Employing the NAL (averaging shifts of the first 3 fractions), the average subsequent 3D vector of correction in prone setups would have been 6 mm. The frequency of respective shifts for subsequent treatment fractions larger than 5, 10, 15 and 20 mm, would have been 57.4, 11.6, 0.4, and 0.4% for prone setup. According mean 3D vector of corrective shifts and frequencies would have been 7.9 mm, and 66.4, 22.6, 8.9, and 3.6% for supine setups, respectively.

Conclusion: In the present study, prone patient setup was found to yield a higher daily repositioning variability than supine positioning. However, following utilization of a NAL protocol to reduce the systematic setup variability component, random setup errors larger 10 mm were significantly more often observed in supine than in prone setups. Thus, if daily image-guidance or NAL protocols are not employed, the potential advantages of removing small bowel from the pelvic region using a supine setup on a belly board and reducing target ventilatory motion may be associated with higher inter-fraction setup variability. Based on the number of clinically relevant corrective shifts observed in the studied population, daily on-line image-guidance is advised. While NAL protocols may provide sufficient systematic setup error reduction to justify off-line image-guidance strategies in prone patient setup, the observed remaining setup variability in supine patient setup warrants further investigation. The present data are especially relevant to future clinical trials of IMRT for rectal and anal malignancies.

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926 POSTER

Prospective study of decompression surgery and intraoperative radiation therapy (IORT) for metastatic spinal tumours

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Background: Metastatic spinal tumors often cause spinal cord compression and jeopardize the quality of life of the patients much. To decrease the local symptomatic recurrence rate, we have been adding IORT to decompression surgery.

Materials and Methods: For those patients whose life expectancy was more than 6 months were eligible for this treatment. Posterior decompression by laminectomy of the involved vertebrae was performed. Following decompression, the patient was irradiated the lesions intraoperatively with electrons generated from Microtron by shielding the spinal cord with lead plate. The central aspects of the vertebrae were irradiated by scattered electrons detouring from the edge of the lead shield up to 40% of the administered dose. Following IORT, posterior instrumentation was performed. External beam radiotherapy might be added pre- and/or postoperatively when considered necessary.

Results: 108 patients were treated between 1992–2005. There were 58 males and 50 females. Age ranged from 26 to 85 with a median of 62.5. By primary sites, 26 breast, 24 kidney, 18 colorectum, 17 lung, 12 prostate and 11 thyroid cases were included. Irradiated spines were cervical in 6, thoracic in 76, and lumbar/sacral in 27. Overall median follow-up period was 12.7 months. Median IORT dose was 20 Gy (range 15–26 Gy) and median electron energy was 16 MeV (range 11–22 MeV). There were 37 cases with preoperative RT and 41 cases with postoperative RT. Overall median survival time was 14.5 months (breast 15.3, kidney 22.6, colorectum 5.7, lung 6.2, prostate 31.6, thyroid 60.6 months). Neurological response rate was 73.1%. Ambulatory rates were 87.0% for success and 80.6% for rescue by Klimo's definition (2005). There were only 8 symptomatic relapses (7%). As for major complications, only one myelopathy has been observed.

Conclusions: Decompression surgery and IORT for metastatic spinal tumors with impending spinal cord compression was a promising treatment modality with excellent local control and neurological response rate and with minimal toxicity especially for those patients with long-term prognosis.

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927 POSTER

Efna1, a radioresistant marker, detected in a murine tumor model by gamma and carbon ion irradiation

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Purpose: This study investigated the genes involved in radioresistance after radiotherapy.

