determined only in five of these patients, who had a reduction of the capillary density in the irradiated field at the end and 3 months after RT. A dilatation of the skin capillaries we saw in all patients already early in time during the RT (usually after 10,0 Gy). Micro bleedings/micro thromboses occurred in 5 resp. 6 cases. In agreement with published data we found a rise of the LDF quotient (irradiated/unirradiated skin) under radiotherapy in 7 of 8 patients, only in one case it was missing.

Conclusion: Already very early during radiotherapy pronounced modifications in the capillary morphology can be found: capillary dilatations. The reduction of the capillary density follows later. Microhemorrhagia and capillary thrombosis, associated with edema formation, can be interpreted as damage of the capillary endothelium leading to increased permeability. Damage of this vessel compartment is crucial for nutrition of the skin. It is accompanied by an increase in blood flow in the thermal regulation plexus, possibly as a sign of increased inflammatory blood circulation caused by opening of functional arterial- venous shunts.

Radiotherapy techniques

761 POSTER

Expression of epidermal growth factor receptor (EGFR) and proliferation markers during fractionated radiotherapy in fadu human squamous cell carcinoma xenografts

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Purpose: Rapid repopulation of clonogenic tumor cells is the major cause for the time factor in FaDu human squamous cell carcinoma (hSCC) during fractionated radiotherapy (RT). In this tumor, acceleration of repopulation ocurs after three weeks of treatment. Because EGFR blockade is a promising therapeutic concept to inhibit proliferation, we examined the expression of EGFR during fractionated radiotherapy in the human SCC FaDu.

Methods: FaDu xenografts grown in nude mice were irradiated with 12 to 18 fractions fractions of 3 Gy under clamp hypoxia. The fractions were given daily or every second day up to 36 days. Tumors were excised one or two days after the end of RT and routinely processed for immunohistochemistry. For the estimation of proliferation, BrdU was injected 1 hour prior to tumor dissection. EGFR, BrdU, and Ki67 were immunostained on paraffin sections. The results were compared to the radiobiological data.

Results: EGFR immunosignal was predominantly confined to the cell membrane of tumor cells with some cytoplasmic staining. The membrane staining score was significantly increased during the second part of the fractionated RT, when acceleration of repopulation was observed in functional assays. The BrdU and Ki67 labelling indices were not significantly different, whereas the proportion of BrdU positive versus BrdU negative tumor cells in the viable tumor area was increased.

Conclusion: Upregulation of EGFR might contribute to acceleration of repopulation in FaDu hSCC after three weeks of fractionated radiotherapy. EGFR blockade in combination with radiotherapy might be a useful approach to counterbalance the time factor in tumors overexpressing EGFR.

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762 POSTER

Basic treatment equivalent (BTE) - a better measure of linear accelerator workload

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Purpose: 1. To develop a better measure of linear accelerator throughput that considers complexity. 2. To prospectively test the model in departments of radiation oncology in Australia, New Zealand, U.K. and Canada.

Methods: Treatment durations of linear accelerator treatments were collected prospectively. Patient-, tumour- and treatment technique-related factors were collected and assessed for significant variables that impact upon treatment duration using multivariate analysis. The significant variables were then weighted and included into a model of linear accelerator Basic Treatment Equivalent (BTE) using the generalised estimating equation with exchangeable correlation structure.

Results: Treatment times were collected on 7929 patient episodes, on 2424 patients in 26 departments of radiation oncology in Australia and New Zealand. Significant factors for treatment duration were number of fields, number of shields, number of junctions, patient performance status, first fraction of treatment, beam type and whether an anaesthetic was required. A treatment BTE can be calculated by BTE= F(0.42 + 0.18B1 + 0.57B2 + 0.12J + 0.13N + 0.11S + 0.05W + 0.15P + 0.2E + 0.66A) where F=1.5 for the first fraction and 1 for all subsequent fractions and B1 = photon beam, B2 = mixed photon/electron, J = junction, N = number of fields, S = number of shields, W = number of wedges, P = number of port films or electronic portal imaging exposures, E = 1 if performance status is ECOG > 2 (otherwise E=0), A = 1 if use of sedation or anaesthesia required (otherwise A=0) and BTE = predicted treatment time in minutes/10.This allows the calculation of a relative weight for each radiotherapy technique in comparison to a simple treatment of a parallel pair of fields that took 10 minutes.

The BTE model has now been tested prospectively in several U.K and Canadian departments and shown to be a more accurate assessment of linear accelerator throughput compared with fields or patients per hour. Some of these results will be presented.

Conclusion: BTE is a better measure of linear accelerate throughput compared with number of patients or fields per hour as the model also considers variations in technique complexity. This model has proven useful to predict treatment durations for more efficient bookings and also to compare departments that have dissimilar casemix.

