isodose. Normally, 3 x 12.5 Gy were delivered. Tumours close to stomach or small bowel received 7.0 Gy in 5 fractions.
All patients received prophylactic antiemetic medication one hour before starting SBRT and proton pump inhibitors for three months starting with first SBRT.
Clinical history, laboratory findings, early and late toxicity scores, PET/CT, and MRI in cases of liver lesions were gathered at the 6-week follow-up visit and then at 3-month, 6-month, 9-month, and 12-month follow-ups.
Results: All patients received the planned therapy. 1/30 p developed gastroduodenal ulcera ºII, 30/30 p showed temporary elevation of liver enzymes without clinical symptoms.
Local tumour control rate is 100%, median overall survival 21.2 months. 3/30 p died due to non-tumour-related reasons, 16/30 as a result of distant metastases.
Conclusion: High precision radiotherapy like SBRT offers excellent local control rate for patients with advanced CCC/Klatskin tumours. Interdisciplinary strategies and studies should be found to prevent patients from distant metastases for further improvement of overall survival.

6534 POSTER

Stereotactic Body Radiation Therapy for Liver Metastases − Preliminary Results

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Background: Liver metastases represent a common site of life limiting metastatic spread. Stereotactic body radiation therapy (SBRT) is an emerging local treatment option. We report our preliminary results of liver metastases treated with SBRT.
Material and Methods: We reviewed 23 consecutive patients treated with SBRT for 27 liver metastases: 8 women and 15 men, median age 69 years (26 to 87). Patients were selected for SBRT when the disease was considered life limiting and unsuitable to resection or radio-frequency ablation. The median radiation dose was 40 Gy (20 to 50 Gy) delivered in 1 to 10 fractions. Response to treatment was measured according to RECIST criteria on post-treatment CT, MRI and/or PET imaging. Acute and late toxicities were graded according to CTCAE v4.0.
Results: 22 patients completed SBRT. One stopped treatment after 3 fractions due to biliary obstruction from progressive tumour. Treatment was well tolerated, with 3 (13.6%) patients presenting grade I and 2 (9%) presenting grade II acute gastrointestinal toxicity. One patient was lost to follow-up. One patient had symptomatic colitis that resolved with conservative treatment, no other late toxicity was reported. Complete response was initially achieved in 8 of 25 (32%) lesions, partial response in 4 (16%), disease stabilization in 12 (48%) and continued progression in 4 (16%). With a median follow up of 15 months (3.3 to 42.9), six of 21 patients (28.6%) had progression of a treated lesion. Overall actuarial 1-year and 2-years survival rates were 93.8% and 59.5%, respectively. Median survival was 30.1 months.
Conclusions: SBRT is a promising well-tolerated treatment for non-resectable liver metastases.

6535 POSTER

A Study on Different Methods for Internal Margin Expansion of Esophageal Cancer Based on 4D-CT

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Objective: To evaluate the difference of internal margin expansion measured by contouring the whole or layers parallel to the level of the adjacent vertebra (top and bottom edge and center level)of esophageal cancer based on 4D-CT.
Methods: Based on T0 phase of 4D-CT scanned for 13 patients with esophageal cancer,an irradiation oncologist contoured the gross tumour volumes of 10 respiratory phases in treatment planning system, the center coordidates of target volumes were recorded. Then based on the adjacent vertebra level (top and bottom edge and center level), target volumes on CT slices of 10 respiratory phases were contoured, the center coordidates (X?Y) and maximum diameters (d) were recorded. Internal margins of esophageal cancer layers accorging to the adjacent vertebra were caculated by IM = $X(Y)_{T0-10} - X(Y)_{T0} \pm (d_{T0-10} - d_{T0})$, then the maximum data of the same direction were filtered. The relationship of three dimensional movement of esophageal cancer and the difference of internal margin expansion measured by the whole or layers of esophageal cancer were analyzed.
Results: The motion range of the whole esophageal cancer was 1.32±0.73 mm in LR,1.09±0.77 mm in AP, and 2.92±2.10 mm in CC. There was a significant relationship between motion range in LR and AP (r = 0.597, p = 0.04), in LR and CC (r = 0.662, p = 0.019) and in AP and CC (r = 0.723, p = 0.008). There was a significant difference of internal margin expansion measured by contouring the whole or layers of esophageal cancer in thee dimensions (p < 0.01).
Conclusions: There was a significant relationship between motion range in three dimensions, internal margin expansion measured by the whole esophageal cancer less than that by layers.

