRES USED FOR INTRACORONARY BRACHYTHERAPY

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Objective:
A method for dosimetric source check was developed which complies with the recommendation of SGSMP.

Material and Methods:
The dose homogeneity along and around the source wire is assessed with a gafchromic film wrapped around the catheter in 2mm distance of the wire. This is achieved by bending the film to form a tube which then is inserted into a hole that is drilled in the center of a small perspex cube. The outer diameter of the catheter is thickened by ribbon band so that it matches the inner diameter of the phantom.
The radial dose falloff is measured by inserting absorbing material between the source wire and an ionisation chamber.

Results:
The bending of the film leads to certain artefacts which themselves contribute to inhomogeneity. Its typical magnitude can be found by homogeneous irradiation at the Linac and is sufficiently small so that the films still can be used.
The measurement of the radial dose falloff proved to be very reproducible.

Conclusion:
The presented procedures yield a fast method to simultaneously measure dose homogeneity along and around a source wire as well as the dose falloff in radial direction. This allows to check every newly delivered source against the specifications of the manufacturer.

P3

COMPUTER MODELS OF ANGIOGENESIS

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Objective:
Better physiological understanding of angiogenesis could result in new methods for anti-angiogenic cancer therapy. However, few models exist that are capable of providing satisfactory biological insight needed by realistic numerical simulations. This presentation describes two modeling approaches of vascular systems formation developed in our lab.

Material and Methods:
The modeling is done "in silico" by developing physical models of the biological phenomena and running numerical simulation codes on a computer. In one approach the blood vessels are modeled as pipelines flowing a non-newtonian fluid. The growth process is controlled by metabolic activity of the tissue. The other model addresses microscopic interactions between endothelial cells and flowing fluid and the growth process is guided by flow induced shear stress.

Results:
The macroscopic flow network model includes basic physiological properties of the vessel formation process and is able to generate visually realistic vascular structures. The resultant network contains flow and pressure information according to given inflow/outflow boundary conditions. The microscopic model provides detailed information on flow conditions in a porous cellular medium and is able to reproduce spontaneous bifurcation formation observed in vivo.

Conclusion:
Two physiologically oriented modeling approaches of angiogenesis have been developed in our lab. The pipeline model is able to explain structural complexity of some real vascular structures while the microscopic model explains bifurcation formation.

P4

PORTAL IMAGING FOR ORGAN TRACKING BY IMPLANTED GOLD MARKERS: ANALYSIS OF DAILY PATIENT SETUP ACCURACY DURING IMRT OF PROSTATE CANCER

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Objective:
To investigate the accuracy of on-line setup by implanted gold markers in IMRT of prostate cancer.

Material and Methods:
All prostate patients get 3 gold markers implanted under TRUS control prior to the CT-scan. Before each treatment orthogonal setup images are acquired with the aS500 portal imager and a novel dose saving acquisition mode (1 MU per image). The positions of the markers are compared to the ones in the corresponding DRRs. For deviations >1mm the position of the couch is corrected accordingly via remote control. During treatment the aS500 acquires one image per field in the dose integration mode. Despite the modulation of the fluence, the position of the markers can clearly be identified. We analyzed in 13 patients the first (180°) and the last (270°) field of a total of 5 fields. The time between the application of these two fields is about 7 min.

Results:
Our on-line setup procedure ensures a setup accuracy in the right-left (R/L), posterior-anterior (P/A) and superior-inferior (S/I) directions of 0.0±1.0 mm. The analysis (mean±SD) of field 1 reveals an accuracy of prostate position in R/L and S/I direction of -0.6±1.5 mm and 0.5±1.8 mm, respectively. For field 5 we find in P/A and S/I direction 0.4±2.2 mm and -0.1±2.0 mm, respectively.

Conclusion:
Gold markers can be safely used for daily organ tracking using an aS500 EPID. The mean intrafraction prostate movement is far below 5 mm, allowing a substantial reduction of the conventional PTV safety margins of 10-12 mm.