Materials and Methods: Using single-color oligo-microarrays, we analyzed the gene expression profiles of two murine squamous cell carcinomas: NR-S1 (radioresistant) and SCCVII (radiosensitive), after irradiation with 137-Cs gamma rays at doses of 30, 50 and 70 Gy or 290 MeV/u carbon ions at a dose of 30 Gy. Potential genes related to radiosensitivity were selected by comparing the expression values before and after irradiation (with both gamma rays and carbon ions) using a filter for at least 1.5-fold changes. Furthermore, candidate genes which had significantly different ratio values between the two tumors (P < 0.05) were detected by unpaired Student's t-tests. Subsequent analysis by quantitative reverse-transcription polymerase chain reaction (RT-PCR) confirmed our microarray data. Protein expression and function were examined by immunohistochemical studies.

Results: Four genes, Efna1, Sprr1a, Srgap3 and Xrra1, were selected as potential genes related to radioresistance after gamma and carbon ion irradiation. RT-PCR confirmed that Efna1 was induced in radioresistant NR-S1. Efna1, a proangiogenic factor, was expressed in the cytoplasm of tumor cells and significant increases in microvascular density were observed in the radioresistant NR-S1.

Conclusions: We found that Efna1 may be a potential molecule related to radioresistance in murine tumors.

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928 POSTER

p73 protein expression correlates with radiation-induced apoptosis in the lack of p53 response to radiation therapy for cervical cancer

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Background: p73 belongs to a p53 tumor suppressor family of genes and can inhibit cell growth in p53-like manner by induction of apoptosis or cell cycle arrest. The aim of this study was to investigate whether p73 could compensate for impaired p53 function in apoptosis induced by radiation therapy (RT) for cervical cancer.

Materials and Methods: Sixty-eight patients with squamous cell carcinoma of the cervix who received definitive RT combined with (n = 37) or without (n = 31) cisplatin were investigated. Biopsy specimens were excised from the cervical tumor before RT and after 9 Gy. All tissues were stained with hematoxylin and eosin, and terminal deoxynucleotidyl transferase mediated dUTP-biotin nick end labeling method assay and immunohistochemical staining for p53 and p73.

Results: Mean Apoptosis Index (AI) was 0.93% before RT and 1.97% after 9 Gy with a significant increase (p < 0.001). For all patients, there were significant correlations between AI ratio (AI after 9 Gy/AI before RT) and p73 expression positivity after 9 Gy (p = 0.021). Forty-one patients were regarded as p53-responding group according to the expression of p53 after 9 Gy, while the remaining 27 patients were regarded as p53-non-responding group. In the p53-non-responding group, a significant correlation between the AI ratio and p73 expression after 9 Gy was observed (p < 0.001) although there was not significant correlation between them in the p53-responding group (p = 0.940).

Conclusions: Our results suggested that p73 had an important role in compensating for the lack of p53 function in radiation-induced apoptosis of cervical cancer.

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929 POSTER

Cardiac complications after radiation therapy for stage I esophageal cancer patients

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Background: Cardiac complication after chemoradiotherapy (CRT) for esophageal cancer is one of the recent noteworthy topics. However there are few reports about cardiac complications after radiotherapy (RT) alone for comparison with CRT data. The purpose of this study is to assess the cardiac complications after RT alone for stage I esophageal cancer patients.

Material and Methods: Ninety-five patients with stage I esophageal cancer received definitive RT alone between 1992 and 2002. There were 8 females and 87 males. The median age was 70 (43–89) years. Eighty-five percent of patients had tobacco history, 84% had history of drinking alcohol, 15% had diabetes and 20% had hypertension. Fourteen patients (15%) had histories of cardiovascular diseases before RT (ischemic heart disease: 8, arrhythmia: 3 and others: 3). Histologic types were squamous cell carcinoma in 94 (99%) and adenocarcinoma in 1 (1%). Ten patients (11%) had the main lesion in the upper thoracic, 71 (76%) in the middle thoracic and 14 (15%) in the lower thoracic esophagus. Twenty-seven patients (28%) were treated with high-dose-rate brachytherapy (HDR-BT, median 35 Gy/14 fr.) alone, 60 patients (63%) with combined external RT (median 54 Gy/27 fr.) and HDR-BT boost (median 10 Gy/4 fr.) and 8 with external

RT alone (median 66 Gy/33 fr.). RT-induced cardiac complications were evaluated retrospectively using Common Terminology Criteria of Adverse Events v3.0.