763 POSTER

The effect of treatment techniques on the volume of small bowel in the pelvic radiotherapy fields

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Aim: The dose of radiation and volume of radiotherapy field are two important factors that contribute to the acute and late gastrointestinal side effects of pelvic radiotherapy. In general the effectiveness of several treatment techniques in displacing small bowel out of radiation field is reported. This study reports the results of the relationship between the different treatment techniques and amount of small bowel in the field.

Materials and Method: The volume of small bowel in the pelvic box radiotherapy fields of 6 patients were evaluated. The study included 5 patients with cancer of the endometrium and 1 patient with bladder cancer. Barium sulfate was diluted 50% by adding water and this mixture was administered 1–2 hours before simulation. Pelvic small bowel volumes were compared using several treatment positions including, prone with bladder distention (pos. 1), prone with bladder distention and with anterior abdominal wall compression (pos. 2), and supine without bladder distention (pos. 3). Patients were instructed to drink fluids prior to simulation and not to void until its end for pos. 1 and 2. Small bowel volumes were determined by dividing the area of opacification in the AP and lateral views into 1 cm segments and summing the products of the segment lengths in the two projections.

Results: The minimum and maximum volumes of small bowel in the pelvic radiotherapy field were 38 and 959 cm^3, 0 and 894 cm^3, 268 and 1132 cm^3 for the positions 1, 2, and 3, respectively. The mean volumes of small bowel in the field were 384.2 ± 126.2 cm^3, 301.3 ± 177.3 cm^3, and 652.8 ± 150.6 cm^3 for the positions 1, 2, and 3 respectively. It was found that pos. 2 was significantly better than the other two positions in terms of displacing small bowel out of the radiotherapy field ($p < 0.05$).

Conclusion: It's reported that certain maneuvers can minimize the small bowel volume in the pelvic radiotherapy fields and reduce the risk of small bowel injury. The current study appears to confirm that oral contrast is a useful adjunct in treatment planning to localize dose limiting small intestines. This study also demonstrates that small intestines can be displaced out of the radiation field by using bladder distention and compression device in the prone position.

764 POSTER

Assessment of organ motion using gated radiotherapy tools

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Purpose: Recent advances aimed at decreasing toxicity related to internal organ motion include respiratory-gated radiotherapy. The accuracy of such

systems is dependent on the reproducibility of target positioning related to organ motion. However, normal respiratory motion of internal organs is not yet clearly understood. This is likely related to the lack of dynamic 3D imaging tools. We used a commercial respiratory gating system and fluoroscopy to evaluate the motion of normal structures during respiration.

Materials and Methods: A wall mounted video camera tracks the motion of reflective markers placed on the patient's chest. Imaging or treatment can be triggered based upon the motion signal using the marker position. Audio or video coaching can be used to train patients. Fluoroscopic 'movies' can be recorded simultaneously. These movies can be analyzed on a frame-by-frame basis using our in-house edge detection and pattern recognition software.

Simultaneous chest wall monitoring and fluoroscopy was performed on 6 patients. Each patient participated in 5 daily sessions over 2 to 3 weeks. In each session, five 30-second fluoroscopic movies were recorded with and without coaching. The diaphragm was divided into 3 'sectors' and the chest wall into 2 halves for motion analysis.

Results: Over one hundred fluoroscopy sessions were analyzed. The amplitude and phase of motion of the different sections of the diaphragm were almost identical. The motion of the central 'sector' of the diaphragm was slightly less predictable in successive sessions. The two halves of the chest wall moved in phase with each other and the diaphragm. A large amplitude of motion of the chest wall was not seen (2 to 3 mm mediolateral). This may be related to 'noise' in the video images caused by the motion of the ribs. Re-positioning of the diaphragm using gating based upon the external marker was more accurate with audio and video coaching.

Conclusions and Future Direction: The diaphragm and chest wall moved in phase with each other. Coaching improved the accuracy of reproducing organ motion. Improvements in imaging techniques and image analysis are needed to better understand organ motion. These early results increase our understanding of respiratory organ motion and point towards the accuracy of gated radiotherapy.

765 POSTER

Validation of a method for automatic image fusion (BrainLAB System) of CT-data and C11-Methionin-PET data for stereotactic fractionated radiotherapy using a LINAC

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Purpose: a) To establish a method for automatic image fusion of CT/MRI and C11-methionin-positron emission-tomography (MET-PET) for stereotactic treatment planning. b) To discuss the impact of MET-PET for the treatment planning of stereotactic fractionated radiotherapy (SFR) in patients with brain tumors (meningiomas and gliomas).

