Severe Radiation Therapy-related Soft Tissue Toxicity in a Patient with Porphyria Cutanea Tarda: A Case Report and Literature Review

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Purpose: Porphyrias are caused by enzyme deficiencies in the heme biosynthetic pathway and subsequent accumulation of heme precursors. Some porphyrias are associated with phototoxicity due to activation of porphyrins by ultraviolet light, but the effects of ionizing radiation are not clear. Here we report a case of severe, late radiation therapy-related soft tissue toxicity in a patient with porphyria cutanea tarda (PCT) and review the literature for similar reports.

Methodology: A 50 year-old man with PCT was treated with definitive radiation therapy at UTMB in 2004 for a cutaneous lower lip cancer, squamous cell carcinoma, clinical stage T2N0M0. He was treated to a total dose of 70 Gy to the lower lip lesion and 50 Gy to the upper elective neck, via traditional opposed lateral photon beam arrangement and 3D conformal radiation therapy technique.

Results: During radiation therapy, acute toxicity was of an expected onset and severity considering the total dose and tumor location, but the time course was protracted. By six months after treatment completion, he began to develop progressively severe, sharply demarcated skin hypopigmentation and subcutaneous fibrosis and retraction within the treatment field, with areas of painful denuded skin and crusting. The crusty lesions improved as his PCT went into clinical remission with repeated phlebotomy and temporarily improved with hyperbaric oxygen, which was done in preparation for a tooth extraction. The hypopigmentation, fibrosis, retraction, and pain persisted. He had a complete and durable
clinical response (4 years) of the lip cancer and neck control. There is conflicting, scant medical literature with no clear increased radiation therapy sensitivity or increased toxicity associated with porphyrias.

**Conclusion:** In this case, PCT was associated with severe, late radiation therapy-related skin and soft tissue toxicity. In PCT patients being considered for radiation therapy, caution is warranted, especially when skin dose is expected to be high.

2 **Bilateral Perineural Invasion on Prostate Biopsy Significantly Lowers Five Year Cancer Free Survival in Patients Treated with Prostate Brachytherapy**

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**Introduction:** Perineural invasion (PNI) discovered on prostate needle biopsy has been found to effect cancer outcomes. The goal of this study was to determine if PNI involving both lobes would have a decreased five year cancer free survival in patients receiving brachytherapy.

**Methods:** Pathology reports of prostate needle biopsies of 650 men receiving brachytherapy as primary treatment for prostate cancer were retrospectively reviewed. Patients were excluded from analysis if followup information was not available. The cohort was divided into three groups: no PNI (n=355), one lobe of PNI (n=65), and bilateral PNI (n=10). Fisher exact tests were used to compare the groups. Independent groups’ t-tests were used to compare the two groups on D90 gray. Cox proportional hazard regressions were performed to examine the effect of bilateral PNI on disease-free survival both before and after adjustment for the clinical covariates of external beam radiation, D90 gray and hormone use.

**Results:** Statistically significant relationships were found with external radiation and D90gy, p=.0019 and p=.0355 respectively. Cox regression showed a significant greater likelihood of disease recurrence in the the bilateral PNI group, Hazard Ratio=7.65 (95% CI 2.69-21.79). After adjustment for the clinical covariates of external radiation, D90gy and hormone use the bilateral PNI group still exhibited a greater likelihood of disease recurrence, Hazard Ratio=4.81 (95% CI 1.52-15.25). Kaplan Meier curves estimated the cancer free survival at five years for the no perineural invasion group to be 93%, one lobe of perineural invasion to be 87%, and bilateral perineural invasion to be 51% (p=.0001)

**Conclusion:** In this large retrospective review of pathology reports, patients with bilateral perineural invasion had a significantly lower five-year cancer free survival.

3 **Inter-observer and Intra-observer Variability in Measuring Compliance of Breast Tissue with Tissue Compliance Meter (TCM) in Healthy Volunteers: Implications for Studying Fibrosis in Breast Cancer Survivors**

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**Background:** Improved survival of breast cancer patients presents a challenge in
managing long-term toxicities. Therapeutic intervention for radiation-induced fibrosis (RIF) or chemotherapy-(CIF) occurs frequently when it’s irreversible. Objective quantification of RIF/CIF in evolution remains a challenge. Prior to embarking on measuring fibrosis with TCM, we assess this tool in healthy volunteers with regard to inter-observer/intra-observer variability.

**Methods:** Three independent physicians applied TCM to 4 locations of the right and left breasts, respectively: upper outer quadrant, lower outer quadrant, lower inner quadrant, and upper outer quadrant. In the blinded fashion, every investigator obtained 3 consecutive measurements in each quadrant. Forty healthy volunteers, with no breast disease or surgical intervention, partook in this project. The intraclass correlation coefficient (ICC), based on a two-way random effects model, was used to assess inter-observer reliability stratified by breast and quadrant. The paired t-test and pearson correlation coefficient (r) were used to assess intra-observer variability for each rater (right breast vs. left breast) stratified by quadrant. All subjects were matched for use of oral contraceptives (OC), hormonal replacement therapy (HRT), pre/post ovulation status, and pre/post menopausal status. The effects of parity and nursing were assessed.

**Results:** The median age was 45 years (range, 24-68). The median bra cup size was 35C (32A-40DD). There were 27 Whites (67%), 4 Blacks (10%), 5 Asians (13%), and 4 Hispanics (10%). ICC’s indicated excellent inter-observer reliability (low variability) amongst the 3 raters, by breast and quadrant (all ICC’s ≥0.99). The paired t-test and correlation coefficient both indicated low intra-observer variability for each rater (right breast vs. left breast), stratified by quadrant (all r’s ≥0.94, p<0.0001). There were no significant differences in mean TCM compliance between pre and post ovulation status, between OC use and OC non-use, and between post-menopausal HRT-use and HRT non-use (p>0.05). Significant differences in the mean TCM compliance between women with ≤1 versus >2 children were evident in all 4 quadrants (p≤0.006), as well as between women having larger bra size 32-34 versus 36-40 (p<0.001) and cup A-C versus D-DD (p<0.0001).

**Conclusions:** Our data indicate that TCM objectively measures breast tissue compliance. Inter-observer and intra-observer variability is small and the measurements are reproducible. We can now embark on analyzing TCM in evolution of RIF/ CIF. Potential implications for the survivors of breast cancer are detection and treatment of early functional impairment induced by fibrosis, while it is still in evolution and reversible.

4 Induction Chemotherapy with Vinorelbine/Cisplatin followed by Docetaxel with Concurrent Radiotherapy in Patients with Locally Advanced Non-Small Cell Lung Cancer

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**Purpose:** This study was conducted to determine the efficacy and toxicity of docetaxel given concurrently with radiotherapy after induction chemotherapy using vinorelbine and cisplatin in patients with locally advanced stages of non-small cell lung cancer.

**Materials and Methods:** Patients with previously untreated, unresectable and stage IIIA or IIIB NSCLC with ECOG PS of ≤2, were ≥18 -70years, and had adequate organ function.
Two cycles of induction chemotherapy were given in the form of Cisplatin (80 mg/m²) on day 1 and vinorelbine (25 mg/m²) on day 1, 8, 15 and 22 every 28 days. For patients who attained responses or stable disease, docetaxel (20 mg/m²) weekly with thoracic radiotherapy was given for approximately 6-6.5 weeks (2 Gy per fraction; total dose, 60-66 Gy).

**Results:** 32 patients with stage IIIA or IIIB NSCLC were enrolled into the study between June 2003 and December 2006. The median age was 66 years (range, 31-70 years), 22 patients (69%) were men. Performance status was measured by ECOG and it was 0 in 21 patients (66%), 1-2 in 11 patients (34%). Three patients out of the 32 eligible patients were not assessable at the end of induction chemotherapy (2 for toxicity and 1 refused continuing treatment). Twenty-nine patients received weekly docetaxel with concurrent TRT, 3 patients were not assessable (2 for progressive disease and one died because of extensive myocardial infarction). Partial response after induction chemotherapy was evident in 50% of patients; 31% showed NC and 9% showed PD. While 48% of the assessable patients for concurrent CT/RT showed PR; 21% showed NC and 21% showed PD. After a median follow up time of 32 months; the median survival time was 12 months and the progression free survival time was 7 months. 1- and 2-year survival time were 68.2 and 25.9% respectively; and 1-and 2-year PFS were 33.6 and 23.7%.

Grade 3-4 esophagitis was a prominent toxicity for the concurrent RT-CT phase (24%), while 10% of patients developed grade 3-4 pneumonitis. No treatment related deaths (neither due to sepsis nor bleeding) were reported in the study.

**Conclusion:** Weekly docetaxel concurrent with radiotherapy following induction chemotherapy using vinorelbine/cisplatin regimen for treatment of patients with locally advanced NSCLC is an acceptable regimen (safe and effective) and it needs further investigations to include larger number of patients.

5 Single Fraction vs. Multi-fraction Radiotherapy in Treatment of Patients with Metastatic Spinal Cord Compression (MSCC): Functional Outcome

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**Purpose:** As the overall survival of cancer patients with MSCC is markedly reduced, as well as the effort of the patient and the high cost of RT, this study was done to determine the efficacy of single treatment fraction RT 1×8Gy instead of multi-fraction RT 10×3Gy for the treatment of patients with MSCC in terms of functional outcome. Patients and Methods: Forty four patients diagnosed as MSCC by CT and/or MRI were divided into 2 groups and treated either with single fraction (1×8Gy) in 21 patients (48%) or with multi-fraction RT (10×3Gy) in 23 patients (52%). The data of the treated patients were collected and analyzed for the functional outcome before RT, and then up to 24 weeks after RT.

**Results:** From January 2004 to April 2007, 44 patients with MSCC were enrolled into the study; they were treated and assessed in Ain Shams University hospitals and private centers, 24 patients (55%) were < 65 yrs, 24 patients (55%) were women, primary tumor site was breast in 41%, lung in 16%, myeloma in 11%, prostate in 19%, GIT in 11% and pheochromocytoma in only 2% of the enrolled patients. There were no statistically significant differences between these populations in demographic features including age,
sex, distribution and primary tumor characteristics. Univariate analysis showed that the two compared RT fractionation schedules showed no statistical significant difference for improvement, no change or deterioration of motor function either before RT, at the end of RT, at 6 weeks, at 12 weeks or at 24 weeks posttreatment with RT. Seven (33%) out of the 21 patients treated with single fraction RT and 9(39%) out of the 23 patients treated with multi-fraction RT had become more able to walk after their treatment with RT (p= 0.21). Multivariate analysis showed a significant effect on the results of motor function for two of the important prognostic factors (performance status and pretreatment ambulatory status); while there was no effect for the age, nor the sex, number of irradiated vertebrae, presence or absence of visceral metastases or the RT fractionation schedule on the functional outcome. No late radiation induced toxicity was recorded in either group. Median overall survival time was 4.4 months.

**Conclusion:** Comparing the functional outcome of patients treated for MSCC with either single RT fraction or multi-fraction RT proved to be the same in either group. Shortening of the duration of treatment will reduce the treatment's cost and the effort in addition to reducing the wait list in cancer centres for patients in need of RT. Therefore; single fraction RT in treatment of patients with MSCC should be considered effective as well as safe and economic alternative to more protracted RT regimens in treating such a category of patients.

6 Normal Tissue Sparing in the Treatment of Anal Carcinoma: Unique Challenges in the Setting of HIV Disease

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**Purpose:** To compare normal tissue radiation doses in IMRT and modified segmental treatment plans and to address special considerations in the treatment of early stage carcinoma of the anal canal in a patient with AIDS.

**Methodology:** A 42-year-old gentleman with AIDS was diagnosed with early stage squamous cell carcinoma of the anal canal and treated with concurrent chemoradiation therapy. Chemotherapy consisted of 5-fluorouracil and mitomycin C. Organs at risk (OARs) including the genitalia-skin region, bladder, small bowel, and femoral heads were contoured. Two treatment plans were created for comparison: a conventional modified segmental plan and an IMRT plan. Treatment was delivered with step-and-shoot inverse-planned IMRT in an effort to reduce the radiation dose to normal tissues and thereby decrease the acute side effects of treatment. Dose-volume histograms (DVH) were analyzed to compare the radiation doses to the OARs and tumor planning treatment volumes (PTVs). We also assessed the side effects he experienced during treatment.

**Results:** DVH comparison confirmed reduced dose to the OARs with IMRT. The percent decrease to the genitalia-skin region, bladder, small bowel, and femoral heads was 16%, 62%, 17%, and 39%, respectively. Dose coverage of the PTV was comparable based on the DVH analysis. In the IMRT plan the percentage of the PTV receiving more than 90% of the prescription dose was 100%, and < 1% of the PTV received more than 110% of the prescription dose. The patient experienced no acute side effects greater than grade 1. There were no treatment interruptions. More than one year after completion of treatment, the patient remains disease-free.

