

radiation in medicine, (b) the elaboration of the model, standards and recommendations for Quality Management System (QMS) in radiotherapy based on the experience of Great Poland Cancer Centre.

**Materials and Methods:** The comparison analysis of EU and Polish acts of law issued in years 1980–2006. For the elaboration of QMS in radiotherapy, the universal industrial ISO norm 9001:2000, referring to quality management system was used. Recommendations of this norm were completed with detailed quality standards based on authors' work experience, the review of articles on quality assurance and quality control standards for radiotherapy published between 1984–2006 and the review of current recommendations and guidelines of American, International, European and National bodies (societies, agencies etc). for quality assurance in radiotherapy.

**Results:** As a result of the comparison analysis of selected documents: (I) the level of transposition of EU law into the Polish law was verified and several phases of implementation were observed. (II) The original model of QMS in radiotherapy with the package of 352 quality standards in radiotherapy: organizational, physical-technical and clinical, documentation for QMS and detailed instruction for implementation of QMS in hospitals were elaborated.

**Conclusions:** The national mandatory regulations regarding quality management in radiotherapy were elaborated mostly due to: continuing transposition of EU law into the Polish law and the irradiation accident in Bialystok in 2001. The elaborated QMS in radiotherapy, can be used in any institution using ionizing radiation for medical procedures, and its implementation, as it was done in Great Poland Cancer Centre could be the first step for the improvement of the organization of work in radiotherapy due to (i) the improvement of safety conditions, (ii) optimization of treatment through the identification of processes and the relation between them, and identification of resources essential for the correct realization of these processes, (iii) decrease of the risk of radiation accidents and incidents, (iv) establishment of clear organizational structures in the hospital.

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POSTER

#### Cone beam CT (CBCT) for breast-planning: reliability and quality

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**Introduction:** Cone Beam CT (CBCT) can be used for Target delineation and planning, image guided radiotherapy and adaptive treatment planning. Systematic and ad random errors can be avoided. But, soft tissue contrast is inferior compared to a classic CT scan (CCT).

**Purpose:** 1. Is breast-planning on a CBCT reliable? 2. Has respiration a significant impact on soft tissue contrast?

**Methods and Materials:** 1. When implementing CBCT in clinic, 10 patients had both a CCT and a CBCT. We compared 13 plans: photon tangential breast plans (n=3); photon and electron parasternal plans (n=10). Comparison was done by measurement of differences in MU and in equivalent path length (EPL) (= corresponding length in a density equal to water). Planning was based on a Pencil Beam Algorithm. 2. During simulation, the movement of the sternum was quantified by the Varian RPM system (n=62). The EPL was measured on a parasternal plan. We tested the hypothesis of a correlation between large amplitudes in movement of the sternal bone due to respiration and large differences in EPL.

**Results:** 1. EPL is significantly shorter for CBCT compared to CCT ( $p < 0.0001$ ), which means that the density of the CBCT is consistently less than for the CT scan. For breast planning with photons, this results in a statistically significant ( $p = 0.002$ ), but clinically acceptable (<2%) difference in MU between CBCT and CCT. For electrons, larger differences were seen. 2. We found no correlation between respiration movement and EPL.

**Conclusions:** 1. We can conclude that CBCT is a reliable tool for breast planning with photons. For electrons, it appears to be less reliable. 2. Soft tissue contrast on CBCT might be influenced by respiration movement, but with the method used, we could not detect a correlation.

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POSTER

#### IGRT with helical tomotherapy – experiences of the first 8 months in Heidelberg

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**Background:** Helical tomotherapy was introduced into clinical routine at the department of radiation oncology in the University hospital of Heidelberg in July 2006. This report is intended to describe the experience of the first 123 patients treated with this new for of intensity modulated image guided radiotherapy. Patient selection, time effort, handling of daily image guidance with megavoltage CT and quality of radiation plans shall be assessed.

