1.1_Hyperthermia and radiotherapy with or without chemotherapy in locally advanced cervical cancer: A systematic review with conventional and network meta-analyses

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Aims: A systematic review with conventional and network meta-analyses (NMA) was conducted to examine the outcomes of loco-regional hyperthermia (HT) with radiotherapy (RT) and-/or chemotherapy (CT) in locally advanced cervix cancer, IIB-IVA (LACC).
Methods: 217 abstracts were screened from five databases and reported as per PRISMA guidelines. Only randomized trials with HT and RT±CT were considered. The outcomes evaluated were complete response (CR), long-term loco-regional control (LRC), overall survival (OS), acute and late grade III/IV toxicities.
Results: Eight articles were finally retained. Six trials with HTRT (n=215) vs. RT (n=212) were subjected to meta-analysis. The risk differences for achieving CR and LRC were greater by 22% ($p<0.001$) and 23% ($p<0.001$) respectively with HTRT compared to RT. A nonsignificant survival advantage of 8.4% with HTRT was noted with no differences in acute or late toxicities. Bayesian NMA, incorporating 13 studies (n=1000 patients) for CR and 12 studies for OS (n=807 patients), comparing HTCTRT, HTRT, CTRT and RT alone was also conducted. For CR, HTCTRT scores over RT (OR: 4.52, 95% Cr.I: 1.93-11.78) and CTRT (OR: 2.91, 95% Cr.I:1.97-4.31) while for OS, outcomes with HTCTRT are better than CTRT (OR: 2.65, 95% Cr.I: 1.51-4.87) or RT (OR: 5.57, 95% Cr.I: 1.22-23.42). On the rankogram, the "Surface under the cumulative ranking curve" (SUCRA) value of HTCTRT for CR and OS was highest at 0.952 and 0.979 respectively, compared to CTRT, HTRT and RT. This further indicated the superiority of HTCTRT over remaining options.
Conclusions: In LACC, HTRT demonstrates a therapeutic advantage over RT without significant acute or late morbidities. On NMA, HTCTRT appears promising but needs further confirmation through prospective randomized trials.

1.2_Can tracking be beneficial in SBRT pancreas treatments?

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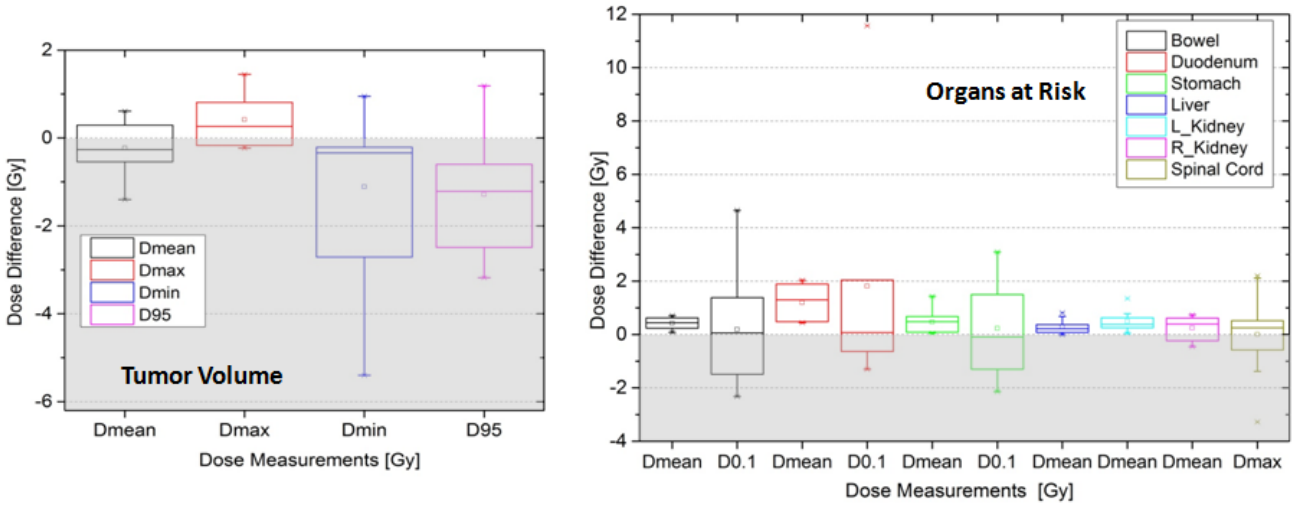
Introduction: Radiotherapy for pancreatic cancer has two major challenges: (I) the tumor is adjacent to several critical organs and, (II) the mobility of both, the tumor and its surrounding organs at risk (OARs). A treatment planning study simulating stereotactic body radiation therapy (SBRT) for pancreatic tumors was performed to compare dosimetrically the internal target volume (ITV) to the tumor tracking concept.

Methods: Treatment plan optimizations for volumetric-modulated arc therapy (VMAT) were performed in Eclipse™ (Varian) for 10 previously treated pancreatic cancer patients. Planning target volume (PTV) was defined as follows: ITV concept: The ITV enclosed the GTV within each breathing phase. An ITV-to-PTV margin of 5 mm was used. Tumor tracking concept: The GTV was delineated on one phase of the 4DCT image set. A GTV-to-PTV margin of 5 mm was used.
A dose of 25 Gy in 5 fractions was prescribed to the 60%-isodose surrounding the PTV, corresponding to a maximum allowed dose of up to 41.5 Gy. 4D dose calculations on the different respiratory phases were performed using MIM software. The statistical analysis was based on the two-sided Wilcoxon paired signed-rank test.