6536 POSTER

Comparison of the Gross Tumour Volume Based on Three-dimensional CT and Four-dimensional CT Simulation Images of Primary Liver Cancer

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Objective: To compare positional and volumetric differences of the gross tumour volume (GTV) delineated basing on three-dimensional computed tomography (3D-CT) and four-dimensional computed tomography (4D-CT) images of primary liver cancer.
Methods: Twenty patients with primary liver cancer suitable for three-dimensional conformal radiotherapy (3D-CRT) sequentially underwent 3D-CT and 4D-CT simulation scans of the thorax and abdomen under normal free breathing. During 4D-CT scanning, real-time position management (RPM) system simultaneously recorded the respiratory signals. The CT images with respiratory signal data were reconstructed and sorted into 10 phase group in a respiratory cycle. Data sets for the 3D-CT and 4D-CT scans were then transferred to Eclipse treatment planning software. GTV-3D from 3D-CT, GTV-0%, GTV-20%, GTV-50% and GTV-70% from end-inspiration, mid-expiration, end-expiration and mid-inspiration of 4D-CT, and IGTV-10 from fused phase of 4D-CT were delineated based on the 50% phase images. And the patients were divided into A group and B group based on the location of the target center and were divided into C group and D group based on the three-dimensional (3D) motion vector of the target center. The position of the target center, the volume of target, the matching index (MI) and the degree of inclusion (DI) were compared between 3D and 4D volumes based on different groups.
Results: The difference of the center of GTV from different phases of 4D-CT and GTV-3D on three dimensional direction induced by respiration motion was not statistically significant ($F = 1.174$, $P = 0.327$). The ratios of GTV-0%, GTV-20%, GTV-50%, GTV-70% to GTV-3D were 0.76±0.16, 0.73±0.20, 0.71±0.20 and 0.77±0.18 respectively, while the ratio of IGTV-10 to GTV-3D was 1.41±0.31, which showed a statistically significant correlation to the motion vector ($r = 0.321$, $P = 0.001$). The median of ratio of IGTV-10 to GTV-3D was 1.49 in group A versus 1.31 in group B, the difference between group A and group B was not statistically significant ($z = -1.783$, $P = 0.075$). The median of the ratio for IGTV-10 to GTV-3D was 1.23 in group C versus 1.58 in group D, the difference between group C and group D was statistically significant ($z = -2.773$, $P = 0.004$). MI of IGTV-10 to GTV-3D was 0.56±0.11, which showed no statistically significant correlation to the motion vector ($r = 0.084$, $P = 0.406$). ID of IGTV-10 to GTV-3D was 0.64±0.12, which also showed no statistically significant correlation to the motion vector ($r = -0.216$, $P = 0.375$).
Conclusions: The beginning time of 3D-CT axial scan is random in the breathing cycle, there is not intrinsic correlation between the beginning time of 3D-CT and any phase of 4D-CT. The volume of GTV-3D is more than that of GTV delineated basing on ang single phase images of 4D-CT, but statistically significantly less than that of IGTV-10. As the amplitude of tumour motion increases, the degree of GTV-3D covering IGTV-10 becomes less, while the motion information included by IGTV-10 increases.

6537 POSTER

Comparative Study Between the Three Methods to Delineate Internal Target Volume of the Primary Hepatocarcinoma Based on Four-dimensional CT Simulation Images

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Objective: To compare the position and magnitude of ITV of the primary hepatocarcinomas delineated by the three methods based on 4D-CT and to investigate the relative factors affecting the position and magnitude.
Methods: Twenty patients with primary hepatocarcinoma underwent 4D-CT simulation scan of the thorax and abdomen assisted by RPM system. The CT images with respiratory signal data were reconstructed and sorted into 10 phase group in a respiratory cycle, with 0% phase corresponding to end-inhale and 50% corresponding to end-exhale.

Maximum intensity projection (MIP) image was generated. ITVs of the primary tumour were delineated using three methods as following:

- the GTVs on each of the ten respiratory phases were delineated and fused ten GTV to produce ITV_{10};
- the GTV delineated separately based on 0% and 50% phase were fused to produce ITV_{IN+EX}
- the visible tumour on the MIP images were delineated to produce ITV_{MIP}.

