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Treatment planning for the second stereotactic radiosurgery utilizing the previous target reconstructed by image fusion

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Purpose: The intracranial recurrence of brain metastases often manifests in patients treated with stereotactic radiosurgery (SRS) alone. Although such patients would be retreated with SRS for their new lesions, the precise dose distributions of prior irradiation have been difficult to take into account, and often ignored, in the reirradiation planning. We present a methodology for fusing the volumetric images of the previous and current targets into a 3D image, by which the accumulated doses to the normal structures during repeated SRS can be minimized.

Materials and Methods: From October 1997 through February 1999, 13 lesions of recurrent metastatic brain tumors were retreated with SRS. Treatment planning was conducted with the X-Knife 3-D planning system (Radionics) in the following manner: (1) The previous MR and current CT (with stereotactic frame) images were fused; (2) the current MR and current CT images were fused; (3) the bone data were contoured from the current CT images and the internal brain structures were acquired from the current fused images; (4) the previous and current targets were contoured in the respective fused images; (5) the previous targets were transferred into the current fused images; and finally (6) optimum beams were selected by Beam's-eye-View method not to overlap with the previous beams.

Results: By fusing the previous and current targets in a 3D image, it has become feasible to carry out safe treatment planning for the second SRS. For all the 13 lesions, volume doses between the current and the previous targets were 10–15% either of the current or the previous prescribed dose. The number of beams and total arc degrees selected for each new target were 3 to 7 (median 5) and 220–440 degrees (median 305 degrees), respectively. Only an extra 15 minutes was needed for this method.

Conclusion: Accurate reproduction of the previous dose distribution in the current 3D image could facilitate a safe and effective reiiradiation. We hope that this method will be widely used for the SRS retreatment planning.

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'Recumbent position' and Stanford methods of total skin electron irradiation in the treatment of mycosis fungoides: Comparison of long-term side effects

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Purpose: The long-term side effects of a recumbent position for Total Skin Electron Irradiation were compared to those of the Stanford method in the treatment of mycosis fungoides (MF).

Methods: From 1979–97, 69 patients (pts), mean age 66 years (y)(range, 32–84 y), suffering from MF according to the Sanford staging classification: IA-15%; IB-42%; II-26%; III-10%; IV-7%; were treated; 66 pts were available for response. From 1979–92, 45 pts were treated in the recumbent position with 4 MeV electron beams (Philips SL 75/10 Linac), SSD 150 cm; median total dose was 32 Gy (range, 16–44 Gy). Median follow-up was 79 months (m)(range, 4–237 m). From 1992–97, 21 pts were treated by the Stanford method: median total dose was 30 Gy (range, 20–34.5 Gy). Median follow-up was 20 m (range, 4–152 m).

Results: Recumbent position: CR/near CR – 91%. Late cutaneous complications: minimal skin damage – 46%; severe skin damage, including matchline fibrosis and telangiectasis developing within the irradiated volume – 18%. Stanford method: CR/near CR – 89%. Only 2 pts developed severe skin damage.

Conclusion: The Stanford method is preferable because of the fewer late side effects.

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Effectivity of lead blockages of the lung in tangential breast irradiation

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Purpose: Aim of the study is the assessment of dose volume histograms of the lung in breast irradiation with tangential fields to check whether lead blockage is able to reduce the dose delivered to the lung.

Materials and Methods: 3-D planning (TM3 of the firm HELAX) was performed on 110 patients, who underwent radiotherapy with tangential photon beams delivering 56 Gy to the entire breast. All treatment plans were calculated with and without lead blockage of the lung. Both lung doses were analyzed using the dose volume histograms of the radiation plans.

Results: A reduction of the dose delivered to the lung during radiation of the breast was found in 61%. In 38% the usage of a lead blockage wasn't possible. The average dose difference with and without blockage was about 1.37%, which means 0.77 cGy. Even this small dose reduction is only available for 30% of the irradiated lung.

Conclusion: Using lead blockage of the lung reduces the average dose during radiation. Looking at the small volume of the radiated lung affected by this little dose reduction, the usage of this technique seems not to be considerable especially regarding the average risk dose causing lung toxicity.

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Virtual two dimensional (2D) step wedge for film dosimetry calibration for megavoltage photon beams

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Purpose: Photographic film can be used for dose integrating measurements of 2D megavoltage photon beam distributions. Due to the dependence on the photon energy spectrum and film development condition, an optical density to dose conversion curve should be calibrated for the beam, depth and field size when each time films are used. Conventionally, a conversion curve is obtained by exposing several films to different doses. With the Virtual 2D Step Wedge (VSW) proposed in this paper, a conversion curve can be obtained by one film.