**Conclusions:** Although significant acute morbidity is common with conventional treatment of anal carcinoma, patient tolerance of IMRT is excellent. Dosimetric comparison of IMRT
and conventional treatment plans demonstrated significant reduction in radiation dose to normal structures with delivery of comparable dose to the tumor PTV. This dose reduction to normal tissues allowed this patient with AIDS to tolerate standard concurrent chemoradiation therapy without unexpected complications.

7 Outcome Analysis of Early Stage Prostate Cancers Treated with CyberKnife® Delivered Hypofractionated Radiotherapy

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Purpose: To evaluate acute toxicity outcomes of prostate cancer patients treated with CyberKnife® delivered hypofractionated radiotherapy.

Materials and Methods: This was a retrospective chart review analysis of the first 50 patients treated with Cyberknife® radiotherapy for prostate cancer. Most patients were affected with early stage prostate cancer (n=47). Two patients had metastatic disease at diagnosis and were excluded. A total of 37 patients received radiation treatment at a dose of 35-37.5 Gy in 5 fractions of 7-7.5 Gy per fraction. Assuming an alpha/beta of 1.5, this delivered an equivalent dose of 85-96 Gy in 2 Gy fractions (EquivGy2). A subset of patients (n=11) received standard Linac-based pelvic radiation treatment via either IMRT/IGRT or Tomotherapy and received a Cyberknife® boost at a dose of 17.6-21Gy in 2 fractions (n=8, EquivGy2 = 51.8-72Gy). One patient received a boost of 24Gy in 3 fractions (EquivGy2 = 65Gy), and two patients received a boost of 25Gy in 5 fractions (EquivGy2 = 46.4Gy). The maximum rectal dose was limited to 1ml receiving <36Gy and 50% of the volume receiving <50% prescribed dose. The bladder was limited to 10ml receiving <37Gy. The prostate was expanded by 3mm posteriorly and 5mm in all other directions to the PTV. The dose was prescribed to PTV with >85% coverage with the maximum dose <15%. The acute toxicities were recorded using the Common Terminology Criteria for Adverse Events (CTCAE), version 3.0 at the end of treatment and at patients’ follow up visits.

Results: The mean patient age at presentation is 66 years (range, 46-80). The median pretreatment PSA value and Gleason score were 9.16 ng/ml and 7, respectively. The CTCAE Grade 1 genitourinary (GU) and gastrointestinal (GI) symptoms were reported by 54% (n=26) and 10% (n=5) of patients, respectively. Grade 2 GU acute toxicity was reported by 10% of patients (n=5). Only 3 patients reported Grade 3 acute toxicity in the form of urinary frequency, urgency, and/or dysuria. There were no gastrointestinal Grade 2 or Grade 3 toxicities reported.

Conclusion: CyberKnife® delivered hypofractionated radiotherapy for treatment of prostate cancer has an acceptable acute toxicity profile.

8 The effect of reconstruction algorithm and number of projection images used as input data on the final quality of megavoltage digital tomosynthesis datasets.

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Purpose: To investigate the effect of reconstruction algorithm and number of projections
used on the quality of megavoltage digital tomosynthesis images.

**Methodology:** Various phantoms were used to investigate the end image resolution, contrast-to-noise ratio (CNR), artefact spread of megavoltage digital tomosynthesis datasets reconstructed using the shift-and-add algorithm, the filtered back-projection algorithm and the simultaneous algebraic reconstruction technique. While the tomosynthesis angle was set at 40 degrees, the number of projections used as input data to the various reconstruction algorithms varied between 2 and 41. The image parameters were analyzed using the ImageJ software from the NIH. The reconstruction speed was also considered in the final evaluation of the performance of each algorithm.

**Results:** It was found that a bar pattern with 2 mm bars was resolved using a minimum of three projections by all reconstruction algorithms. The filtered back-projection algorithm produced the noisiest images and therefore produced the lowest CNR while the shift-and-add algorithm produced the highest CNR values. CNR got better as more projections were used. The shift-and-add algorithm produced much worse artefact spread compared to all other algorithms. While the shift-and-add and filtered back-projection algorithms showed increasing artefact spread when more projections were used, the algebraic reconstruction algorithm showed the opposite effect. Execution time for each algorithm showed a linear increase with number of projections used with the algebraic algorithm taking much longer to execute compared to the other two algorithms.

**Conclusions:** When all results were considered together, the filtered back-projection algorithms, when used with 11 projection images, offered the best compromise between image quality and reconstruction speed.

9 Initial PSA response and toxicity after Cesium-131 prostate brachytherapy : A single institution experience.

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**Purpose:** Cesium-131 is a relatively new encapsulated isotope that has been approved by FDA for use in prostate brachytherapy. The energy of Cs-131 is similar to I-125 but its half-life is only 9.7 days. The lower half-life of Cs-131 makes it radiobiologically suitable for the treatment of prostate cancer and may also result in lower intensity and duration of short term and long term side effects. This report evaluates initial PSA response, RTOG genitourinary and gastrointestinal toxicity after Cs-131 implant for patients with early stage prostate cancer.

**Materials:** 10 patients with early stage prostate cancer received Cs-131 implants as a definitive treatment (monotherapy) between December 2005 and May 2007. The doses ranged to 100-115 Gy. Serial PSAs were drawn in radiation oncology or urology. The GU and GI toxicity was assessed using RTOG criteria. No hormones were used in any of the patients either before or after the implant. Data collection was done using chart review, telephone interviews and direct patient interviews.

**Results:** The Cs-131 seed activity was between 2.1-2.4 U. The pre-radiation PSA was between 3.44-6.4 ng/ml. All patients had gleason 6 prostate cancer. The minimum follow up was 6 months (range 6-23 months). 9 of 10 patients showed a sharp fall in PSA within 1-3 months after the implant. One patient that was implanted recently shows a rising PSA at 6
months post-implant. Post implant PSAs ranged from 0.2 to 7.12. Acute GU toxicity grade 1-2 was observed during immediate post-implant period and up until 1 year later, with resolution of symptoms as early as one week in one patient and 3 weeks in another patient. There were no grade 3 or 4 GU toxicities. Only 2/10 patients reported Grade 1-2 GI toxicity. There were no grade 3 or 4 GI toxicities. Of the 5 patients in whom sexual history was available, 3 patients did not report any erectile dysfunction post implant. One of the patients reported a slight erectile dysfunction but required no medication. Another patient reported significant improvement in erectile function after using Viagra (Sildenafil).

Conclusions: Cs-131 prostate brachytherapy as monotherapy is feasible and safe. The initial PSA results are encouraging. Though it is difficult to give a comparison with other radioisotopes at this time, the acute GU and GI side effects seem to be limited. More studies and needed for definitive conclusions.

10 Image-Guided Radiotherapy for Prostate Cancer: Analysis of Prostate Movements and Pelvic Rotation

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Purpose: To analyze prostate translation movements and pelvic rotation in daily treatments.

Introduction: Studies published previously have showed that the prostate can move during the course of radiation therapy. These movements can affect dose delivery and outcomes of patients treated with conformal radiation, or intensity modulated radiation therapy (IMRT). With the use of an image-guided radiotherapy (IGRT) system with daily images before treatment, it is possible to attempt correct these movements.

Methods and Materials: Ten patients treated with IMRT and total dose of 7560 CGy in 42 fractions to the prostate were analyzed. The IGRT system, Primatom Siemens, consists of a linear accelerator and a diagnostic CT scanner running on rails in the same treatment room, sharing the same couch. The daily CT image is fused with the treatment planning CT and shifts in three orthogonal axes can be made. We analyzed a total of 376 images from 10 patients. The pelvic rotation of the treatment day was determined for all images, using the angle between two references points localized in the most anterior portion of both femoral heads where they appear in the largest diameter. With these values we obtained an average angle for each patient.

Results: Of the 376 daily CT scans, isocenter shifts of less than 3 mm were required in the left-right direction in 46%, between 3 and 5 mm in 38%, 6 and 9 mm in 16% and more than 1 cm in 0.8% of the cases, respectively. In the anterior-posterior direction, 41% required shifts less than 3 mm, 39% between 3 and 5 mm, 20% between 6 and 9 mm, and none of the cases above 1 cm. When we analyze the superior-inferior direction, we observed that 42% were less than 3 mm, 35% were between 3 and 5 mm, 18% between 6 and 9 mm, and 5 % of the cases required shift larger than 1 cm. The total displacement was calculated for each patient and each day, we observed that in 15% they were less than 5 mm, in 61% they stayed between 5 and 9 mm, and in 23% of the cases they were larger than 1 cm. The pelvic rotation calculated between the two reference points discussed above, 8 patients presented the average angle between 0 and 2°, and 2 patients between 3 and 4°.
Conclusions: Our study showed shifts are most frequent in the superior-inferior direction and less frequent in the right-left direction. The largest range of the total displacement was between 0.6 and 0.9 mm with considerable number of cases with more than 1 cm. We did not observe any significant pelvic rotation based in bonny anatomy. Our data strongly suggest that the an IGRT system is necessary to maintain its planning objectives in case tight margins are used.

11 Prognostic Factors For Large Volume Recurrent Glioma Treated With Pulsed Reduced Dose-Rate Radiation Therapy

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Purpose: Despite aggressive treatment for CNS glioma, median survival remains poor due to recurrence near the primary tumor in nearly 90% of cases. Pulsed reduced dose-rate radiotherapy (PRDR) is a reirradiation technique which reduces the effective dose-rate and increases the treatment time. This pulsed approach allows sublethal damage repair processes to remain active during irradiation, and low dose rate hypersensitivity may allow favorable tumor cell killing.

Methodology: Between January 1999 and March 2007, 103 patients with recurrent glioma were re-irradiated using PRDR (median dose 50 Gy, range 20-60 Gy) delivered in 1.8-2.0 Gy fractions. PRDR was delivered via a series of 0.2 Gy pulses separated by 3-minute time intervals, creating an apparent dose rate of 0.0667 Gy/min. The dose rate of the linear accelerator is reduced to ~100 cGy/minute during each pulse of 0.2 Gy. Prior to the initiation of PRDR, all patients had received conventional radiotherapy, 60 had multiple surgeries, 14 radiosurgery, 4 GliaSite brachytherapy, and 95 received conventional chemotherapy and/or one or more experimental therapies. The mean treatment volume was 336 cc, including the volume of the contrast enhancing lesion and surrounding edema on pre-treatment MRI scan plus a 2 cm margin.

Results: Median overall survival based on initial histology since time of initial diagnosis was 6.3 years for low grade tumors, 4.1 years for grade 3, and 1.6 years for grade 4 tumors. Median survival since time of initiation of PRDR was 11.4 months for low grade, 5.6 months for grade 3, and 5.1 months for grade 4 tumors based on the histology of the tumor at time of initial diagnosis. For the entire cohort, median overall survival since time of initiation of PRDR was 5.8 months. Survival for patients with initial low grade tumors was statistically improved compared to grade 3 and 4 tumors (p=0.001). The effect of initial low grade histology remained significant on multivariate analysis. Multivariate analysis also revealed age at initial diagnosis and KPS ≥ 80 to be significant predictors of survival following initiation of PRDR. Four of 15 patients had pathologic evidence of radiation necrosis at autopsy without clinical suspicion for treatment related toxicity.

Conclusions: PRDR is a reirradiation strategy which allows safe re-treatment of larger target volumes to high doses with palliative benefit. Cumulative doses in excess of 100 Gy were well tolerated.

12 The Use of Helical Tomotherapy for Total and Partial Scalp Irradiation: A Clinical Validation Study
Purpose: To assess the use of image-guided helical tomotherapy (HT) for total and partial scalp irradiation by studying dose-volume histogram (DVH) parameters, in vivo dosimetric measurements, and acute skin reactions in the treatment of 10 consecutive patients.

Method and Materials: Ten patients requiring total (n=5) or partial (n=5) scalp irradiation underwent CT simulation for treatment planning with thermoplastic immobilization and without bolus. Dose homogeneity to the planning tumor volume (PTV) in the HT plan was assessed using the homogeneity index (HI): (Dmax–Dmin)/Prescribed Dose. DVH parameters for the brain, eyes, lenses, optic nerves, and optic chiasm were also calculated. By affixing MOSFET dosimeters to the patient at specified locations for entire image-guided fractions, in vivo dosimetric measurements (n=30) were obtained and compared to 1) doses calculated at the corresponding measurement points on the treatment plan (planning dose) and 2) the prescribed dose. Acute skin reaction was graded by the RTOG Acute Skin Reaction Scale.