Results: The median follow-up for surviving patients was 85 months. The overall and cause specific survival rates were 59% and 79%, respectively. Ninety-three patients were analyzed for evaluation for cardiac complications. Cardiac complications ($\geqslant$G3) were observed in 10 patients (10%): pleural effusion in 1 (1%), cardiac ischemia in 5 (5%) and arrhythmia in 4 (4%). Among 5 patients with cardiac ischemia, 2 died in acute myocardial infarction and 3 needed the stent placement. Among 4 patients with arrhythmia, 2 died in heart failure and 2 needed the pacemaker implantation. Four of 13 patients (31%) with cardiovascular diseases before RT experienced deterioration of the disease.

Conclusions: Cardiac complications ($\geqslant$G3) were observed in 10% of patients treated by RT alone for stage I esophageal cancer: pleural effusion in 1%, cardiac ischemia in 5% and arrhythmia in 4%. We think our data can be used for comparison with the data of cardiac complications after CRT for esophageal cancer patients.

930   POSTER
Comparative dosimetric study of dynamic conformal arc (DCA), conformal beam (CB) and intensity-modulated radiosurgery (IMRS) for childhood cerebral arteriovenous malformations (cAVM) treatment

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Purpose: To investigate the dosimetric differences among DCA, CB and IMRS techniques for cAVM treatment in children.

Methods and Materials: Between 03/05 and 11/06 we have treated six children with cAVM younger than 18 years (range: 6−18 years). First symptoms were: hemorrhage in 5 patients and neurologic deficit in 1 patient. cAVM volume ranged from 0.15 to 7.22 cc (mean = 2.26 cc). Spetzler-Martin grade was as follows: Grade 2, n = 1 and Grade 3, n = 5. AVM score ranged from 0.175 to 1.62. Three patients (50%) had other treatment before radiosurgery: 2 embolization and 1 partial surgery. Prescribed dose at the peripheral isodose (81−92%) ranged from 16.7 to 19 Gy (mean = 17.6 Gy).

We calculated DCA, CB and IMRS plans for each patient. The following dosimetric parameters were analysed for all plans: conformity index (CI), heterogeneity index (HI), normal brain tissue complication probability (NTCP), obliteration probability (OP), success probability (SP), normal brain dose-volume histograms and probability of a second cancer incidence (PSC).

Results: IMRS was superior to DCA and CB for homogeneity and conformity, IMRS was discreetly worse for NTCP than DCA and CB (5.9%, 5.3%, 5.4% respectively), and so for SP (58.9%, 59.4% and 59.4%). Equal OP was obtained for each plan on each patient (range 70.8−77.5%), since OP only depends on the minimal dose on the lesion. Percentage of normal brain volume receiving low doses was higher in IMRS than in DCA and CB approaches respectively but without clear influence in PSC. Dosimetric parameters always fulfilled the RTOG recommendations.

Conclusions: IMRS treatment improves target conformity and homogeneity, but increases the volume of normal tissue exposed to low doses of radiation. No important differences were found between DCA and CB techniques.

931   POSTER
Cost-effectiveness of particle therapy: current evidence and future needs

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Background: Due to the ever-expanding health care expenses, knowledge about the cost-effectiveness of treatments is continuously gaining importance. In spite of the fact that radiotherapy (RT) is a rather cheap treatment modality, increasing complexity will inevitably translate in higher costs. This is certainly so for proton and light ion therapy. In order to find current evidence on cost-effectiveness of particle therapy we systematically searched the literature.

Methods: Twelve databases were searched systematically with a pre-defined search strategy. No limit was applied to language or study design.