Methods: A VSW is formed by asymmetric collimator settings. For a 4 × 4 VSW, a film is exposed 4 times with a different X2 each time then 3 times with a different Y1 each time. These 7 exposures result in 16 subfields with escalated doses. VSW of 2 × 2 or 3 × 3 can be formed by exposing a film 3, or 5 times in a similar way. 3 × 3 and 4 × 4 VSW are suitable for large field sizes, and 2 × 2 VSW is for small field sizes. The dose and film density profiles were measured with RFA300 scanning system to obtain a conversion curve.

Results: VSW was studied for Kodak XV-2 ready-pack film and a 6MV-photon beam. It took 2.5 minutes to move collimators and expose a film 7 times for a 4 × 4 VSW. To minimize the off-axis effect of 3 × 3 or 4 × 4 VSW, the central subfields should be smaller than the peripheral ones. Good coincidence is observed between the conversion curves obtained by VSW with one film and those by the conventional approach with several films.

Conclusion: The proposed VSW offers an efficient method for film calibration and makes it feasible to calibrate film at several depths with one film/phantom setting-up.

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NSCLC: Dose escalation by target splitting with asymmetric collimation

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Purpose: To reduce the radiation doses to normal tissues and to increase the target dose.

Methods and Materials: The target volume is split into a cranial and a caudal part. Both volumes are planned and treated completely independent, using half-collimated fields to prevent over- or underdosage in the junction plane. For comparison with conventional techniques, planning to identical doses is performed for 5 different clinical situations. Dose-volume-histograms (DHVs) for normal lung tissue are presented for both methods.

Results: The irradiated volume of normal tissue of the ipsilateral lung can be lowered at dose levels ≥65 Gy, ≥45 Gy and ≥20 Gy to values of 37% (range 25%–54%), 49% (range 46%–54%) and 86% (range 55%–117%), respectively. Other organs at risk like heart or esophagus can also be spared significantly.

From December 1995 to October 1998, the technique of target splitting has been applied to >70 patients. In this period, 35 patients have been treated with doses > 80 Gy (ICRU-specification, mean 85.1 Gy, range 80.1–90.2 Gy).

Only 1 patient showed a transient grade 3 toxicity (pneumonitis), and there where no grade 4 acute/subacute side-effects. Two patients with stage III A central tumors in close proximity to the large vessels died due to a pulmonary hemorrhage 2 and 4 months after therapy, respectively. No patient developed esophagitis. Antimycotic prophylaxis for esophagitis and posttherapeutic steroid prophylaxis for pneumonitis (by turbohaler) for several weeks are used routinely.

Conclusions: This method allows to reduce radiation doses to normal tissues significantly and enables dose escalation in radiotherapy of lung cancer.

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A simple technique for the optimization of the dose distribution in the lower neck and upper thoracic area

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Propose: Caused by the changing anatomy and tumor localisation, it is not easy to reach a conformal dose distribution in the lower neck and upper thoracic area. A simple technique with three blocked fields makes it possible to fit the dose to the planing target volumes.

Materials and Methods: For tumors of the cervical esophagus and the trachea three to four CT-scans are required. The planing target volumes in these planes are drawn and superimposed at the central plane. Computer planing is done for a three-field technique with one ventral and two ventral-oblique fields. Special blocking and collimator rotation gives a conformal dose distribution in all planes with different contours. With the proper choice of the central plane a optimal dose is reached in all planes.

Results: With this three-field technique it is possible to reach excellent dose distributions in tumors of the lower neck and upper thoracic region inspite of the big difference of body contours.

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Subcutaneous amifostin during fractionated radiotherapy: A randomized phase II study in pelvic tumours

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Purpose: In the present study we investigated the radio-protective efficacy of a schedule of amifostin delivered subcutaneously.

Methods: A total of 40 patients undergoing radiotherapy for locally advanced pelvic cancer (bladder 14 pts, gynecological 12 pts, rectal 11 pts, sarcomas 3 pt) were enrolled in a randomized phase II trial. 20 patients received amifostin 500 mg rejected sc. 15–20 min before each fraction of conventionally fractionated radiotherapy. Amifostin was diluted in 5 ml of NS and rejected in 2 different sites. The toxicity was recorded daily following the WHO scale.