Twenty patients were divided into A group and B group based on the location of the target center and were divided into C group and D group based on the tumour D, the patients were divided into E group and F group based on the 3D motion vector of the target center. The position of the target center, the volume of target, the degree of inclusion (DI) and the matching index (MI) were compared reciprocally between ITV_{10}, ITV_{IN+EX} and ITV_{MIP}, and the influence of the tumour position and 3D motion vector on the relative parameters were compared based on the grouping.
Results: The volume of ITV_{10} was larger than that of ITV_{IN+EX}, and the volume of ITV_{10} was larger than that of ITV_{MIP}, but the differences were not statistically significant. DI of ITV_{IN+EX} in ITV_{10}, ITV_{MIP} in ITV_{10} were (74.85 ± 15.09)% and (68.87 ± 13.69)%. MI between ITV_{10} and ITV_{IN+EX}, ITV_{10} and ITV_{MIP} were 0.75 ± 0.15, 0.67 ± 0.13, respectively. The median of ratio of ITV_{IN+EX}/ITV_{10} was 0.57 in group A versus 0.87 in group B, the difference between group A and group B was statistically significant ($P = 0.001$). The median of ratio of ITV_{MIP}/ITV_{10} were 0.51 in group A versus 0.72 in group B, the difference between group A and group B was statistically significant ($P = 0.001$). The median of ratio of ITV_{IN+EX}/ITV_{10} was 0.79 in group C versus 0.74 in group D, with no statistically significant difference ($P = 0.358$). The median of ratio of ITV_{IN+EX}/ITV_{10} was 0.87 in group E versus 0.68 in group F, the difference between group E and group F was statistically significant ($P = 0.004$).
Conclusions: The center displacement of the ITVs delineated separately by the three different techniques based on 4D-CT images are not obvious; ITV_{IN+EX} and ITV_{MIP} can not replace ITV_{10}, however, ITV_{IN+EX} is more close to ITV_{10} comparing to ITV_{MIP}. The ratio of ITV_{10} and ITV_{MIP} is correlated to the 3D motion vector of the tumour. When the tumour in the upper part of the liver and with a 3D motion vector less than 9 mm, ITV_{10} should be the ideal ITV.

6538 POSTER

Comparison of the Different Planning Targets Defined Basing on Three-dimensional CT and Four-dimensional CT Images for Liver Cancer

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Background: To compare positional and volumetric differences of planning target volumes (PTVs) based on axial three-dimensional CT (3D-CT) and four-dimensional CT (4D-CT) for liver cancer.
Materials and Methods: Fourteen patients with liver cancer suitable for three-dimensional conformal radiotherapy (3D-CRT) underwent axial 3D-CT and 4D-CT simulation scans of the upper abdomen during normal breathing. Three internal target volumes (ITVs) were produced based on the clinical target volume from 3D-CT (CTV_{3D}) (The GTV to CTV margin was defined as 10 mm): A conventional ITV (ITV_{conv}) was produced by adding 10 mm in superior-inferior direction and 5 mm in left-right and anterior-posterior directions to CTV_{3D}; A specific ITV (ITV_{spec}) was created using a specific margin in transaxial direction; ITV_{vector} was produced by adding a isotropic margin derived from 3D motion vector of the tumour. ITV_{4D} was defined on the fusion of CTVs on all phases of 4D-CT. Finally, PTV_{conv}, PTV_{spec}, PTV_{vector} and PTV_{4D} were generated by adding a 5 mm setup margin to ITVs. The differences in target position, volume and degree of inclusion (DI) among PTVs were evaluated respectively. The definition of DI of volume X included in volume Y [DI(X in Y)] is the percentage of the overlap between volume X and Y in volume X.
Results: Average differences between PTVs from 3D-CT (3D PTV) and PTV_{4D} in transaxial direction were less than 1 mm, with no statistically significant difference. Comparing PTV_{4D} to PTV_{conv}, PTV_{spec}, PTV_{vector} resulted in a decrease in volume sizes by 32.27%, 24.95%, 48.08% on average. The mean degree of inclusion (ID) of PTV_{4D} in PTV_{conv}, PTV_{spec}, PTV_{vector} was 0.98, 0.97, 0.99; while the mean ID of PTV_{conv}, PTV_{spec}, PTV_{vector} in PTV_{4D} was 0.66, 0.73, 0.52 respectively.
Conclusion: The center displacement of PTVs derived from 3D-CT and 4D-CT are not obvious. The size of patient-specific PTV based on 4D-CT is less than those of 3D PTVs. The treatment plans based on 3D PTVs would result in more normal tissues being necessarily irradiated. 3D PTVs generated using anisotropic expansions contribute to reducing the size of normal tissues, but a geometric miss should be focused on.