Results: Dose homogeneity (HI) to the PTV for all patients (mean±SD) was 0.13±0.07. Mean (±SD) Dmax and Dmean of the brain for all patients were 47±14 Gy and 18±9 Gy, respectively. Mean Dmax for the eyes, lenses, optic nerves, and optic chiasm was 11±8 Gy, 5±3 Gy, 20±14 Gy, and 15±5 Gy, respectively. No DVH parameter for any structure exceeded the published TD 5/5 value. The percent difference (mean±SD) of the in vivo measurements compared to the planning dose and to the prescribed dose was -1.0%±3.5% and -1.7%±4.0%, respectively. Grade ≤1 (n=2 cases), Grade 2 (n=5), and Grade 3 (n=3) acute skin reactions occurred in patients receiving total doses in the range of <36 Gy, 45-60 Gy, and 55-70 Gy, respectively.

Conclusion: Image-guided HT can treat scalp lesions without the use of bolus and with excellent PTV dose homogeneity and normal tissue sparing. In vivo dosimetric measurements and acute skin reactions are consistent with the planning and prescribed doses delivered to each patient. This study validates the clinical use of HT for total and partial scalp irradiation.

13 Pathologic Analysis of CT and Ultrasound Imaging Accuracy for Prostate Radiation Therapy.

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Purpose: The 30 to 50% overestimation of prostate volumes using Computerized tomography (CT) imaging in comparison to transrectal ultrasound (TRUS) has been a challenge for radiation oncologists. To our knowledge, no study has utilized prostate pathologic specimens to detail the accuracy of and compare the two imaging modalities. We determined the difference in prostate volumes assessed by ultrasound and CT, using in vivo and ex vivo ultrasound, and ex vivo CT.

Methods and materials: Fourteen patients with localized prostate cancer treated with radical prostatectomy were enrolled in an IRB approved study. All patients (and prostate
specimens) were scanned with TRUS pre and post-surgery. Seven prostate specimens had additional post-surgical CT scans. All imaging studies and the surgery were performed in succession with minimal delay, on the same day. Ultrasound and CT scans were acquired from the base to the apex of the prostate in 2 mm and 1.25 mm slices, respectively. The prostate gland was contoured on each image set by one radiation oncologist and then volume calculations were made using both the ellipsoid formula and 3D voxel based approaches.

**Results:** The in vivo prostate 3D voxel and ellipsoid formula based volumes acquired with ultrasound were on average 30.4 cc (range 20.0 – 44.4) and 27.9 cc (16.0 – 43.8), respectively. The ex vivo prostate 3D voxel and ellipsoid formula based volumes acquired with ultrasound were on average 30.0 cc (range 20.7 – 46.3) and 27.4 cc (17.3 – 40.7), respectively. There was a 2% reduction between the imaged pre and post-surgery prostate ultrasound volumes. Ellipsoid formula based calculations on average underestimate the volume of the prostate by approximately 10% in comparison to the more accurate 3D voxel based approach. The ex vivo CT and ultrasound voxel based volumes of the seven prostate specimens imaged with both modalities were 34.4 cc (range 24.9 – 43.5) and 34.9 cc (24.7 – 46.3), respectively. Overall the Pearson correlation coefficients between in vivo and ex vivo ultrasound, and ex vivo CT and ultrasound were 0.986 and 0.917, respectively.

**Conclusion:** TRUS prostate gland measurements using the more accurate 3D voxel based calculations remain consistent both in vivo and ex vivo. CT and TRUS imaging are comparable in terms of actual prostate volume measurements ex vivo. Therefore, this study verifies that overestimation of prostate gland size seen with in vivo CT imaging as compared to in vivo TRUS is secondary to the difficulty with precise prostate contour delineation encountered with in vivo CT. These results will help to design future studies to resolve difficulties with CT based treatment planning in prostate radiation therapy.

**14 Whole-Pelvic IMRT versus 3-Dimensional Conformal Radiotherapy in Adjuvant Treatment of Gynecological Malignancies: Dosimetric Comparison and Evaluation of Acute Toxicities.**

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**Purpose:** There is a paucity of data regarding the role of intensity modulated whole pelvic radiotherapy (IM-WPRT) in the treatment of gynecologic malignancies. This paper describes our initial clinical experience using IM-WPRT.

**Methodology:** From 9/2007 to 2/2008, eight consecutive gynecologic patients underwent IM-WPRT. Secondary 4-field 3D conformal whole pelvis radiotherapy (3D-CRT) plans utilizing 18MV photons were then created for these patients. All patients underwent CT-based planning with custom immobilization. For the IM-WRT patients, the clinical target volume (CTV) included the upper vagina, parametria, uterus, and cervix, as well as the presacral and pelvic lymph node region. The CTV was expanded by 1cm to create the planning target volume (PTV). Using standard conformal blocks, the same PTV was used in the 3D-CRT plan. Dose volume histograms (DVH) were compared for IM-WPRT and 3D CRT plans. Acute toxicities of 25 matched patients previously treated with 3D-CRT were
compared with our eight IM-WPRT patients, using RTOG acute toxicity criteria.

**Results:** Under both plans, PTV and nodal regions were prescribed 5040 cGy in 180 cGy fractions. For the IM-WPRT cohort, 96.5% of the PTV volume (on average) received the prescription dose, while the 3D-CRT plan resulted in 96% coverage. With IM-WPRT, the volume which received 110% and 115% of the prescription dose was 3.74% and 0.25% respectively. The mean volume of the bladder receiving doses in excess of 40 Gy was reduced by 47% (p>0.0001) with IM-WPRT compared to 3D CRT. Similar results were seen with IM-WPRT in the rectum (p>0.0001) and small bowel (p=0.0199), both having a 40% reduction of volumes receiving greater than 40 Gy. Comparing acute toxicities of 25 historically matched 3D-CRT patients with our eight IM-WPRT, two of the eight IM-WPRT patients had RTOG Grade II or higher lower-GI side effects versus 12 of 25 patients treated with 3D conformal (25% IM-WPRT vs. 48% 3D CRT, p=0.23). Zero of eight IM-WPRT patients and one of 25 3D CRT patients experienced Grade II or higher GU toxicity (0% IM-WPRT vs. 4% 3D CRT, p=0.75).

**Conclusion:** IM-WPRT appears safe and effective in women with gynecologic malignancies. IM-WPRT has shown significant decrease in radiation dose to critical structures in the pelvis with considerable sparing of normal tissues, thus suggesting significantly less long-term morbidity. Furthermore, we anticipate a larger sample size will yield statistically significant values for the reductions in acute toxicity observed. As a result, the use of IMRT in gynecologic cancers is worthy of further study to elucidate the full benefits of this novel approach.

15 **Assessment of Four-dimensional Radiotherapy Planning and Respiratory Motion-induced Dose Difference Based on Radiological Measures**

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**Purpose:** To comprehensively evaluate four-dimensional (4D) treatment planning for nine lung tumor cases with both physical and biological measures using biologically effective uniform dose (BEUD) together with complication-free tumor control probability, Pₛ.

**Methodology:** Nine lung cases were randomly chosen as candidates for this study. Ten MLC-based IMRT plans were developed for different respiratory phases using the Philips (ADAC) Pinnacle³ treatment planning system (ADAC Laboratories, Milpitas, CA, v 8.0d). The general prescription of all plans is to provide 60 Gy to at least 95% of the PTV. The actual probabilities of benefit (Pₛ) and injury (Pᵢ) as well as Pₛ were carried out using an in-house developed software. Moreover, comprehensive comparisons of the composite 4D composite plan to the IMRT plans of fixed phases (denoted as P₀⁰%: end-inhalation and of P₅₀%: end-exhalation), were conducted physically and biologically.

**Results:** Based on the lung cancer patients we chose and PTV margin we applied, we found similar but not identical curves of DVH, and slightly different mean doses in tumor (up to 1.5%) in all cases when comparing 4D, P₀⁰% and P₅₀% plans. When it comes to biological evaluations, we did not observe definitively PTV size dependent in Pₛ among these nine lung cancer patients with various sizes of PTV.

**Conclusions:** In sum, it is not necessary that 4D plans would have better target coverage
or higher $P_\%$, as comparing to the IMRT plan. However, on the contrary to significant deviations (up to 14.7%) in $P_\%$ observed if delivering the IMRT plan made for $P_\%$ incorrectly at $P_{50}$, we estimated the overall $P_\%$, $P_B$ and $P_I$ for 4D composite plans which have accounted for intra-fractional respiratory motion.

16 Stereoscopic arc photography may reduce unnecessary radiation exposure from serial CT imaging required for treatment planning.

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Introduction: Patients undergoing external beam radiation for bulky tumors may receive multiple CT scans during their treatment course for optimal dosimetry. Stereoscopic arc photography can capture volumetric imaging data of visible bulky tumors and quantify response to treatment. This approach may be a viable alternative to computed tomography, and eliminates unnecessary exposure.

Background: Clinical photography of visible disease can document tumor response during treatment. Image-guided radiation therapy (IGRT) is the process of incorporating new patient imaging data into the radiation treatment course in order to enhance treatment delivery. CT scans are commonly used in IGRT to track tumor changes throughout the treatment process. However, there are significant risks associated with radiation exposure, and an ability to decrease this risk may improve outcomes.¹

Methods: In order to assess clinical photography as an acceptable imaging technique suitable for IGRT, we developed a camera-mount system docked within the head of a linear accelerator treatment machine. The accelerator gantry head travels around the patient in an arc to deliver radiation at multiple beam angles. Mounting the camera directly into the gantry affords the camera the same machine-controlled precision used to make rotations during treatment. We used a 35mm macro lens and Canon Rebel 350 camera body. Image acquisition time was accelerated with an RF controlled auto-focusing remote control set from Phottix. The camera can acquire one stereo pair per second while traveling along a fixed arc. Borrowing workflow steps and techniques from IGRT, we developed a system capable of tracking visible tumor response.

Results: The utility of stereoscopic arc photography within an iterative IGRT workflow in a phantom was studied and would consist of the following stages: 1. initial planning CT; 2. creation of treatment plan; 3. initial treatment; 4. stereoscopic arc photography; 5. volumetric post-processing; 6. overlay of processed image data on original treatment plan; 7. physician review of tumor response; and finally: 8a. creation of an alternate treatment plan; 8b. adjustment of the prescribed radiation dose or fields; 8c. reimaging (CT scan) of the patient if necessary. These steps are repeated after ~5 daily treatment fractions and can be tailored based on tumor response, complications, or physician preference.

Discussion: Stereoscopic imaging provides clinical information which can lead to decreased exposure and improved outcomes. Another potential benefit is as a teaching tool. Post-processed images could serve as a teaching aid for radiation therapists.

¹ Computed Tomography – An increasing source of radiation exposure. Brenner et al; NEJM, 20
Clinical Dosimetric Improvements Using the Contura® Balloon Applicator

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Purpose: To evaluate potential clinical improvements in skin and rib dose using the Contura® applicator.

Methodology: Eleven patients with DCIS or < 3cm IDC tumors were treated with intracavitary brachytherapy utilizing the Contura® balloon applicator. All patients were treated according to NSABP B-39 protocol parameters, delivering 3400 cGy at 340 cGy per fraction twice daily. Mean skin and rib distances were 11.7 mm (range 7-17mm) and 16.6 mm (range 4-51 mm) respectively.

Results: All patients completed therapy without treatment interruption. With applicator skin separation distance ≤ 9 mm, the maximum dose was reduced up to 17.9%. In patients where applicator to rib distances were ≤ 6mm, the maximum dose was reduced up to 29.1%. There were no acute toxicities or post therapeutic infections observed.

Conclusions: The Contura® balloon applicator allows significant reduction of dose to the overlying skin and underlying ribs with no observed toxicity.

Fractionated Stereotactic Body Radiation Therapy (SBRT) in the Treatment of Previously-Irradiated Recurrent Head and Neck Carcinoma-Updated Report of the University of Pittsburgh Experience

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Purpose: To assess the feasibility, safety and outcome of stereotactic body radiotherapy (SBRT) in patients (pts) with recurrent previously-irradiated squamous cell carcinoma of the head & neck (SCCHN).

Methods: Between January 2003 and May 2008, 85 pts (64 M, 21 F, mean age 65.0 ± 11.98 years) with recurrent, previously-irradiated SCCHN were treated with Cyberknife™ (CK) & Trilogy™ Intensity-modulated radiosurgery (IMRS). 78 pts completed treatment with CK and 7 pts with IMRS. The following endpoints were evaluated post-SBRT: tumor response (complete response (CR), partial response (PR), stable disease (SD), progressive disease (PD)), time-to-progression (TTP), acute & late toxicities, local control (LC) rates, and overall survival (OS). Kaplan-Meyer survival analyses were used to estimate the LC and OS rates. All toxicities were graded according to the CTCAE v.3.0. The median follow-up of all patients was 6 months (range 1.3-39 mo). 78 pts (92%) had PET/CT or CT performed at 1 to 3-month intervals post-treatment, the remaining 7 were evaluated by detailed physical examination for treatment response.