**Materials and Methods:** Between July 2006 and February 2007 123 patients were treated with helical tomotherapy in the University hospital of Heidelberg. This very heterogeneous group of patients was composed of

the following tumor entities: head-and-neck tumors (n=24), prostate cancer (n=19), gastrointestinal tumors (n=20), breast cancer (n=13), multiple metastases (n=11), spinal reirradiation (n=7), thoracic tumors (other than lung) (n=6), radiosurgery (n=5), malignant pleural mesothelioma (n=5), sarcoma (n=4), lung cancer (n=3), whole abdominal irradiation for ovarian cancer (n=3), skin malignancies (n=2), craniospinal axis treatment (n=1). In 98% of the fractions a pretreatment megavoltage ct scan was performed. After matching with the kilovoltage planning ct scan corrections for translations and roll were done.

**Results:** Helical tomotherapy was able to treat very small, very big or multiple targets. Image-guidance with MV-CT allowed precise position correction and hereby safe treatment application even if patients could not be properly immobilized due to obesity, pain, claustrophobia or neurological impairment. For the described tumor entities average time on table was 24.6 minutes, average treatment time 10.6 minutes. Excellent dose distributions with homogeneous target coverage and sparing of organs at risk could be achieved for all the described tumors.

**Conclusions:** Helical tomotherapy and daily image-guidance with megavoltage ct could be introduced fast and successfully into daily clinical routine. This method is suited to treat standard IMRT cases or patients with very big and complex shaped targets.

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POSTER

#### Tomotherapy for prostate cancer – comparison of dose distribution with linac-based IMRT planning and inter- and intra-fraction prostate motions

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**Background:** With tomotherapy, intensity-modulated radiation therapy (IMRT) and image-guided radiotherapy can be performed readily. In the present study, we compared dose distribution of tomotherapy planning for prostate cancer with linac-based planning and evaluated prostate motion between daily fractions and during treatment.

**Patients and Methods:** We made linac-based IMRT planning for 15 MV X rays using Pinnacle3 and tomotherapy planning in 13 patients. We then compared dose distribution and dose-volume histogram for PTV, rectum, bladder and femoral heads between the two plans. We measured interfraction prostate motions from distance between a couch position adjusted based on bony structures and that adjusted based on prostate contour in 21 patients (701 fractions). All patients were fixed using a body frame which was fixed to the couch during treatment. Interfraction prostate motions were measured from both the position at the first fraction and the average position. We took megavoltage (MV) CT also after treatment for initial 5 fractions of treatment, and we evaluated intrafraction prostate motions by comparing MVCT images before and after treatment in 21 patients (105 fractions).

**Results:** Dose distributions of tomotherapy plans were superior to linac-based IMRT plans for many constructions (PTV, rectum and femoral heads). Average (+ SD) interfraction prostate motions were  $0.7 \pm 0.6$  mm in right-left (RL) direction,  $1.6 \pm 1.6$  mm in superior-inferior (SI) direction and  $2.3 \pm 1.9$  mm in anterior-posterior (AP) direction from the prostate position at the first fraction. They were  $0.6 \pm 0.6$  mm in RL direction,  $1.3 \pm 1.2$  mm in SI direction and  $1.6 \pm 1.5$  mm in AP direction from the average position. Intrafraction prostate motions were  $0.3 \pm 0.6$  mm in RL direction,  $0.2 \pm 0.6$  mm in SI direction and  $1.4 \pm 1.8$  mm in AP direction.

**Conclusions:** IMRT planning using tomotherapy seems to more readily produce an optimal plan than linac-based IMRT planning. Interfraction prostate motions were largest in AP direction and smallest in RL direction. Intrafraction prostate motions were largest in AP direction and relatively small in both RL and SI directions. Based on this study, we are planning to reduce internal margins in both RL and SI directions in order to reduce adverse effects on the rectum and bladder.