Results: Out of 773 identified papers, only 13 papers were dealing with the economic aspects of particle therapy. Seven papers described aspects of the workload, staffing levels, setting up and operating costs of a proton therapy facility. Only three papers reported on "cost-effectiveness", all on proton therapy, and performed by the same Swedish research group (Karolinska Institute, Stockholm). An economic evaluation model

for childhood medulloblastoma, a cost-effectiveness analysis model for breast cancer and a cost-utility analysis based on a Markov model for breast cancer, prostate cancer, head & neck cancer and medulloblastoma was reported. The results of this latter study indicated that the average cost per QALY gaining for the four types of cancer assessed was about € 10,130. If the value of a QALY was set to € 50,000 (benchmarked varies highly between countries: € 20,000–100,000), proton treatment may be cost-effective. However, due to a high level of uncertainty because of a lack of data and many assumptions, these results should be interpreted with caution.

The content of the remaining three papers was miscellaneous.

Conclusion: So far, literature data on cost-effectiveness of proton therapy is limited, and is lacking for carbon ions. Further research into cost effectiveness of particle therapy is needed. In order to obtain valid results and decrease uncertainty, a large amount of data on costs and effects are needed. To achieve this goal, a multidisciplinary international collaboration is required.

932   POSTER
Reliability of the linear-quadratic formula for evaluating biological equivalence between single-fraction and hypofractionated radiation doses: an in vitro study

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Background: No appropriate model exists to estimate how single doses of radiation as used in gammaknife radiosurgery biologically correspond to hypofractionated doses as used in cyberknife and other stereotactic radiotherapy. The linear-quadratic (LQ) model is often used for convenience, but should be applied to 8- or more-fraction radiotherapy. In this study, we compared biological effects of single-high and hypofractionated doses in single cells and spheroids, and examined the reliability of the LQ model.

Material and Methods: V79 and EMT6 single cells received single doses of 2−12 Gy, and 2 and 3 fractions of 4 and 5 Gy each given at 4 h intervals to allow full repair of sublethal damage. Surviving fractions were determined by a colony assay. Single and fractionated doses to actually reduce cell survival to the same level were determined. From surviving fractions after single doses, the α/β ratio was obtained, and using the ratio and the LQ formula, equivalent single doses for the hypofractionated doses were calculated. The calculated doses were then compared with actually determined equivalent single doses for the hypofractionated doses. V79 spheroids (approximately 0.8 mm) received single doses of 5−26 Gy and 2−5 fractions of 5−12 Gy given at 2−4 h intervals. After irradiation, spheroids were dissociated into single cells and cell survival was determined by a colony assay. Equivalent single doses for the hypofractionated doses were calculated as done with single cells, and then they were compared with actually determined equivalent single doses for the hypofractionated doses.

Results: The α/β ratio was 5.1 for V79 single cells and 0.23 for EMT6. In both cell lines, equivalent single doses for hypofractionated doses calculated from the LQ formula were approximately 12%-15% lower than the actually measured biologically-equivalent single doses. In V79 spheroids, the former doses were approximately 20%-24% lower than the latter doses. Thus, the LQ model calculation underestimated the equivalent dose in both single cells and spheroids.

Conclusion: It is not appropriate to use the LQ formula for estimation of equivalent single and hypofractionated doses. The use of the LQ model may underestimate the effect of hypofractionated radiation.

933   POSTER
Quality Management System and organization of services in radiotherapy as a result of implementation of European Union directives and other international documents to the Polish law based on the experience of Great Poland Cancer Centre

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Background: There are many reasons for the implementation of the Quality Management System in radiotherapy: lawful regulations, safety of patients and staff, progressive computerization of the process of treatment, technological development, implementation of sophisticated techniques, increasing awareness of the society, the possibility of free selection of treatment centre all over Europe etc.

Aims of this work were (a) the evaluation of the level of influence of EU law and recommendations of European and International organizations on the development of Polish law establishing conditions for safe use of ionizing