Results: The mean total dose of prior radiation to the primary site was 74 Gy (range 32-170 Gy). The mean interval from SBRT treatment to maximum response was 2.5 ± 1.4 months. Maximum tumor responses were 34% CR, 34% PR, 20% SD and the remainder had PD. Among those who had initial tumor response followed by progression (65.9%), there was a
mean interval of 5.3 ± 5.6 months for TTP. Progression rates by tumor differentiation were 44.4%, 73.9%, 63.6% and 75.0% for well, moderate, poor and unknown, respectively. Overall, the mean TTP post SBRT was 5.54 ± 4.85 months. The 1-year and 2-year LC rates for all pts were 51.2% and 30.7%, respectively. The 1-year and 2-year LC rates for pts with at least 6 months follow up (n=40) were 69.1% & 41.5%, respectively. Location of recurrence after SBRT was classified as local (n=7), regional (n=18), distant (n=23), locoregional (n=11), local-distant (n=2), regional-distant (n=5), local-regional-distant (n=1). The 1-year and 2-year OS for patients without distant metastasis (n=52) were 61.9% and 23.4%, respectively. The 1-year and 2-year OS rates for all pts were 48.5% and 16.1%, respectively. The median survival for pts without distant metastasis and for all pts, were 16.2 months (range 3.03-51.3) and 11.5 months, respectively. Treatment was well tolerated with no grade 4 or 5 treatment-related toxicities.

Conclusions: SBRT with CK and IMRS is feasible and safe for treatment of recurrent SCCHN patients with prior radiation therapy deemed to be poor candidates for re-irradiation by conventional means.

19 Margin on Gross Tumor Volume and Risk of Local Recurrence in Head and Neck Cancer.

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Introduction: No consensus currently exists regarding margins necessary to construct the clinical target volume (CTV) and planning target volume (PTV) from the gross tumor volume (GTV) in intensity modulated radiation therapy (IMRT) for head and neck cancer. Recommendations range from anatomic expansions based on primary site and involved structures to standardized volumetric expansions ranging from 0.5 cm (i.e, direct GTV to PTV expansion) to 1.5 cm in RTOG 0522 (PTV = (GTV + 1 cm) + 0.5 cm), or even larger.

Methodology: Patients with nasopharyngeal, oropharyngeal, oral cavity, hypopharyngeal, or laryngeal squamous cell carcinomas treated definitively with IMRT with or without chemotherapy were included. All patients without local relapse had a minimum follow-up of 12 months. Treatment plans of 85 available patients were reviewed and GTV to PTV expansion of was estimated.

Results: GTV was volumetrically expanded in 71 of 85 patients a median of 1.5 cm (range 0.4 – 2.5 cm). GTV was expanded anatomically in 7 patients and both anatomically and volumetrically in 7 patients. Twenty-one of 44 patients with a volumetric expansion of 1.5 cm or less had an associated intermediate risk volume, which was prescribed 54 – 64 Gy. Smaller volumetric margins were associated with use of altered fractionation, while anatomic expansions were associated with a lower KPS. At a median follow up of 26 months, 18 patients suffered local failure, and actuarial local control was 77.2% at 2 years. There was no significant difference in local control between patients expanded volumetrically versus those with an anatomic component to their expansion. In patients expanded volumetrically, no increase in risk of local failure was seen in patients with a total GTV expansion of 1.5 cm or less. In a subset of 21 patients with a direct (i.e., not accounting for CTV) GTV to PTV expansion (0.4 – 0.6 cm), no increase in risk of local failure was seen.

Conclusion: In this retrospective study, there was not an increased risk of local failure
using smaller margins on GTV or expanding solely volumetrically when treating patients definitively with IMRT for head and neck cancer.

20 Using Monte Carlo Simulations and Experimental Measurements to Calibrate An HPGE Gamma Detector Precisely

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Purpose: A new method of an HPGe (High Purity Germanium) detector precise γ efficiency calibration is developed, which is important for accurate radiation detection during cancer radiotherapy practices.

Methodology: First, radioactive nucleus 24Al was produced and separated with Momentum Achromat Recoil Spectrometer (MARS) at the K500 superconducting cyclotron of Texas A&M University. Then, 24Al was collected and delivered to a detector station that consists of a 1-mm-thick BC404 plastic scintillator, an HPGe detector, and a fast tape-transport system. Finally 24Al positron decays (beta plus) followed by γ transitions up to 8 MeV from 24Mg excited states were used for β-γ coincidence measurements to calibrate the HPGe detector efficiency precisely.

Results: When considering the effects of summing, positron annihilation, internal conversion, and β detector efficiency during 24Al spectrum analysis, we obtained the efficiency 0.192(6)% for γ-ray energy 7070 keV at 49 mm distance away from the source sample 24Al, by carefully making corrections. The Monte Carlo (MC) simulations with CYLTRAN code gave a value of 0.189%, which was in agreement with our measurements. The precise efficiency calibration curve of the HPGe detector up to 7070 KeV at 49 mm distance away from the source sample was obtained. By using the same procedure, we obtained the efficiency 0.0385(8)% for the 7070 keV γ-ray at 151 mm distance away from the source sample 24Al. MC simulation value for the efficiency was 0.0399%, which differed from the measurement value by 4(2)%. This discrepancy led us to assign an uncertainty of 4% to our efficiencies at 151 mm up to 7070 KeV. The Monte Carlo simulations also reproduced the intensity of observed single- and double-escape peaks, providing that the effects of positron annihilation-in-flight were incorporated.

Conclusion: A new method of combining Monte Carlo simulations and experimental measurements was established. The precise calibration curves obtained from this work are useful for accurate radiation detection and for improving quality assurance (QA) control to intensity-modulated radiation therapy (IMRT).

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21 Parameters Associated With Local Failures in Patients with Unresected Brain Metastasis Treated With Gamma Knife Radiosurgery

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Purpose: To evaluate parameters associated with local failures in patients with unresected
brain metastasis treated with gamma knife radiosurgery.

**Methodology:** Forty eight patients with a total of 122 brain metastases were treated at William Beaumont Hospital between December 2006 and December 2007. All patients had post-treatment Magnetic Resonance Imaging (MRI) at our institution, with a minimum of 3 months follow-up required. Patients were required to have enhanced MRI imaging (enhanced thin-slice MRI scanning) to evaluate for multiple lesions prior to GK. The most common histologies treated were lung cancer (non-small cell, n= 65 and small cell, n=11), melanoma (n= 10), and breast cancer (n= 8). Eight patients (33 lesions) received whole brain radiation therapy (WBRT) prior to treatment with GK. The median marginal tumor dose (TD) was 18 Gy (range 8-24 Gy). Multiple factors were evaluated for association with local failure (LF) including: conformity index (CI), tumor volume (TV), maximum tumor dimension (MTD), marginal tumor dose (TD), tumor histology, and prior WBRT.

**Results:** With a median follow-up of 4.8 months (range 3 - 13.4 months), the LF rate was 11% (13/122); 85% (11/13) of the failures were of primary pulmonary origin (9 non-small cell, 2 small cell). The median time to failure was 4.8 months (range 3-9.6 months). The median values for failure vs. non-failure cases were as follows: CI (2.8 vs. 4.4), TV (3.1 cm³ vs. 0.14 cm³), MTD (2.0 cm vs. 0.76 cm) and TD (18 Gy in either case). Lung non-failures (n=65) had a similar median CI to all failures. On univariate analysis, only tumor volume significantly predicted for local failure (p<.0001). Further analysis demonstrates that failure occurred in 9 of 19 (32%) tumors with a volume greater than or equal to 2 cm³ where as only 4 of 94 (4%) tumors failed with treatment volumes less than 2 cm³ (p<0.001). On multivariate analysis, none of following parameters was predictive of local failure: conformity index, tumor volume, maximum tumor dimension, marginal tumor dose, prior WBRT, or primary tumor histology.

**Conclusion:** Gamma Knife radiosurgery offers excellent local control (90%) for patients with unresected brain metastases. Only tumor volume was predictive of local failure in this population. Tumors with treatment volumes more than 2 cm³ are at increased risk of failure. Additional follow-up will be required to document durability of local control.

**22 Mediastinal Large B Cell Lymphoma and Mediastinal Classic Hodgkin’s Lymphoma : Contrasting the Clinical Course of Patients**

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**Purpose:** The molecular signature of MLBCL differs from other large B cell lymphomas and shares features with CHL. CHL and MLBCL share number of common clinical features such as preponderance among females and early young age of patients affected with the median age being slightly older in MLBCL patients. Both have nodular sclerosing type, exhibit common genetic abnormalities like gains of chromosome 2p and 19p, lack Ig expression, and functional expression of HLA class-I antigen and also have been noted to have amplification of REL locus on chromosome 2p and JAK locus on 9p. However, both CHL and MLBCL require different therapeutic approach and also have different clinical out come as well. We are interested in determining whether their clinical courses supported the apparent underlying biologic relationship.

**Methodology:** Eligibility criteria included a diagnosis of MLBCL or CHL based on
mediastinal or neck node biopsy, with the mediastinal site being dominant area of the disease. Sixty six adult patients with MLBCL and CHL were treated at our institute between 1/1990 and 12/2005. Forty three patients were available for evaluation. 25 patients had CHL and 15 had MLBCL. The data was analyzed using chi square and log rank test.

**Results:** Patients with CHL were younger with a mean/median age of 29.4/24.8 years (range 10.2 – 58.0) compared with 39.4/34.5 (range 14.2 – 80.2) for patients with MLBCL (p = 0.027). Females comprised of 28% of CHL group and 46.7% of MLBCL group. CHL patients presented less dramatically with cough and chest pain (64%), compared with shortness of breath (60 %) in MLBCL group. All but one patient in CHL was clinical stage I/II, compared with MLBCL patients (stage I = 4, stage II = 7, stage III = 3, and stage IV = 1). The mean size of mediastinal mass was 8.8 cm (2.8 – 15.0 cm, n = 18) in CHL group compared with 10.1 cm (4.0 – 14.8 cm, n = 15) in MLBCL group (p = ns). Twenty-two patients with CHL received chemotherapy with ABVD, compared with standard CHOP +/- Rituximab for 14 MLBCL patients. Involved field radiation was used in 22/25 patients with CHL and 8/15 patients with MLBCL. Overall survival was 5.2 years (range 1.0 – 13.1 years) for CHL and 5.3 years (0.8 – 11.4 years) for MLBCL (p = 0.0053). Four patients with MLBCL died at 1.7 – 3.6 years. Eight patients (5 with CHL and 3 with MLBCL) relapsed, which was uniformly in the mediastinum. All of these patients were salvaged (to-date) with second line chemotherapy and transplant.

**Conclusions:** Patients with MLBCL and CHL with mediastinal dominance have an excellent prognosis. Despite their shared molecular/pathologic similarities, they differ slightly in their demographics and clinical presentation.

**23 Fiducial Placement for Robotic Stereotactic Radiotherapy of Pulmonary Tumors: The Waukesha Memorial Experience**

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**Purpose:** To report our experience with metallic fiducial implantation in lung tumors to be treated with robotic stereotactic radiotherapy.

**Materials and Method:** Patients with early stage lung cancer, recurrent lung cancer, or solitary pulmonary metastasis were implanted with gold fiducials and metallic coils. All implantation was either transcutaneous with computer tomographic guidance (CT) or transbronchial using the superDimension/Bronchus system.

**Results:** From July 2007 to August 2008, a total of 44 patients were implanted with metallic fiducials. The number of fiducials used for each patient varied according to the size of the lesion, ranging from 1-3 fiducials per lesion. Implantation was performed transcutaneously in 23 patients and transbronchially in 21 patients. 2 patients (10%) who underwent transbronchial implantation developed pneumothorax, compared to 10 patients (43%) who developed pneumothorax with transcutaneous implantation. 3 patients (14%)
had fiducial migration after transbronchial implantation, compared to no migration with transcutaneous implantation.

**Conclusion:** Transbronchial fiducial placement with the superDimension/Bronchus system is less invasive and associated with less pneumothorax rates than transcutaneous fiducial placement. Although most fiducial placements have been stable, there appears to be a higher migration rate with transbronchial placement compared to transcutaneous.