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POSTER

#### A study on the optimization of beam direction and virtual organ delineation to minimize radiation pneumonitis in the intensity modulated radiotherapy of lung cancer

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**Background:** This study introduces an intensity modulated radiotherapy (IMRT) process in lung cancer patients and evaluates the utility of intensity

modulated radiotherapy technique that is used to minimize the dose applied to lung and heart by evaluating the use of the number of beams, beam direction, and virtual organ delineation in order to optimize radiotherapy treatment plans.

**Materials and Methods:** The subject in this paper were five patients with lung cancer who represent relatively small errors caused by organ motions by penetrating tumors into mediastinum. The number of beams and beam direction used in a treatment plan were 5, 7, 9, and 14 portals ranged from 200 to 160 in an equispaced field and 7 and 9 portals (non-equispaced and arbitrary fields), respectively. The dose constraint (V20 and V25) was configured based on references. Also, the optimized treatment plan can be obtained using a certain proper use in virtual organs. Dose-volume histogram (DVH), isodose line, and dose statistics were used to evaluate the radiotherapy treatment plan. In particular, the utility of the virtual organ delineation was evaluated by analyzing the results before and after applying it.

**Results:** The nine portals equispaced field-IMRT and 7 portals non-equispaced field-IMRT method demonstrated desirable results within 20% in the PTV (planning target volume), dose homogeneity, mean lung dose, V20, and V25 and showed the same results in these methods due to the application of the virtual organ delineation. Also, it is able to complement possible errors in a treatment process by applying a lung cancer intensity modulated radiotherapy protocol to clinics.

**Conclusions:** This study designed such a lung cancer intensity modulated radiotherapy protocol and obtained the optimal radiotherapy treatment plan based on the virtual organ delineation and irradiation plan.

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POSTER

#### Development of a new normoxic polymer gel dosimeter (TENOMAG)

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**Background:** In recent years, the verification of the three-dimensional (3-D) dose distribution in tumor volume has been significantly considered in a radiation therapy treatment plan. Because the conventional dosimeter including an ion chamber doesn't represent 3-D dose distribution, this study attempts to develop a gel dosimeter that performs 3-D dose analysis using MR images for the chemical change caused by the radiation in tissue equivalent gel in order to overcome this problem.

**Materials and Methods:** This study produced polymer gel that can be produced in a normoxic condition using anti-oxidants instead of using a polymer gel dosimeter that can only be applied in a hypoxic condition using nitrogen gas. Also, this study investigated the characteristics of normoxic polymer gel according to the composition of gel compound samples to produce practical polymer gel and composited polymer gel with five different compositions. A glass bottle filled with gel that was fabricated to measure dose was produced to investigate the relationship between the amount of radiation and the transverse relaxation time in MR images whereas the MR image of the glass bottle was obtained after applying irradiation. MR images, R2 mapping image, dose-R2 response curves in accordance with composition ratios, and dose distribution were analyzed as evaluation elements.

**Results:** This study showed the polymer gel that was composited using the combination of a 6% gelatin and 9% MAA applied in this study demonstrated excellent characteristics in the radiation dose. Also, it was evident that it showed very high radiation sensitivity due to the strong oxygen removal reaction of the applied anti-oxidant. The gradients of the sets were 0.60, 0.775, 0.683, and 0.954, respectively, and the intercepts of the curve were 0.322, 0.473, 0.611, and 1.032, respectively. In the case of the set 3, it showed better results in the linearity, such as 0.9491, than other groups.

**Conclusion:** This study composited polymer gel (Tetrakis hydroxymethyl phosphonium chloride-Normoxic-Methacrylic acid-Gelatin, TENOMAG) in a normoxic condition using anti-oxidants and obtained a composition ratio that can be practically applied to clinics.

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POSTER

#### Administered dose to the rectum and colon in prostate cancer patients treated with curative radiotherapy presenting a secondary intestinal cancer

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**Background:** Radiotherapy (RT) is a known strong risk factor for cancer development. Controversy still exists, however, on the possible carcinogenic

hazard on colon and rectum derived from the irradiation of a prostate cancer. This study aims to evaluate the administered dose to the rectum-colon and technique characteristics of patients presenting an intestinal tumor after curative RT for prostate cancer.