6539 POSTER

Radiotherapy of Anal Carcinoma − Outcome in an Unselected National Cohort

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Background: This study presents treatment results in a large unselected national cohort. The purpose was to evaluate our treatment results, elucidate whether national guidelines were followed, and identify areas demanding further treatment optimization.
Materials and Methods: In Norway, between July 2000 and June 2007, a total of 328 patients were treated with curatively intended (chemo)radiotherapy for squamous cell carcinoma in the anal region, according to national treatment guidelines based on tumour stage. The median age was 63 years (range 33−91), 72% were females. T stage distribution: T1 12%, T2 40%, T3 22% and T4 26%. Regional lymph node metastases were present in 35%, and inguinal lymph node metastases in 21%, no patients with distant metastases were included.
Results: Complete response after (chemo)radiotherapy was obtained in 286 (87%) patients. After salvage surgery, a total of 306 (93%) patients achieved primary locoregional control. Eighteen (43%) patients with residual tumour did not receive salvage surgery, mainly due to frailty and comorbidity.
The 3-year rate of recurrence-free survival (RFS) was 79%. Recurrence occurred in 73 (24%) patients after a median follow-up of 49 months. Locoregional recurrences were predominant, occurring in 56 (18%) patients, most commonly in the primary tumour site. Despite receiving radiation to the groins according to guidelines, 10 (3%) patients had recurrence in inguinal lymph nodes. Eleven of 20 patients initially salvaged due to residual tumour, recurred during follow-up. Treatment of recurrence had curative intent in 33 (45%) patients.
At the time of analysis, 111 of 328 patients were dead, 68 due to anal cancer. The 3-year rates for overall survival and cancer specific survival (CSS) were 79% and 84%, respectively.
The risk of adverse outcome increased significantly with more locally advanced tumours and in male gender in both uni- and multivariate analyses for RFS and CSS.
Conclusions: This study reports the outcome in an unselected national seven years cohort. Treatment results after (chemo)radiotherapy is satisfactory for patients with early-stage tumours. Still, it is essential to improve results for patients with locally advanced disease, in particular measures to reduce the rate of locoregional recurrence. Male gender as a potential risk factor for inferior outcome requires further investigation.

6540 POSTER

The Impacts of Intraoperative Radiotherapy With Image-guided Enzyme Targeting Radiosensitization (KORTUC-IORT) for Stage IVa Pancreatic Cancer

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Background: Based on our experimental results that demonstrated hydrogen peroxide to be a strong radiosensitizer in a highly radioresistant osteosarcoma cell line, we developed a new radiosensitizer injection technique in which hydrogen peroxide and sodium hyaluronate are injected immediately prior to intraoperative radiotherapy (IORT) for advanced pancreatic cancer, named KORTUC-IORT (Kochi Oxydol-Radiation Therapy for Unresectable Carcinomas + IORT). The purpose of this study was to evaluate the safety and efficacy of KORTUC-IORT in pancreatic cancer patients.
Patients and Methods: Twelve patients with stage IVa locally advanced pancreatic cancer were enrolled in the KORTUC-IORT trial after providing fully informed consent. They were treated with KORTUC-IORT, external-beam radiotherapy (EBRT), and systemic chemotherapy. KORTUC-IORT involved injection of a maximum of 9 ml of solution into tumour tissue just prior to administration of IORT under ultrasonic guidance. The solution is composed of 0.5% hydrogen peroxide and 0.83% sodium hyaluronate. For IORT, tumours were irradiated at a dose of 25 Gy in a single fraction with a 12 or 15 MeV electron beam; no tumour resection was performed. For EBRT, patients received radiation to the abdomen 5 times a week at a dose of 2 Gy/day in 15 fractions (total dose: 30 Gy) with a 10 MV x-ray. Chemotherapy was initiated at the same time as EBRT, and was continued for as long as possible. Gemcitabine hydrochloride was given intravenously