24 **Dosimetric Predictors of Pharyngoesophageal Stricture Requiring Dilation in Patients with Squamous Cell Carcinoma of the Head and Neck**

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**Purpose:** Esophageal stricture is a significant source of late morbidity in patients receiving definitive radiation for squamous cell carcinoma of the head and neck. Recent evidence suggests that IMRT-mediated dose constraints on swallowing structures may diminish late dysphagia. We sought to examine the risk of pharyngoesophageal stricture as a function of dose distribution utilizing a large retrospective database.

**Methodology:** A database of 252 patients treated definitively with radiotherapy from 2001 – 2006 at the University of Alabama-Birmingham was queried. Patients were excluded if they were previously treated for head and neck cancer, had developed a local recurrence, had less than 12 months of follow-up, were treated with conventional fields, or were without CT-based treatment plans. 67 patients remained for analysis. Each patient's swallowing structures were contoured including: (1) the soft palate, (2) base of tongue, (3) larynx and supraglottis (GSL), (4) pharyngeal constrictors as one structure (PC), (5) pharyngeal constrictors separately as superior (SPC), middle (MPC), and inferior pharyngeal constrictors (IPC), and (6) esophagus. Pharyngoesophageal stricture was defined as present if patients required dilation at any point after definitive radiation. Logistic regression was used to examine the relationship between the mean dose to each swallowing structure and the risk of stricture. For each structure, the volume V receiving D dose (V_D) was examined in 5 Gray (Gy) increments for significant association with stricture.

**Results:** At a median follow up of 23 months, twelve strictures had developed. On univariate analysis, only mean dose to the MPC was significantly associated with pharyngoesophageal dilation (p=0.05); no strictures occurred if the mean dose was less than 68 Gy. Mean dose to the PC exhibited a trend towards statistical association (p=0.08), while mean doses to all other structures were not significant. The V_70 of the MPC was also significantly associated with stricture (p=0.04); only one stricture occurred if the V_70 was below 61.6%.

**Conclusions:** These results suggest that constraining mean dose to the MPC, and potentially the PC, may decrease the probability of pharyngoesophageal stricture; of note, no strictures developed if mean dose the MPC was less than 68 Gy. Dose volume analyses also indicate that only one stricture occurred if the V_70 of the MPC was below 62%. Together, these data suggest potential constraint thresholds that may diminish the risk of late pharyngoesophageal stricture.

25 **Characterization of a prototype GRID compensator for spatially fractionated radiation therapy**
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**Purpose:** Spatially fractionated GRID therapy is utilized to treat large tumours by irradiating the volume through isolated small openings. The technique has shown high efficacy for bulky tumours receiving doses of 10 to 20 Gy in a single fraction. Although the results are promising, the number of institutions practicing GRID therapy is few. The difficulty lies in mounting and dismounting the GRID from the collimator, creating a GRID block that follows the beam divergence, and the lack of understanding of the biological mechanisms behind GRID therapy. In this study, we exploit the use of a prototype GRID made of brass, which if implemented clinically, could make GRID therapy more attractive to physicians and more widely available to patients.

**Methodology:** A prototype GRID compensator was constructed by milling a cube of brass, by .decimal Inc. (Sanford, Florida). The GRID block is manufactured so that it can irradiate a maximum field size of 25x25cm\(^2\), and can be placed in the same location as a regular solid IMRT compensator. Measurements for the characterization of the dosimetric properties of the GRID were performed using a Varian 23Ex linac. The measurements were performed for both energies available: 6MV and 18MV. All measurements were performed in a solid water phantom placed so that the source to surface distance (SSD) was 100.0 cm. Kodak EDR2 films were placed in the phantom at the depths of \(d_{\text{max}}\) 5.0 cm and 10.0 cm, perpendicular to the beam axis to obtain lateral profiles. Another set of film measurements was performed with the films parallel to the beam axis, to find the percent depth doses (PDDs). An ion chamber located underneath the central hole was used to find the output factors of various clinically applicable field sizes, by moving the x and y jaws; and ultra thin TLDs were used to estimate the skin dose.

**Results:** The profiles have an obvious peak and valley pattern, with transmissions through the solid portion of the block of approximately 15% for 6MV and 30% for 18MV. The skin doses measured are higher than for the open field, but are essentially the same between 6MV and 18MV. The PDDs are less penetrating than their open-field counterparts, for both 6MV and 18MV.

**Conclusions:** This prototype brass GRID compensator is a viable alternative to the cerrobend compensators or MLC-based fields currently in use. It’s ease of creation and use give it decided advantages. Its ability to be used universally, by varying the collimation of the linac jaws, makes it attractive from a cost perspective. We believe this compensator can be put to clinical use, and will allow more centers to offer GRID therapy to their patients.

26 Reduction of Hematological Toxicity by Intensity Modulated Radiation Therapy (IMRT) During “Sandwich” Protocol Carboplatin and Paclitaxel Chemo-Radiation Therapy in the Treatment of Uterine Papillary Serous Carcinoma (UPSC)

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**Purpose:** The use of combination chemotherapy and radiation therapy (RT) has improved patient outcomes in uterine papillary serous carcinoma (UPSC), although with substantial
acute treatment toxicity. The development of IMRT in recent years has allowed for improved normal tissue sparing during RT, providing good local control with the potential for reducing toxicity. Our institute has initiated a “sandwich protocol” for the treatment of UPSC, consisting of chemotherapy with carboplatin and paclitaxel, administered both before and after RT (CT sandwich). Herein, we retrospectively compared the hematological toxicities during CT sandwich chemotherapy after IMRT vs. 3D-conformal RT (CRT) in the treatment of UPSC.

Methodology: We reviewed the records of 49 pts with UPSC that were accrued to the IRB-approved “sandwich” protocol at our institution between 11/2000 and 11/2007. All patients underwent surgical staging followed by adjuvant chemo-RT. Chemotherapy consisted of paclitaxel (175 mg/m²) and carboplatin (AUC=6.0, 6.5, 7.5) every 21 days for 2-5 cycles each before and after RT. In 10/2005, the protocol was amended to change RT delivery from CRT to IMRT. The worst toxicity grade during post-RT chemotherapy for leukopenia (WBC), neutropenia (ANC), anemia (Hb), and thrombocytopenia (Plts) was recorded for each pt according to RTOG Common Toxicity Criteria. Toxicities between treatment cohorts were compared using Fisher’s exact test.

Results: 21 pts received CRT and 27 received IMRT. 3 (14%) CRT pts and 2 (7%) IMRT pts were treated to extended paraaortic lymph node fields for lymph node involvement (p=0.64). 17 (81%) CRT pts and 28 (100%) IMRT pts received intracavitary HDR brachytherapy (p=0.028). Patient characteristics were similar between cohorts. All pts completed their prescribed course of RT. 10/28 pts who received IMRT experienced Grade 3 or 4 neutropenia, compared with 16/21 pts who received CRT (76.1% vs. 35.7%, p=0.009). No differences in the incidence or severity of leukopenia, anemia or thrombocytopenia were observed between the IMRT and CRT treatment groups.

Conclusions: Patients who received IMRT experienced significantly less neutropenia during post-RT chemotherapy than pts who received CRT. Our results suggest that the reduction in dose to bone marrow by IMRT may decrease the risk of hematological toxicity during post-RT chemotherapy in the treatment of pts with UPSC. Further investigation in other concurrent chemo-RT and sequential RT-chemotherapy treatment regimens is warranted.

27 Developing a new gamma evaluation index with biological information of organs

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Purpose: Developing a new gamma evaluation index (gamma plus) to more effectively describe the quality control of IMRT treatment by considering biological effective uniform dose (BEUD) information.

Methodology: A gamma index proposed by Low et al.[1, 2] has been used to evaluate the physical dose delivery and spatial discrepancies between the treatment planning system (TPS) and practical treatment. It does not, however, consider the important biological information of organs, which can be described as biological effective uniform dose (BEUD) concept proposed by Mavroidis et al.[3]. We proposed a gamma plus index by adding BEUD concept to extend the existing gamma index. A Matlab computer code was developed to compare the 2-D delivered dose distributions for a 2-D test pattern by considering BEUD concept. We also calculated the gamma plus index for one clinical case,
in which the film dose distributions acquired in a solid water phantom were compared to the planar doses exported from Pinnacle Treatment Planning System (TPS).

**Results:** Our 2-D test pattern calculation not only gives similar results as the gamma index does, but also shows difference from the gamma index. The difference comes from the consideration of biological dose information. With different treatment parameters in the clinical case, such as dose per fraction, the gamma plus index will change its values, which imply the treatment outcome information has been included.

**Conclusion:** Gamma plus index combined with BEUD concept shows its advantages on quantitative evaluations of the dose distributions. It could get better quality control of IMRT treatment because it incorporates the information of treatment outcome and biological dose of organs.


28 Ewing Tumors of the Head and Neck

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**Purpose:** Retrospective review describing the 40-year University of Florida experience treating Ewing tumors of the head and neck region with review of the pertinent literature.

**Patients and Methods:** Nine patients were diagnosed and treated for Ewing sarcoma of the head and neck at our institution between 1965 and 2007. Primary sites included mandible (3 patients), calvarium (2 patients), paranasal sinus (2 patients), oral cavity (1 patient), and the extrasosseous soft tissue of the neck (1 patient). Mean age at diagnosis was 13.7 years (range, 6.3-20.1 years). Median observed follow-up was 10.2 years (range 1.5-37 years).

**Results:** All patients received multi-agent chemotherapy and radiation therapy to a median dose of 55.8 (range 36 to 67.2 Gv). Three patients also underwent wide local excision. The actuarial 10 year overall survival, cause-specific survival, event-free survival, and local control probabilities were 66%, 66%, 56%, and 89% respectively. Late complications included poor dentition, mild xerophthalmia, cataract, and mandibular hypoplasia. A literature search revealed eight previous series with Ewing tumors of the head and neck analyzed as subsets of larger studies.

**Conclusions:** Combined modality therapy provides excellent local control with reasonable acute and late toxicity. Radical surgery may be avoided with preoperative or definitive radiation therapy.
29 Analysis of rectal bleeding risk with hypofractionated radiation therapy for clinically localized prostate cancer.

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Purpose/Objective: A low alpha/beta, improved localization and more precise delivery of modern radiation therapy have renewed interest in hypofractionated radiation therapy for prostate cancer. In 2002, we began treating patients with 70 Gy at 2.5 Gy/fraction and reviewed our experience to perform a detailed analysis of the risk for rectal bleeding, the most common dose limiting toxicity.

Materials/Methods: From 2002 to 2007, 179 patients were treated. All patients received 70 Gy in 28 once daily fractions of 2.5 Gy to the prostate plus a 5mm PTV margin with a rectal balloon in place using Tomotherapy (87 pts) or Linac-based IMRT (92 pts) with daily image guidance (MVCT or U/S, respectively). In addition, 37 pts simultaneously received 56 Gy at 2 Gy/fraction to at risk nodal volumes according to our high-risk dose escalation protocol. CTCAE v3.0 was used to assess all rectal toxicity.

Results: We reviewed 149 consecutive patients with sufficient follow-up (median follow-up 26 months; maximum 65). Rectal bleeding was the most common late GI toxicity observed. The cumulative incidence of grade 2 rectal bleeding at 3 years follow-up is 15%. There was no grade 3 toxicity. One patient developed grade 4 rectal bleeding in the setting of a supratherapeutic INR = 7. Within our cohort, 31 patients were taking Warfarin and/or Plavix. The 3 yr. actuarial grade > 2 rectal bleeding for anticoagulated patients is 46% vs. 16% in those not taking anticoagulants, HR 2.5 (95% CI 1.1-7.2; p = 0.03). Among 118 non-anticoagulated patients, the 3 yr. actuarial grade > 2 rectal bleeding for those taking daily aspirin (51 pts) is 20% vs. 13% for those who do not, HR 1.1 (95% CI 0.37-3.4; p = .84). Analysis of our high-risk patients reveals V70 > 10% increases the risk of bleeding to 50% vs. 9.1% for lower exposed volumes, HR 3.3(95% CI 1.0-15.2; p=0.048). At the time of last follow-up, 75% of anticoagulated patients and 90% of non-anticoagulated patients had achieved resolution of rectal bleeding either spontaneously or after simple cautery.

Conclusions: To our knowledge, we provide the first compelling evidence that daily aspirin therapy does not statistically increase the risk for rectal bleeding. As observed with conventional fractionation, anticoagulation significantly increases the risk of rectal bleeding and patients should be counseled accordingly. Although useful for prostate immobilization, the use of a daily rectal balloon does not appear to decrease rectal injury in comparison to historical controls.