P5

OPEN LOW-FIELD MAGNETIC RESONANCE (MR) IMAGING IN PROSTATE RADIOTHERAPY TREATMENT PLANNING

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Objective:
To evaluate the use of open low-field MR imaging as sole imaging modality for prostate external beam radiotherapy planning.

Material and Methods:
MR images, with and without image distortion corrections, were acquired in 12 patients using a 0.23 Tesla machine (Panorama 0.23T). Organs of interest were contoured using MR images, and treatment plans were created using these contours. Next, fusion with CT images was performed using bony anatomy, and CT organ contours were transferred onto the MR images. Using different heterogeneity corrections MR and CT dosimetric plans as well as organ volumes were compared.
These variations were also compared with results of previous studies of weekly control CTs.

Results:
More uncertainty was encountered in contouring using CT images, especially in the apex region, than using MR images. The prostate volumes contoured on MR were smaller than those on CT images, 0.85 ± 0.25 (1 SD). The differences in monitor unit calculations between CT and MR plans were within ±2 %.
The differences observed between MR and CT plans are comparable to the difference observed between weekly CT plans.

Conclusion:
Use of MR images improves organ contouring. Our results using MR alone for dosimetric calculations are promising, warranting further investigation.

P6

POTENTIAL ROLE OF STEREOTACTIC LINAC BASED RADIOTHERAPY USING MICROMULTI LEAF COLLIMATOR IN THE TREATMENT OF BILATERAL RETINOBLASTOMAS

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Objective:
To assess the potential role of improved dose distribution with stereotactic radiotherapy (SRT) compared to conventional radiation therapy (RT) on the incidence of treatment induced secondary cancers in retinoblastomas

Material and Methods:
Five children were used as models for the purpose of this study. A comparative dosimetric study is presented in which a four or five field stereotactic 6MV x ray plan is compared with a one D shaped field conventional RT 6MV x ray plan.. The gross tumor volume encompasses all known gross disease. For the unfavorable patients the clinical target volume includes the entire retina and vitreous and spares the anterior segment of the eye. A prescribed dose of 45 Gy at 1.8 Gy par fraction was used. Dose volume histograms (DVHs) of the lens, lacrimal gland, bony orbit, soft tissues and brain parenchyma were compared.

Results:
The non coplanar approach result in a limited exposure of bony volume (dose delivered to 50% of the volume: 5-6 Gy), and soft tissue volume. No dose was delivered to controlateral eye, chiasma, frontal or temporal lobes, pituitary gland

Conclusion:
SRT may help to reduce the irradiation of normal brain, soft tissue and bony orbit that is responsible of second malignancy and functional long term complications in children with retinoblastoma.

P7

THE CLINICAL IMPLEMENTATION OF IMPT

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Objective:
To present our experiences with the first 14 IMPT patients treated in 2002 and 2003

Material and Methods:
14 patients have been treated with IMPT in 2002 and 2003. Each field of each plan has been individually verified, and for 1 case, detailed 2 dimensional CCD based dosimetry has been performed. A daily topogram based imaging and correction protocol has been used to ensure an accurate patient set-up.

Results:
5 skull base, 8 spinal axis and 1 head and neck lesions have been treated, with IMPT being used as a second or third series plan of a proton treatment. In only one case has IMPT been used for the complete treatment. The average fields per plan is 3 and maximum used is 4. Patient specific verifications have shown that the dose can be delivered with an accuracy of +/3% of the prescribed dose and an absolute precision of +/- 0.04Gy. Using a correction protocol based on daily orthogonal topograms, systematic positioning errors could be eliminated (mean errors alon each axis << 0.5mm) and random errors could be reduced to between 0.8-1.4mm SD depending on the axis and whether the lesion was in the head or abdomen/pelvis.

Conclusion:
IMPT is a powerful new treatment method for proton therapy. It can be delivered safely and accurately, but our initial experience shows that some improvements need to be made to the optimization algorithm before its full potential can be realized.