Results: Local rejection of the drug caused mild pain and bruises while grade 1 erythema was noted in 2/20 (9%) patients. Mild nausea was the main side-effect. Severe vomiting and asthenia that enforced amifostin interruption (after 4–15 rejections) was observed in 3/20 (9%) patients. One allergic episode with fever and generalised rush was observed. The incidence of intestinal radiation toxicity and the delays of radiotherapy were significantly reduced in the group of patients receiving amifostin ($p = 0.04$). Cystitis never occurred in the amifostin group. A substantial protection of the pelvic skin and perineal area was also observed.

Conclusions: Subcutaneous administration of Amifostin during fractionated radiotherapy is feasible and well tolerated. The profile of tolerance seem to be better that the iv. administration. The efficacy of the regimen in terms of radioprotection of pelvic tissues is confirmed.

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Total body irradiation (TBI) before bone marrow transplantation (BMT): Technique and acute toxicity

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Purpose: to evaluate the TBI methods in the National Institute of Oncology between January 1984. and February 1998.

Patients and Methods: 124 patients underwent TBI prior to BMT in the last fifteen years. A special cobalt unit has been used, the dose rate was 6–8 cGy/min. The source-midline distance (SMD) was 340 cm and the field size was 80 × 200 cm. The dose calculation was done on the basis of Tissue-Phantom Patio curve measured in TBI conditions and effective tissue thickness (ETT). Between 1984 and 1992 the beam direction was horizontal, the patients lay in lateral position. In 11 cases the total dose to the abdominal midline was 10 Gy, in one fraction. Form 1986 the fractionation changed to 4 × 3 Gy in 4 days. With individual lung shielding the average lung dose was 8,5 Gy. In 44/124 cases the order of conditional treatment was chemoradiotherapy. Since 1992 vertical beams were used, and the patients (80/124) laid in prone/supine position. The fractionation remained the same but radio-chemotherapy regime has been used.

Results: The irradiation in prone position proved to be safer than lateral because of smaller patient motion and it resulted in a more accurate positioning of lung shielding too. In all cases, the acute side effects (headache, nausea, vomiting) were moderate. Using radio-chemotherapy the acute side effects during the TBI were uncommon, and well tolerable.

Conclusion: Our technique with the large SMD, vertical beam direction and the supine/pronc position is stable, convenient and safe to produce homogenous dose distribution and ensures accurate and reproducible lung shielding.

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External beam radiotherapy of intraocular metastases

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Purpose: We tried to assess if the use of lens-sparing irradiation is justifiable in patients with intraocular metastatic disease. As the results of primary cancer therapy are improving and life expectancies are increasing, the incidence of late distant metastatic tumors is growing. Several patients develop metastatic tumors at previously unexpected sites such as choroidal metastasis with serous retinal detachment, accompanied by visual impairment. This can cause a significant worsening of quality of life.

Methods: From February 1994 to September 1998 the radiotherapy of 14 patients with intraocular metastases was performed at our department. Breast, lung and bladder were the primary tumor sites. Diagnosis and follow-up was based on ophthalmologic, ultrasonography, CT and/or MR examination. Rectangular wedged-pair or moving field therapy was applied first, then we switched to a modified lens-sparing method, of Schipper's technique.

Results: 3 patients are alive after 5 months with excellent visual acuity, useful vision was preserved in the other 11 patients, for a mean survival time of 6 months. No radiation cataract was observed during the follow-up period (1 to 29 months, mean: 6 months.)

Conclusion: The use of lens-sparing radiotherapy techniques results in improved or maintained visual acuity and so the quality of life of selected patients with intraocular metastases can be significantly improved.

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Procedures of radiotherapy with boron neutron capture reaction at the Petten irradiation facility

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Purpose: to establish standard procedures for a complex radiation modality according to the accepted rules of radiotherapy assuring the safety, good reproducibility and high quality of the performance.

Method: The different steps of the preparation for the treatment planning, procedures of the planning using the RTPE/RTT_MC treatment planning system, patient positioning, blood boron content monitoring, irradiation at HFR, reporting on BNCT the quality control and documentation of these procedures have been established for the first European clinical trial.

Achievements: The agreement on the special definitions for patient radiotherapy with BNCT, the detailed description of the preparation and treatment performance procedures proved their applicability during the BNCT of the first patient cohort. The boron neutron capture absorbed dose DB is defined for the group of patients in a physically defined point, where the thermal fluence is a maximum for a given treatment plan. The doses in the organs at risk, dose distribution in the volume of interest together with the dose-volume histograms for the target and the healthy brain are calculated. The positioning to the fixed horizontal beam under special conditions was solved. The blood boron concentration is measured by prompt gamma ray