30 Re-irradiation for Post-lumpectomy In-breast Tumor Recurrence with Minimum Ten Year Follow-up

Melvin Deutsch¹, ¹University of Pittsburgh Medical Center, United States

Purpose: In-Breast Tumor Recurrence (IBTR) following lumpectomy and breast irradiation for carcinoma of the breast is most often managed by mastectomy. A repeat lumpectomy followed by a repeat course of high dose partial breast irradiation has been offered to women who present with an IBTR following lumpectomy and breast irradiation and wish to
avoid mastectomy. This is a report of the first twenty-six women treated, all of whom have had at least a ten year follow-up from re-treatment.

**Methodology:** Twenty-six (26) women presented with an IBTR after lumpectomy and whole breast irradiation for carcinoma of the breast. All had received at least 50Gy to the breast. The interval from the end to the first course of radiotherapy to the IBTR was 16-189 months (median 49.5 months). All patients had a repeat lumpectomy and 25 received an additional 50Gy in 25 fractions to the new operative area using electrons of appropriate energy. One patient discontinued therapy at 32Gy for non-medical reasons. At the initial surgery, 23 patients had invasive carcinoma and 3 had ductal carcinoma in situ (DCIS). The IBTR was invasive carcinoma in 21 patients and DCIS in 5 patients.

**Results:** With at least ten years follow-up following completion of the second course of radiotherapy there have been 9 (34.6%) subsequent IBTRs. Among the 20 patients who initially had negative lymph nodes, 6 developed a subsequent IBTR and 4 continue to be alive and free of disease following mastectomy. Two of the six with a subsequent IBTR also developed distant metastases and died. Of the 6 patients who initially had involved axillary nodes, 5 developed distant metastases and 3 also had another IBTR. All 5 died of metastatic cancer. The sixth patient died free of disease sixty-three months from completion of radiotherapy for the IBTR. There have been no serious sequelae from the repeat course of radiotherapy. The absolute ten year overall survival for the entire group, including two patients who initially had suspicious bone scans, 65.3%.

**Conclusions:** A repeat course of high-dose partial breast irradiation (50Gy/25 fractions) after repeat lumpectomy appears to be an acceptable alternative to mastectomy for selected patients with an IBTR after prior lumpectomy and breast irradiation.

**31 Solid Modulated Accelerated Radiation Therapy for Breast Conservation**

Theodore Yaeger, Nancey Cost, Wake Forest University, United States

**Background and Purpose:** Accelerated partial breast irradiation is being studied for the treatment of early stage breast cancer conservation. The purpose of this presentation is to introduce a modification to standard external beam techniques. The authors describe a regimen treating with intensity modulated radiation therapy (IMRT) that allows concurrent partial breast irradiation (to the seroma cavity) with conventional whole breast prophylaxis. This technique concurrently treats the whole breast and the lumpectomy seroma with a shortened course by using beam modulated IMRT.

**Materials and Methods:** Patients with stage 0, 1 or early 2 breast cancers were planned for both conventional tangents to separate boost and IMRT. Patient plans that developed improved dose homogeneity with IMRT were treated with beam modulation. Patients without any dose advantage from IMRT were treated with conventional half-beam blocked tangents to enface or reduced field tangents boost. The populations were compared for treatment tolerance and outcomes.

**Results:** 33 patients were treated for breast conservation. 17 were given IMRT and 16 conventional radiation with 3-D planning. After a total of 2.5 years of follow-up no patient had developed a local or global failure. However, the treatment tolerance differed greatly. Approximately 50% of the conventionally treated patients developed treatable skin reactions; two of them required dose modification. Only one patient getting IMRT needed
skin care. No patient on the IMRT arm developed breast edema of any kind and at the first
month of follow-up completely resolved any reactions. In contrast, nearly all patients in the
conventional arm developed at least areola edema, some global edema. The global edema
usually took at least 3 months to resolve with a few patients showing permanent areola
edema and long-term skin pigmentation. Both groups had similar demographics, stage
distributions and prescribed doses.

Conclusions: Solid Modulated Accelerated Radiation Therapy (SMART) is a useful form of
IMRT delivery that has similar tumor control probabilities. For larger volume patients it
significantly enhances treatment tolerances with acceptable cosmetic outcomes. Thus far,
it has proved to be a shortened course, non-invasive alternative for low nodal risk early
stage breast cancer patients seeking conservation therapy.

32 Megavoltage CT simulation as an alternative to conventional CT when metallic
artifact is severe: Comparison of two TomoTherapy planning methods

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Purpose: To compare two treatment planning techniques (Tomo Plan vs. StatRT) on a
patient with substantial spinal metallic hardware to determine advantages/disadvantages of
the two approaches and to evaluate the utility of MVCT-based simulation for treatment
planning when metal artifact is severe.

Materials/Methods: A patient with metastatic non-small cell lung cancer involving the
thoracic spine underwent treatment planning CT simulation. The degree of metal artifact
due to stainless steel spine-stabilizing rods was too severe for treatment planning despite
attempts to correct by density override. The patient was then re-simulated using 4MV
megavoltage CT (MVCT) on a TomoTherapy unit. Plans were generated using conventional
TomoTherapy planning and StatRT.

Results: The MVCT simulation demonstrated much less metallic artifact and provided
enough detail for patient positioning, contouring and treatment planning. Full scatter mode
with a total of 5 iterations was used for the StatRT plan in a shorter planning window
(<10min). DVH analysis revealed that the two planning methods yielded comparable results
for max/min/avg doses to heart, lungs and CTV’s. There was a noticeable “thread artifact”
visible at the 105% dose level with the StatRT plan (possibly due to the limited number of
iterations for optimization). Treatment time was 376 sec with conventional planning and 203
sec for StatRT.

Conclusions: MVCT-based simulation may be advantageous when conventional CT is
unintelligible because of severe metal artifact. Either StatRT or Tomo planning can be used
in such situations. Radiation dose distributions from StatRT planning appear comparable to
TomoPlan, except for a thread artifact at the 105% dose level. StatRT appears to be a
feasible treatment planning tool for physicians to scan, contour and treat patients within one
hour, even in challenging cases where metallic artifact is severe.

33 Initial clinical experience with pulsed reduced dose-rate radiotherapy on a helical
tomotherapy unit

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**Purpose/Background:** To investigate the feasibility of using helical tomotherapy (TomoTherapy) for pulsed reduced dose-rate radiotherapy (PRDR) re-irradiation. PRDR has become a useful method of re-irradiation because of its potential to reduce late normal tissue toxicity while yielding nearly identical tumoricidal effect. A typical technique using a conventional linac is to deliver a series of 20cGy pulses separated by 3-minute intervals to give an average dose-rate of 6.67cGy/min. Unlike a conventional linac, TomoTherapy PRDR wouldn’t require the 3 min interlude between fractions if the sub-fraction time is approximately 3 min, since the top of the PTV will have had a 3 minute “rest” by the time the bottom is finished. The TomoTherapy unit is commissioned to deliver 850cGy/min to the machine isocenter. Due to intrinsic MLC leaf open time (LOT) limitations, the dose volume histogram (DVH) can be significantly degraded when attempting to deliver very low doses such as 20-40 cGy. We investigated various means of overcoming this limitation in an effort to deliver PRDR with a TomoTherapy device.

**Method and Materials:** Five plans were generated with different combinations of jaw width, pitch, and modulation factor (MF) to administer eight 25cGy sub-fractions as part of a 2Gy fraction to the axillary PTV. The total planned dose was 40Gy. Plans were compared using DVH, homogeneity indexes (HI), treatment time and dose-volumes to normal tissues. DQA for each plan was performed to assess deliverability.

**Results:** Significant DVH degradation occurred below 40cGy with a large jaw, medium MF and small pitch combination. With medium jaw, small MF, and medium pitch (0.43), we obtained a clinically acceptable DVH. However, a 7% dose discrepancy was noted on ion chamber measurements with this combination. Analysis of sinogram files revealed an average LOT of 40msec in this plan with most of the LOT falling into the high relative error region in the MLC latency curve. Our comparisons show that the combination of small jaw width (1cm), small MF (1.5), and large pitch (0.86) gives the best results for dose distribution, beam-on time, and delivery accuracy. With this combination, the dose discrepancy was reduced to 3% on ion chamber measurements. The 25cGy subfraction delivery time was 3.0 min with this combination.

**Conclusion:** With a careful selection of planning parameters, clinically acceptable PRDR is deliverable on a TomoTherapy unit when the target is not located at the central line of the body. Further investigation is ongoing to expand the clinical applicability of this technique.

34 Uncertainty Due to Detector Size and Position in the Measurement of Asorbed Dose with a Fricke Dosimeter

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**Purpose:** To determine the uncertainty in the measurement of the absorbed dose using a Fricke dosimeter due to its size and position away from an HDR source.

**Materials and Methods:** Measurements were done using a Nucletron Classic HDR unit loaded with an Alpha Omega $^{192}$Ir source. A PTW MP3 water phantom and associated Mephisto Mc² software was used to scan a diode (PTW TN60008) and two ionization chambers (Exradin A16 and PTW TN310310) at distances of 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 cm away from the source. The $^{192}$Ir source was positioned in a catheter and the catheter...
was inserted in a rigid plastic pipette which was hold in position by a clamp system. Each detector was mounted in the scanning system and centered in the direction along and perpendicular to the source by scanning the detector in each plane and centering the coordinate system of the scanning system to the profile center. Measurements away and perpendicular to the source at 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 cm were done. These measurements were plotted for each detector and an offset distance was found to correct for distances away to the source. The uncertainty in the relative positioning of the HDR source was determined to be 0.1 mm. The total uncertainty in determining a given HDR source position in relation to the Fricke device is 0.5 mm.

**Results:** There is an influence of the detector size in the determination of the profile away from the source in the two directions. The smallest detector size is the diode detector and the profiles at 1 cm away from the source was used to determine how much averaging of the dose would happen if a 3 mm height and 1 mm width cylindrical detector around the $^{192}$Ir source is used fill with Fricke solution. We also determined the uncertainty in the Fricke dosimeter based on the repositioning uncertainty of the $^{192}$Ir source. The same study was done at 2.5 cm away from the source.

**Conclusion:** The uncertainty in the measurement of the absorbed dose due to the averaging effect is 1.3 % at 1 cm away from the source. The uncertainty in the measurement of absorbed dose due to the source repositioning is 0.5 % at this distance. If the distance of measurement is done at 2.5 cm these two effects are 0.47 and 0.22%. Based on these findings we proposed that the measurement of the absorbed dose from a $^{192}$Ir source be measured at 2.5 cm away from the source to minimize uncertainties due to the detector size and repositioning accuracy. We also suggest that the dose distribution around the source be normalized at this point instead of 1 cm as is currently defined by AAPM TG-43.

35 Radiotherapy for Chest Wall Recurrence After Mastectomy for In-Breast Tumor Recurrence (IBTR) Following Lumpectomy and Breast Irradiation

Melvin Deutsch¹, ¹University of Pittsburgh Medical Center, United States

**Purpose:** To evaluate radiotherapy for recurrent cancer on the chest wall after mastectomy for in-breast tumor recurrence (IBTR) following lumpectomy and breast irradiation.

**Methodology:** Over the past six years, seven women were treated to the chest wall for local recurrence following mastectomy for IBTR after lumpectomy and breast irradiation. All initially were treated with lumpectomy +/- axillary dissection followed by 50Gy/5 weeks to the whole breast and 4 also had a 10Gy/1 week boost to the operative area. The interval from lumpectomy to mastectomy for IBTR was 20-250 months (median 120). The mastectomy specimen revealed extensive cancer in only one patient. Two patients had just ductal carcinoma in-situ (DCIS) and another had a 5 mm invasive carcinoma. The three other patients had IBTR tumors $< 2.3$ cm. The interval from mastectomy for IBTR to recurrence on the chest wall was 3-144 months (median 24). The chest wall recurrences were treated with 60-70.4Gy (median 66Gy at 2Gy/day).

**Results:** From completion of the chest wall irradiation, 4 patients are alive free of disease at 3, 20, 42, and 106 months respectively. One died at 22 months with uncontrolled local recurrence and distant metastases. One had another recurrence on the chest wall at 64 months and is alive with disease at 71 months and one is alive at 59 months, status of
disease unknown. There were no serious acute or late effects from the repeat course of radiotherapy.

Conclusions: Radiotherapy to the chest wall for local recurrence post-mastectomy is well tolerated, effective, and indicated even in those patients who have had prior lumpectomy and breast irradiation.

36 Brain Metastases in Non Small Cell Lung Cancer: Results of Radiosurgery (RS) in 328 Consecutive Patients

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Purpose/Introduction: Brain metastases are a common complication in cancer patients and an important cause of morbidity and mortality. The purpose of the study is to evaluate our results with radiosurgery, in the management of brain metastases from non small cell lung cancer in an unselected group of patients.