**Materials and Methods:** Using data from the population-based cancer registry, 11/264 (4.2%) prostate cancer patients treated with curative RT presented a rectal or colon cancer. These tumors were diagnosed at a median time of 96.5 months (range, 75–145) after RT. Three secondary cancers were located at the recto-sigmoid and transverse colon, respectively. Other location were sigmoid colon (n=2), caecum (n=2) ascendant colon (n=1). Median delivered dose to the pelvis was 50 Gy (range, 45–54). Median delivered dose to the prostate was 66 Gy (range, 50–70). All patients were treated with high-energy photons (10 MV, 9 patients; 18 MV, 2 patients). Eleven CT datasets were selected to match the patient's clinical characteristics (weight, patient thickness) so as to reconstruct the dose deposition of the curative RT.

**Results:** All but 2 patients were treated with a 4 field box technique for the pelvic fields. One patient interrupted the RT before the boost delivery. The prostate boost was delivered by a 2, 6 and 4 field technique in 7, 2 and 1 patients, respectively. The dose to the intestinal tractus will be detailed at the ECCO meeting.

**Conclusions:** Secondary cancers after curative RT for prostate cancer occur out of the treatment fields in a substantial number of cases.

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POSTER

#### Body immobilization systems: gadgets or tools?

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**Background:** There are cases that highlight the importance of eliminating researcher bias, this is one of them. Fortunately the rigours of proper testing reassert the self-correcting nature of science.

With the introduction of new technology such as intensity modulated radiotherapy (IMRT), image-guided radiotherapy (IGRT), TomoTherapy® etc. small misalignments can result in treatment failure. This prompted the question as to whether immobilization systems are indispensable tools. The purpose of this study is to evaluate the BodyFix® System.

**Materials & Methods:** This device consists of a body size bag (shell) filled with Styrofoam pellets, which moulds to the patient's form as air is removed via a vacuum pump. The patient lies in this shell and is immobilized for treatment. Biweekly anterior and lateral set-up check films (CF) were taken for the duration of treatment for eleven patients undergoing pelvic irradiation with six of them randomly selected to be mobilized with this system. To evaluate the quality of the immobilization, two therapists measured, compared and recorded the distance between the field edge and two bony landmarks for each (CF) and corresponding digitally reconstructed radiograph (DRR). If the measurement on the (CF) differed from those of the (DRR), the patient was realigned, (CF) verified and treatment given. Set up times were recorded biweekly to evaluate the practicality of the product.

**Results:** Our data showed that the immobilized patients were misaligned on average by  $0.8 \pm 0.3$  mm while the non-immobilized patients were misaligned on average by  $4 \pm 8$  mm. Thus, our data shows that this device does provide adequate immobilization. The patient set-up time was virtually unaffected as it increased only by about one minute when the device was used. We found that the major disadvantage of this immobilization system is that a significant amount of space is required to store the shells.

**Conclusion:** Our results suggest that what we thought would be a useless gadget, actually proved to be a helpful tool. Regrettably, due to space restrictions, only a limited number of patients can realistically be treated with this immobilization system. We therefore propose comparative multicenter trials so more systems can be simultaneously tested and results shared. This will help us to soon find an adequate immobilization system that could benefit all patients.

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POSTER

#### Individual superficial applicators – geometric optimization of treatment plans

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**Aim:** to analyze dosimetric parameters of dose distributions calculated for surface applicators in order to optimize the geometry of the individual applicators for small irradiated areas (about 9 cm<sup>2</sup>), to meet requirements of conformal brachytherapy. Treatment plans for individual surface applicators, where temporal and geometrical optimization was employed, are presented in this paper to introduce it's usefulness in treating different localization of skin cancers.