P8

INTENSITY MODULATED PHOTON AND PROTON BEAMS FOR STEREOTACTIC IRRADIATION OF SKULL BASE LESIONS

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Objective:
Stereotactic irradiation of skull base lesions using intensity modulated photons (IMSRT) and protons (IMPT) is evaluated with respect to target coverage and risk organ (OAR) dose.

Material and Methods:
IMSRT and IMPT treatment plans were calculated for six stereotactically treated patients. Multifocal, ovoid and irregular tumor shapes were evaluated. Dynamic micro multileaf collimator (mMLC) beam data was used for IMSRT and a modified spot scanning technique was applied for IMPT dose distributions. OAR dose, specific isodose volumes and PTV coverage was assessed.

Results:
For all tumor shapes, equally good PTV coverage was achieved. Divergence in results was observed for the 50% isodose volume, where in 3 cases it was smaller for IMSRT and in the 3 others for IMPT. The 30% isodose volume favoured IMPT over protons and IMSRT. All techniques spared concave OAR (e.g. the brain stem) well. IMPT spared critical organs the best. Results were achieved with fewer proton beams as for photons.

Conclusion:
An advantage for protons was observed in lower integral dose for all cases. Intensity modulation has been shown to improve PTV dose conformation as compared to conventional methods. IMSRT and IMPT reduced OAR dose equally well with superior sparing as compared to conventional photons and protons.

P9

THE SIMULTANEOUS INTEGRATED BOOST WITH PROTONS OR WITH IMRT IN HEAD AND NECK

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Objective:
The potential benefit of the Simultaneous Integrated Boost (SIB) concept applied to proton therapy in comparison to intensity modulation therapy with photons was investigated at planning level.

Material and Methods:
The fractionation strategy assumed for the study consists of a SIB treatment following a first phase of conventional fractionation to the elective volume. Treatment plans were designed for five patients on the proton planning system developed for spot scanning at the PSI of Villigen (CH) and on a commercial planning system for intensity modulated photons (Varian Eclipse-Helios). Three and five beams were respectively applied for protons and photons. All physical dose distributions were biologically corrected to take into account repopulation and time at repopulation onset. Objective quantities, derived from physical and biological dose distributions and dose volume histograms, were used for the numerical analys.

Results:
Proton plans showed a significant improvement of target coverage for both the elective and boost volumes with increase of minimum significant doses and of V95 (about 5%). Organs at risk irradiation (spinal cord and parotids) was reduced by a factor of about 2 and healthy tissue irradiation by a factor of about 1.7.

Conclusion:
The results showed an highly significant dosimetrical advantage with protons for all target volumes, organs at risk and healthy tissue. It could therefore be worthwhile to clinically explore accelerated SIB treatments with protons

P10

IMPLEMENTATION OF THE RADCALC PROGRAMME FOR CHECKING MONITOR UNIT CALCULATIONS

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Objective:
Hand MU calculation is standard in every radiotherapy department but is often limited to simple field set-ups or for checking TPS plans. RadCalc is a new PC-based dose calculation programme which extends the calculations to include corrections for head and phantom scatter. The implementation of the programme for clinical use is described.

Material and Methods:
Head and phantom scatter factors were measured for photon beams of 1x1cm to 40x40cm, nominal energy 6MV and 18MV and for an 80 and 120 leaf MLC using an ionisation chamber. Electronic equilibrium was achieved by using a mini-phantom or a brass build-up cap. MU calculated with Radcalc were compared with 3D TPS calculations to evaluate scatter and inhomogeneity correction.

Results:
For 85% of all open, wedged and symmetric beams, agreement was within 2.5%. For tangential beams the deviation was within 3.5%. This was expected as the algorithm only partially corrects for missing scatter. No dependence on beam energy or beam geometry was observed. Asymmetric beam deviation was within 4%.

Conclusion:
RadCalc as a reliable tool for quickly checking TPS plans and hand calculations prior to patient treatment. It has been implemented in the clinic for routine MU checks and simple field calculations and will be extended to check IMRT dose calculations.