Materials and Methods: From October 1993 through September 2007, three hundred twenty eight consecutive patients with brain metastases from Non Small Cell lung cancer were treated with Gamma Knife radiosurgery (RS) independent of primary status. The rationale of treatment was to improve survival and quality of life. There were 166 males and 162 females and a total of 594 treatments were given. One hundred and sixteen patients (35%) presented with a single metastasis and up to 22 metastases were treated in a single treatment session. There were 2241 metastases treated with an average of 6.8 metastases per patient. Twelve percent of the patient population had at least one site retreated. Mean minimum dose was 15.8 Gy with a mean maximum dose of 30.2 Gy. The median prescription dose was 16 Gy. The average number of treatment shots was 5.5.

Results: Of the 282 evaluable patients 258 (91%) died of causes other than brain metastases. Twenty three patients are alive with a median follow-up of 12.3 months with a range of 0.7 to 134 months. The Kaplan-Meier estimate of median survival after RS was 7.0 months. Although the Log-rank statistic (p=0.03) did not provide conclusive evidence that the survival curves of patients presenting with single versus multiple metastases were different, the relative expiration rate was more favorable (< 1) for those patients presenting with a single metastasis (HR=0.73 with 95% confidence interval of 0.65-0.82).

Conclusion: Patients with brain metastases from lung cancer treated with radiosurgery can achieve improved survival and excellent local control independent of the primary status. Improved survival is weakly indicated in patients presenting with single versus multiple brain metastases. RS is an effective treatment option as seen in our experience.

37 Radiation exposure to personnel during interstitial prostate brachytherapy I-125 seed implantation

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Prostate adenocarcinoma is the most common malignancy and the second most common cause of death from cancer among American men. Permanent implantation of Iodine-125 (I-125) seeds (interstitial brachytherapy) has become an increasingly common method of
treatment for certain types of prostate cancer. It is logical to question whether radiation exposure to operating room personnel is on the rise as the number of prostate brachytherapy procedures performed increases. An acronym for an important principle in radiation safety is ALARA, which stands for “As Low As Reasonably Achievable.” The purpose of this study is two-fold: it aims to quantify the radiation exposure to personnel and also seeks to find ways to minimize such exposure if it is found to be significant. We placed sterilized thermo-luminescent dosimeters (TLDs) over the gonadal area, thyroid and finger of several members of the operating room team in an attempt to measure the radiation exposure in these radio-sensitive areas during several brachytherapy procedures. We distinguished radiation exposure resulting from seed implantation from that resulting from other radiation sources, most notably fluoroscopic imaging, by removing the TLDs from the room during its use. Our results indicate that exposure resulting from I-125 seeds to operating room personnel is not significant at our institution. That being said, it is still reasonable to utilize practical methods to reduce exposure as much as possible including the wearing of lead shielding aprons (including thyroid collars), limitations on the number of personnel in the room during implantation and reductions in procedural time.

38 What is an adequate radiation therapy quality assurance in phase III clinical trials?

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Background: One of the major challenges in clinical trials involving radiation therapy (RT) is to identify and correct protocol treatment deviations on a timely basis. Since variation in treatment delivery may impact outcomes such as disease control, toxicity and quality of life, the RT quality assurance (RTQA) then becomes of paramount importance to ensure that any outcome differences (or lack of) are due to the treatments as defined in the protocol. The objective of this study is to review the existing use of RTQA, the manner in which it is reported, and its reported impact on protocol deviations. Based on the findings a minimum acceptable RTQA will be recommended.

Material and Methods: We used PubMed (www.pubmed.org) as the Internet search engine. The original search phrases were: radiation therapy or radiation oncology. We limited the search to human, English language, randomized clinical trials over a period of 10 years, 1996-2006. This search identified 2156 articles. The search phrases were then modified to radiation therapy and quality assurance or radiation oncology and quality assurance using the same limitations. This resulted in 95 articles. We excluded all articles that were not based on a randomized phase III clinical trial and those involving intensity modulated radiotherapy or brachytherapy. This resulted in 27 articles.

Results: The 27 identified articles addressed the RTQA of a total of 21 phase III randomized clinical trials. In 14 of the 21 phase III trials, the primary question under investigation was that of radiation therapy, i.e. dose escalation, target volume, and RT efficacy. Six trials investigated the role of chemotherapy or hormonal therapy with RT and one the role of hyperthermia with RT. A standardized “dummy run” and/or survey questionnaire was the most common form of RTQA performed - 11 trials (52%). Of these, 5 (45%) trials mandated RTQA for all centres and prior to study initiation. Only 3 trials mandated a real time review (RTR). Of these, 2 required approval of the plan prior to the start of RT, and one within 3 days of the treatment. In 4 (19%) trials the RT plans of a selected number of patients were reviewed either during or after the study was closed as
the sole means of RTQA. There appeared to be no pattern regarding the type of RTQA and the nature of the study question: radiation versus other.

Table 1. Radiation Variable and Range of Reported Rates of Non Compliance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dose</th>
<th>Prescription Point</th>
<th>Fractionation</th>
<th>Inhomogeneity Within the PTV</th>
<th>PTV coverage</th>
<th>Contouring Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Studies</td>
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<td>5</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Range (%)</td>
<td>3-44</td>
<td>9-22</td>
<td>3-18</td>
<td>6.6-50</td>
<td>12-67</td>
<td>45-93</td>
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<tr>
<td>Median (%)</td>
<td>15</td>
<td>16</td>
<td>8</td>
<td>22</td>
<td>35</td>
<td>50</td>
</tr>
</tbody>
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Of the 21 reviewed articles, only 9 reported on the impact of their RTQA: 100% of those using RTR and 28% of the remaining methods. For the RTR, the various deviations captured and corrected in a time sensitive manner ranged from 59 to 100%. For the remainder of the methods, the range of correction varied from 44 to 60%. In 2 studies, RTQA led to protocol amendments.

Conclusion: Based on the available literature an adequate RTQA process is feasible in trials involving RT. It is effective in capturing issues stemming from protocol ambiguity and protocol noncompliance. Substantial protocol deviations are reported as being captured by RTR, making it a preferred approach where feasible. For the trials posing a RT question, an appropriate RTQA process including RTR is desirable. On the other hand, trials where RT is the primary treatment but not the primary question a more simplified RTQA process including a "dummy run" with or without survey questionnaire may be sufficient.

39 Intensity Modulated Radiation Therapy versus Three Dimension Conformal Therapy with Concomitant Chemotherapy in Advanced Stage Hypopharyngeal and Laryngeal Cancer

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Purpose: To compare toxicity and patterns of failure for consecutive patient’s undergoing 3DCT versus IMRT.

Materials/methods: We retrospectively reviewed 65 advanced stage (III or IV) laryngeal (n=42) and hypopharyngeal (n=23) cancer patients who received definitive 3DCT (n=24) or IMRT (n=39) at Montefiore Medical Center from June 2002 through November 2007. No post laryngectomy patients were included in this study. Stage (p=.14), average age (3DCT 55 yrs vs. IMRT 58yrs (p=.3), sex (male 66% vs. 60% p=.3) were similar in both groups. The 3DCT group displayed a non significant trend of improved KPS (≥90) (p=.07), and more hypopharyngeal patients (45% vs. 30%) (p=.08). 3DCT patients received 74.4 Gy/1.2 Fx BID, while IMRT consisted of 69.96 Gy at 1.8 Fx for CTV and 2.12 Fx to PTV through concomitant boost. 91% of the 3DCT received concurrent chemotherapy compared with 85% of the IMRT group. In the 3DCT 41% received cisplatin and 37% received
5fu/carboplatin, and in IMRT group 65% received cisplatin. The RTOG common toxicity scale was used to assess short term toxicity. The two sided student t test was used for comparing toxicity and the Kaplan Meier analysis was used for long term follow up.

**Results:** The average percent weight loss was 11% (STD±.5%) in 3DCT versus 10% (STD±.5%) in IMRT group (p=.63). The incidence of acute grade ≥2 xerostomia was higher in the 3DCT group (65% vs. 20% p=.02) as was acute grade 3 dermatitis (15% vs. 0% p=.0004). No difference was noted in acute grade ≥2 dysphagia (p=.94). A non significant trend was noted for an increased grade ≥2 mucositits for IMRT (p=.08). The mean, and median follow up was longer for the 3DCT at 34.6 months (±24 months) and 31.3 (range 72 to 3.8) versus the IMRT group of 11.2 months (±8.6) and 8.06 months (range .57 to 34). 6 patients in the IMRT group had residual disease vs. 1 in the 3DCT group. All 6 patients had either substandard dose (mean 65 Gy) or increased length of treatment (mean 104 days). The disease free survival was 41% in 3DCT vs. 38% in the IMRT group p=.4 (HR 1.35 CI .64 to 2.94) The locoregional control was 68% for 3DCT vs. 80% for IMRT p=.96 (HR .97 CI .38 to 2.4).

**Conclusion:** This is the first known comparison of 3DCT vs. IMRT in advance stage laryngeal and hypopharyngeal cancer. A complete course of IMRT affords a decreased acute toxicity, and with this interim follow up, no loss in disease free survival or locoregional control was noted.

**40 Survival disparities in non-small cell lung cancer patients receiving radiation treatment: An investigation of race and gender**

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**Background:** Multiple studies evaluating non-small cell lung cancer disparities reveal male gender and African American race are independent predictors for poorer outcome. Studies postulate gender disparities may arise from biological differences, while racial disparities may be an issue of access to healthcare. This study aims to evaluate the prognostic factors affecting survival of non-small cell lung cancer patients receiving radiation treatment at the University of Washington hospitals and to investigate whether race and gender disparities persist at the level of access to radiation treatment.

**Methods:** A retrospective case review of 604 patients receiving radiation treatment for non-small cell lung cancer from 1994-2008 at any of the University of Washington hospitals was conducted. Race, age, stage at presentation, radiation treatment length, radiation treatment breaks, and length of time from initial diagnosis to death or last follow-up were recorded. Only those lung cancer patients who had all the preceding information in their medical records and who received the entirety of their radiation treatment at the University of Washington were coded – totaling 485 records.

**Results:** Of the 485 records, 79 patients had a lung malignancy other than non-small cell cancer and 34 patients did not have race coded in their charts – these records were not included in the study. Of a final 372 patients, there were 306 Caucasian, 32 African American, 34 Asian American and 134 female, 238 male patients. Cox regression models showed male gender [hazard ratio (HR, 1.34) p-value .027] and stage at presentation [stage
III: HR, 1.93, p-value .001, stage IV: HR, 2.46, p-value <.001] were significantly associated with shorter survival. In these analyses, race had no significant effect on length of survival.

**Conclusion:** In this study, racial survival disparity was not an issue for patients receiving radiation treatment. However, gender and stage at presentation were predictors for poorer survival. These results suggest disparate origins of race and gender inequity in non-small cell lung cancer outcome, highlighting that race differences in lung cancer survival disappear at the level patients have access to radiation treatment. This supports the notion that gender survival differences are likely the result of biologic differences, while racial survival disparities may be an issue of healthcare access – however, additional studies are needed to conclusively discern the etiology of these disparities in non-small cell lung cancer survival.

41 Small bowel-sparing radiation therapy techniques for vulvar cancer: a dosimetric study

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**Purpose:** Describe two small bowel sparing “split-field” pelvic radiotherapy techniques (SFRT), including “split-field” IMRT (SF-IMRT). Compare SFRT with traditional techniques regarding intestinal cavity (IC) and pelvic bone (PB) dose.

**Methodology:** CT simulation data sets from 5 pts with vulvar cancer were selected. Three types of plans were generated for comparison: 1) traditional AP/PA plans, with the superior border at L5/S1, targeting the vulva, bilateral inguinal, external iliac, and pelvic lymph nodes; 2) SF-4F plans, targeting the primary and lower pelvis with the same beam arrangement as the AP/PA plan, while treating the upper pelvis with a matched four-field beam arrangement, utilizing a half-beam block with the isocenter placed just above the acetabulum; 3) SF-IMRT plans, treated the primary and lower pelvis with the same beam arrangement as the AP/PA plan, while treating the upper pelvis with a matched IMRT plan, utilizing a half-beam block. SF-IMRT plans were optimized the cover the pelvic lymph nodes above the junction plus a 1 cm margin (PTV) while minimizing the IC exposure at all dose levels and PB dose in the low dose region. The target dose was 45 Gy for all pelvic plans. The mean relative volumes of IC and PB above the junction receiving varying doses were recorded and compared, by single-sided paired t-test, and PTV coverage was recorded for all plans.