Materials and Methods: In 10 patients (6 meningeomas and 4 gliomas) CT, MRI and MET-PET were performed for the radiation treatment planning. The CT and MET-PET investigations were performed using the BrainLab head fixation with mask and the localizer. On the localizer were applied 15 external reference markers (5 on each 3 dimensional directions) which could be identified in CT and MET-PET and whose positions were exactly defined for the both investigations. MRI/CT-Fusion was done automatically (BrainLab software). The CT/MET-PET-fusion was performed using two different methods: the gold standard was the CT/PET fusion based on 15 external reference markers, the test method was the automatic, intensity based CT/PET fusion, independent from the external markers. The markers were visible on CT and transmision-PET and were defined manually. The two fusion methods were compared by calculating the mean value of deviation between corresponding points, defined in a VOI. The gross tumor volume (GTV) defined on T1-MRI with gadolinium was compared with the GTV defined using the MET-PET.

Results: The mean deviation of the automatic CT/PET fusion compared with the gold standard CT/PET fusion, based of external markers was 2.40 mm, SD 0.64. In 4 patients with meningiomas and in all 4 patients with gliomas MET-PET delivered additional information concerning tumor extension.

Conclusion: The precision of the automatic image fusion CT/PET was high. A mean deviation of 2.40 mm is acceptable, considering that it is approximately equal to the pixel size of the PET data sets. MET-PET delivers additional information concerning GTV an could be important for the stereotactic fractionated radiotherapy of brain tumors.

766 POSTER

LINAC radiosurgery for brain metastases

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The present retrospective study demonstrates the results of stereotactic radio-surgery in patients with a limited number (one to three) of brain metastases without the routine use of adjuvant whole brain irradiation. Results in terms of response rates, intracranial disease control, neurological survival, and overall survival are analyzed in patients with multiple lesions compared to those with single metastases. From 1990 to 1996, 106 patients suffering from single (70 patients) or multiple (two or three) cerebral metastases (36 patients) were treated by stereotactic radiosurgery with a LINAC (8 MeV) equipped with tertiary collimators. Fifty-nine patients were treated for their first occurrence of brain metastases; 47 patients had been treated prior to radiosurgery by resection and/or whole-brain irradiation. Histology of the primary tumor was non-small cell lung cancer (36 patients), melanoma (20 patients), breast cancer (15 patients), hypernephroma (15 patients), and other (20 patients). All together, 157 metastases (0.04–69.0 ml; median, 2.7 ml) were irradiated with marginal doses of 12–25 Gy (median, 20 Gy) referred to the 65%–80% isodose. Seventy-two percent of the lesions were treated with a single isocenter. Adjuvant whole-brain irradiation was applied in six patients. Onehundredthirtyfive of 157 metastases were evaluated for response: complete response (CR), 24%; partial response, 31%;no change, 30%;and progression of disease, 15%. CR rates were highest (48%) in small metastases (<1 cm diameter), independent of histological type and dose. The overall median survival was 8 months. Multivariate Cox regression analysis revealed a significant impact on survival for Karnofsky performance score, presence of extracranial tumor, and volume of largest metastasis. LINAC-based stereotactic radio-surgery in patients with up to 3 cerebral metastases results in survival rates approaching those of patients with resected single brain metastases. As patients with both single and multiple metastases can effectively be salvaged after receiving radiosurgery, extracranial tumor activity becomes a major determinator of survival.

767 POSTER

Intraoperative radiotherapy (IORT) after breast conserving therapy in breast cancer patients

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Introduction: Local recurrency rate(LR)after breast conserving therapy (BCT)varies between 5% and 8%. One of the reasons for LR could be a "geographic miss" during boost irradiation of the tumor bed. Therefore high quality boost techniques are demanded.

Methods: From 10-98 to 12-00 160 patients with stage I and stage II breast cancer were operated in a dedicated IORT facility. After tumorectomy the tissue surrounding the excision cavity was temporarily approximated by sutures to bring the tissue in the radiation planning target volume. A single fractional dose of 9 Gy was applied to the 90% reference isodose with energies ranging from 4 - 15 MeV, using round tubes 5 to 7 cm in diameter. After wound healing patients received additional 51 to 56 Gy EBRT to the whole breast.

Results: There were no early complications associated with the use of IORT. In five patients a secondary mastectomy had to be performed because of tumor multicentricity in the final pathological report. Two patients developed rib necroses. In five patients wound healing problems occurred. To date there has been no local recurrence, cosmesis of the breast has been excellent.

Conclusion: Preliminary results suggest that IORT after breast conserving therapy could be a reliable alternative to conventional postoperative fractionated boost by accurate dose delivery and avoiding of geographic miss, by enabling of smaller treatment volumes and complete skin sparing and by reducing the postoperative radiation time for 7 to 10 days.