PP1

BREAST IRRADIATION WITH THREE CONFORMAL PHOTON FIELDS FOR PATIENTS WITH HIGH LUNG INVOLVEMENT

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Objective:
Since 2001, 50 breast cancer patients, for whom extensive lung/heart involvement was expected from the use of conventional tangential 2-field technique (2F) due to complex anatomies, were irradiated using a three-field conformal technique (3F).

Material and Methods:
For all patients in the study, dose plans were designed for both 3F and 2F and a Dose Volume Histogram analysis on ipsilateral lung, heart and target has been conducted. in terms of target coverage and lung or heart irradiation

Results:
The 3F technique allowed a significant reduction in ipsilateral lung irradiation: mean dose dropped from 16.0 (2F) to 12.0 Gy (3F) and V45Gy from 20.7% (2F) to 3.2% (3F). Similarly, in patients irradiated to the left breast, heart mean dose was reduced from 8.1 Gy (2F) to 6.8 Gy (3F) and D15% from ~19 Gy to ~14 Gy. All differences reached a high degree of significance. The target coverage was not compromised since the slight reduction with 3F compared to 2F is limited to V95% while V90% was not affected by the 3F technique: 98.2% (3F) and 98.8% (2F). A preliminary report on clinical follow up is also included; with a mean follow up of one year, no pulmonary or cardiac complications were observed.

Conclusion:
The conformal technique adopted can be considered as promising and offered to all breast patients for whom specific anatomical or pathological conditions make the tangential approach to be sub-optimal for lung (and/or heart) sparing.

PP2

ABSOLUTE FILM DOSIMETRY FOR VERIFICATION IN INTENSITY MODULATED RADIATION THERAPY

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Objective:
The aim of the work is to determine Kodak EDR2 film dosimetry and to implement an absolute film dosimetry for verification in intensity modulated radiation therapy (IMRT).

Material and Methods:
Work is divided into two parts. First a sensitometric curve of EDR2 film irradiated by a 6MV X-ray beam is obtained in standard conditions (field size: $10x10cm^2$; depth=10cm). The effects of field size and depth on the sensitometric curve are studied. In a second part films are scanned and the relation between scanner output signal and optical density is determined.
The measurements are made in a solid water phantom. The dose is measured by a 0.6cc ion chamber. Both film and chamber are set up isocentrically.
Film processing is verified at the beginning and at the end of each measurement session. Films are scanned using Vidar VXR-16 Dosimetry Pro digitizer, for which a stability control program is implemented.

Results:
The standard sensitometric curve is obtained and experimental values are fitted using an inverse sigmoid curve. Depth has no effect on the film response, but field size does.
Scanner stability is verified and the relation between output signal and optical density is obtained.

Conclusion:
Absolute film dosimetry is implemented for IMRT verification. The use of the relationship between film optical density and absolute dose allows us to verify the fluence map of each beam in an IMRT planification. Slight differences remain compared to the treatment planning system values due to the effect of the beam size on the film response.

PP3

CRITICAL APPRAISAL OF CTV AND PTV DEFINITIONS BY MATCHING SIMULATOR (SF) AND PORTAL FILMS (PF) IN PROSTATE CANCER PATIENTS (PTS).

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Objective:
To verify accuracy of CTV and PTV definitions through the evaluation of systematic and random errors occuring during treatment.

Material and Methods:
From 09.'03 till 11.'03 a retrospective analysis of PF was performed in 18 pts with prostate cancer. Out of 350 paired SF and PF, 308 remained fully evaluable. Both CTV and PTV (called REAL PTV) were outlined in all patients. Systematic and random setup errors were estimated by comparison of the mean deviation in the X and Y axes, to identify the patient treated with the greatest and lowest accuracy. A new CTV (IDEAL CTV) was then outlined in these 2 patients, expanding it isotropically by 3 times the standard deviation value.

Results:
In both cases, IDEAL CTV was covered by the REAL PTV.

Conclusion:
This study on systematic and random setup errors shows the relevance of an adequate selection of CTV and PTV delineation criteria in prostate cancer patients