**Results:** SF-4F allowed for IC sparing when compared to AP/PA in the higher dose regions (30-45 Gy). For example, SF-4F allowed for a 28.5% (p=0.007) mean reduction in the volume of IC receiving 45 Gy compared to AP/PA. SF-IMRT allowed for a more consistent and a greater magnitude of IC sparing compared to AP/PA and SF-4F all dose levels (5-45 Gy; p<0.05 for all). For example, SF-IMRT allowed for a 68.7% (p<0.002) and 56.6% (p<0.001) mean reduction in the volume of IC receiving 45 Gy compared to AP/PA and SF-4F respectively. SF-IMRT was able to provide PB sparing compared to AP/PA at all dose levels (5-45 Gy; p<0.05 for 15-45 Gy). SF-IMRT was able to provide PB sparing compared to SF-4F at all dose levels (5-45 Gy; p<0.05 for all). For example, SF-IMRT allowed for a 3.8% (p=0.14) and 16.3% (p<0.001) mean reduction in the volume of PB receiving 10 Gy compared to AP/PA and SF-4F respectively. PTV V95% was 100% for all plans.

**Conclusions:** While SF-4F spared IC from the higher dose regions compared to AP/PA,
SF-IMRT allowed for greater IC sparing at all dose levels when compared to AP/PA and SF-4F, without compromise of PB dose in the low dose region.

42 Control of Aggressive Fibromatosis Treated with Radiation Therapy.

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Purpose: To report the single-institution experience of patients with aggressive fibromatosis treated with radiation therapy (RT).

Methodology: Between the years 1996 and 2008, all patients with confirmed pathologic diagnosis of aggressive fibromatosis, whose treatment included RT, were evaluated retrospectively. Patients’ demographic information, including age and gender, the tumor location, the presence of prior surgery, and the use of radiotherapy were recorded and evaluated.

Results: We report on four patients (3 females and 1 male). The median patient age was 26 years (range, 15-28 years). The median time to follow-up was 18 months (range, 14-30 months). Tumor location was noted, respectively, in the right calf, right neck, right ankle, and right gluteal area. Surgical debulking was performed in one case (right neck), while three patients received RT as the only therapeutic modality. All patients received radiation therapy with a median dose of 52 Gy (range, 50.4-58.2 Gy). Excellent locoregional control with minimal toxicity was achieved in all patients. At follow-up, all patients were alive with minor or no symptoms from the disease.

Conclusions: Patients diagnosed with aggressive fibromatosis appear to be effectively controlled with RT administered either as primary treatment or as an adjuvant to surgery.

43 Tolerability of Salvage Daily Intensity Modulated Radiation Therapy in Recurrent Head and Neck Cancers, Previously Irradiated.

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Purpose: For patients that received comprehensive, full dose primary radiation therapy, salvage re-irradiation for recurrent disease has typically not been favored secondary to limited normal tissue tolerances. Intensity Modulated Radiation Therapy (IMRT) has the potential to allow full dose re-irradiation to the recurrent disease while limiting the lifetime dose to the critical normal organs. We report a retrospective review of our experience with the use of salvage IMRT in previously irradiated, recurrent head and neck cancer.

Methodology: 14 patients were identified with recurrent head and neck cancer between 2007-2008. All received comprehensive full dose radiation therapy in the past with a range of 57.4 – 73.8Gy. Recurrent disease was identified and treated at a median of 35 months (Range 14 – 156 months) after the primary treatment. All received salvage daily IMRT on a weekly basis, with 12 receiving concurrent chemotherapy. Median salvage re-irradiation dose to the primary disease was 66 Gy (Range 45 – 70Gy). 10 patients received traditional fractionation, 3 received radiation utilizing a simultaneous integrated boost technique, and one received twice a day radiation at 1.2Gy / Fraction. The PTV received 95% of the prescription dose to 95% of the volume while maintaining a median maximum dose to the
spinal cord of 8.8Gy (Range 4.2 – 13.7Gy).

**Results:** Two of fourteen (14%) patients developed acute grade 3 mucositis. Remaining acute toxicities were limited to ≤ Grade 2. Three of fourteen (21.4%) patients required treatment breaks secondary to acute toxicity during salvage re-irradiation. At a median follow-up of 2.5 months (Range 0-15 months), one patient developed pharyngeal stricture requiring dilatation, one developed a cutaneous fistula, and one developed dehiscence of a suture line with communication to the oral cavity. None of the other eleven patients (78.6%) developed ≥ Grade 3 sub-acute/long-term toxicity after salvage re-irradiation. Three of fourteen (21.4%) patients had persistent/recurrent disease as of last follow-up.

**Conclusions:** Concurrent chemotherapy with salvage daily IMRT utilizing traditional fractionation, twice a day fractionation, or simultaneous integrated boost technique are feasible salvage options in patients with recurrent head and neck cancer and result in significant but acceptable levels of acute/sub-acute toxicity. Lifetime radiation dose to critical normal structures such as the spinal cord can be affectively limited while maintaining prescription dose to the PTV. The effect on survival, local control, and quality of life appears promising, but long-term follow-up is needed to further quantify its effectiveness.

**44 Preserving Neural Stem Cell/ Choroid Plexus in SRS, FSRT, IMRT or 3DCRT Treatment for Intracranial Malignancies: A New Computer Assisted Strategy**

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**Purpose:** Progressive necrosis was more common in the periventricular white matter in our study of patients with brain metastases treated with stereotactic radiosurgery. This may be related to radiation tolerance or repair of specific cell types in this location e.g. neural stem cells, ependymal or subependymal cells and choroid plexus (NESC). Recently, neural stem cells have been shown to contribute to intrinsic brain repair and plasticity. Sparing these potentially important cells/structures may significantly reduce radiotherapy-related morbidity. This study examines the feasibility of defining the NESC as avoidance structures in the radiotherapy of intracranial neoplasms using a new hardware and software system (Anatom-e Information Systems, 2047 University Blvd, Houston, TX).

**Methodology:** Data from treatment plans of ten patients who underwent SRS, FSRT, IMRT or 3DCRT for treatment of intracranial neoplasms adjacent to NESC were used for simulated treatment planning. The Anatom-e system was used to illustrate the areas containing NESC. The resultant map was then overlaid on the patient images and the NESC-sparing treatment plans were created. Care was taken to ensure that PTV was not underdosed. The treatment planning did not require additional imaging or special expertise.

**Results:** The complete maps provided by this new computer program indicated the location of NESC, facilitating the creation of NESC-sparing treatment plans. These new plans were different when compared to the original plans without outlining these critical structures. In these simulated plans, the authors could reduce the dose administered to these areas or decrease the volume of these areas receiving high dose radiation. This approach was found to be feasible.
**Conclusion:** Consideration of NESC as avoidance structures is achievable using a new software and hardware program that offers a clear mapping of these areas. The resultant map may then be overlaid onto the patient image, indicating the expected location of these cells/structures. This information allows the creation of NESC-sparing treatment plan and may reduce the likelihood of radiation-induced necrosis or morbidity. In addition, this program will be useful in research on the radiation sensitivity and tolerance of NESC when delivering SRS/FSRT/IMRT/3DCRT for intracranial neoplasms.

**45 The Importance of Batson’s Plexus Anatomy in Modern Radiotherapy**

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**Purpose:** This communication illustrates the significance of Batson’s venous plexus in three areas of modern radiotherapy: 1. target volume for spinal SBRT, 2. the embolic complications of prostate brachytherapy and vertebroplasty and 3. metastatic spread via this plexus.

**Methodology:** The software and hardware computer system (Anatom-e Information Systems, 20247 University Blvd., Houston TX) was used to demonstrate Batson’s plexus, color coded on 134 normal axial CT images of the cervical, thoracic and lumbosacral spine. Four subcomponents of the system were defined: the internal vertebral venous plexus (anterior and posterior), the external venous plexus (anterior and posterior), the paired radicular veins and basivertebral venous plexus within vertebral body. Associated text boxes provide physiological information. They described the venous flow patterns and their proximal and distal communications. The role of the bidirectional “ebb and flow” in the direct spread of tumors is noted. The functional importance of the plexus in regulating intracranial pressure via suboccipital communications with the cranial sinuses and veins is described. The importance of the plexus components in draining the neural roots and spinal cord is also covered.

**Results:** Detailed axial CT images of the entire extent of Batson’s plexus allowed understanding of target volumes in spinal stereotactic radiation to include the pedicles and posterior spinal elements which are encased within the continuous valveless venous network of Batson’s plexus. To illustrate the clinical significance of Batson’s plexus, examples of extravagation of vertebroplasty cement and migration of prostatic seeds from the prostatic venous plexus into the Batson’s spinal plexus are shown. The clinical implications of these usually asymptomatic events are discussed. Techniques to prevent these complications by minimizing the flow into the plexus are discussed. These include prone positioning and anesthesia assisted elevation of the intrathoracic venous pressure during the procedure. The knowledge of this plexus also explained the metastatic spread of prostate cancer to the spine.

**Conclusions:** A detailed knowledge of vertebral venous anatomy impacts modern radiotherapy treatment planning and the interpretation of complications and metastatic spread of prostate cancer. The Anatom-e Information System makes information on this complex system readily available in a clinically useful axial CT format.

**46 Accurate Coding: Education Paves the Way to Success**
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**Purpose:** To assess the impact of coding education on coding accuracy and billing charges in an academic radiation oncology practice.

**Methodology:** Prior to the 2008-2009 academic year, the attending physician coded each visit and the resident dictated the note. This was identified as a source of inconsistency between the code the attending physician indicated and the level of coding the dictated note supported. As a result the residents began both dictating the note and coding the billing for each visit in 2008. The radiation oncology coding compliance coordinator conducted a coding seminar for the residents before this change took effect. The codes assigned by four attending physicians for consultation and follow-up visits in August 2007 were compared with the actual notes to establish baseline accuracy. The codes assigned by the residents on the same four attending physicians’ services in August 2008 were compared with the actual notes for accuracy. These comparisons were conducted by certified radiation oncology billing clerks.

**Results:** The coding and documentation for 110 consultation visits and 64 follow-up visits in August 2007 and 103 consultations visits and 175 follow-up visits in August 2008 were reviewed for accuracy. The average accuracy of coding for consults increased 16% after the coding seminar. Similarly the accuracy of coding for follow-up visits improved 13%. Overall average coding accuracy improved 14%. Improved coding accuracy of the sampled follow-up visits in August 2007 would have increased billing an average of $129 per visit.

**Conclusions:** Educating residents regarding the required elements for coding consultation and follow-up visits results in significantly improved accuracy and appropriately reflects the evaluation and management documented in the note. Improved accuracy in coding can significantly increase billing charges in an academic radiation oncology practice.

### 47 Skin dose measurements for compensator based IMRT compared to MLC delivery

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**Purpose:** During an IMRT treatment the energy of the primary beam can be a dominant factor determining the skin dose to the patient. Skin sparing during treatment is of high significance in order to avoid skin reactions to radiation treatment. Higher energies lead to better sparing of the skin tissues. The purpose of this study is to examine the effect of the beam hardening to the patients’ skin dose, during a compensator based IMRT treatment, compared to the two MLC delivery methods, step & shoot (SS) and sliding window (SW).

**Methodology:** Initially, two step-wedge plans were developed using Pinnacle® TPS, one using a compensator and one for SS MLC delivery. Both plans were planned delivered on a cubic solid water phantom and skin dose measurements were performed using ultra thin TLDs (3mm×3mm×0.1mm). Point dose measurements at depth were also performed with 0.3cc semflex (PTW N31003) ionization chamber, mainly for normalization purposes. Furthermore, MLC (both SS and SW) and compensator based plans were created in Pinnacle® for an abdomen case. On and off central axis entrance skin dose measurements for these plans were obtained, delivering all the beams from above to the solid water phantom. The plans were finally delivered to a humanoid phantom, in order to include both
entrance and exit skin dose in the measurements.

**Results:** The step-wedge field measurements showed 4.2 to 45.3% lower skin doses for increasing thickness of compensator material compared to the MLC based delivery. Off central axis entrance skin dose measurements for the abdomen case showed lower values for the compensator based plan, up to 23% when compared to the SS MLC delivery and 26% when compared to the SW. However, for the points on the central axis of the fields, the skin doses measured for the compensator based plan exceeded those for the MLC delivery. This was verified from the measurements on the humanoid phantom that included the exit skin doses as well. On average, a decrease of approximately 10% of the skin dose was measured for each treatment field, when compensators were used. Overall comparison of the skin doses between the SS and SW MLC deliveries did not show significant differences.

**Conclusions:** Preliminary results show that an overall decrease in dose delivered to patients’ skin can be achieved when using compensators for IMRT treatment, compared to MLC delivery. Better skin sparing can be achieved this way to avoid skin tissue damage, improving patients’ quality of life, during and after treatment.