Results: Tumor motion extended from 1.30 to 11.21 mm. Tracking led to a reduction of PTV size (max. 39.2%) accompanied with better organ at risk sparing. When 4D dose calculations of ITV concept and tracking were compared (Fig. 1), average reductions in OAR mean dose (D_{mean}) from 5.5% to 12.7% were observed, which were significant ($p<0.05$) for all OARs except for the right kidney.

Conclusions: 3D and 4D dose calculations showed that the OAR dose benefit of tumor tracking is patient-specific. Tracking reduced the PTV subsequently facilitating treatment planning and decreasing mean doses of OARs.

Fig. 1: Box plots for the comparison between 4D ITV Concept and 4D Tracking for tumor volume and OARs. White shaded areas show lower dose values for Tracking , while gray shaded areas show lower values for ITV Concept.



1.3_Dosimetry of FLAH irradiation for studies on the biological effect induced in normal brain and GBM

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* Equal contribution to the work

No abstract

1.4_Calculation of the "effective dose" delivered by IGRT in H&N and breast treatments

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***Aims*:** To create a model, implementable in a TPS, able to calculate the dose distributions delivered by IGRT for H&N and breast patients and use these distributions to calculate the effective dose.

***Methods*:** The OBI (Varian, USA) thorax and the XVI (Elekta, UK) H&N, thorax and 4D cone beam CT (CBCT) acquisition modalities were studied. kV profiles and PDD were measured in water with a Farmer 30013 ionisation chamber (PTW, Germany). The model was created in Pinnacle 14 TPS (Philips, The Netherlands). The model has been validated using the Farmer chamber in the CIRS thorax phantom (CIRS, USA). The model has been used to calculate the dose distribution on five H&N and five breast patients. Organs were contoured on corresponding dedicated CTs. The mean dose received by each organ was calculated with the models and the "effective dose" was calculated using the ICRP 103 recommendations ("effective dose" is in quotes because it is a similar calculation than the effective dose, but for each individual patients, which is not the rigorous definition of effective dose). The robustness of the method was studied.

***Results*:** The "effective dose" depends on the CBCT modality used, going from 1 to 10 mSv. The maximum uncertainty was about 7%. The most important organs for "effective dose" calculations are the one close to the isocenter and the one with a high tissue weighting factor.

***Conclusion*:** The model created allows to calculate dose distributions due to IGRT in patients and to determine the corresponding "effective dose" The model is robust in terms of uncertainty.

1.5_Impact of the radiation dose on hepatic perfusion evaluated using liver scintigraphy mebrofenin.

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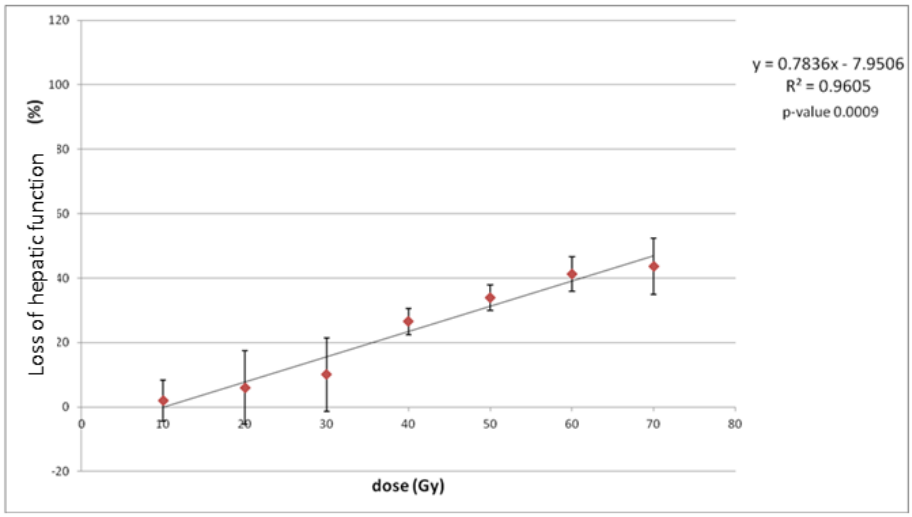
Introduction: Aim of this study is to evaluate the impact of the radiation dose on hepatic perfusion by integrating mebrofenin liver scintigraphy (HBS) before and after radiotherapy (RT) in patients treated with stereotactic body radiotherapy (SBRT) on liver.

Methods: Between April and September 2015, six patients with primary (three patients) or secondary liver cancers (three patients) were treated with SBRT (3x15 Gy: 4 pts, 5x8 Gy: 1 pt or 6x5 Gy 1 pt). All patients received an HBS to assess hepatic perfusion before and three months after RT. The HBS was co-registered with the planning phase of the simulation CT-scanner. For each patient, the biological equivalent dose of 2 Gy per fraction (EQD2) was calculated with an alpha / beta = 10 Gy, to assess the acute toxicity. Isodoses (5, 10, 20, 30, 40, 50, 60, 70, 80 and 90 Gy) were drawn. Then, we calculated the activity (MBq) in these volumes before and after treatment.

Results: Linear regression analysis showed a significant reduction in liver function at three months. This decrease was proportional to the increase of the radiation dose ($p = 0.0009$, Figure 1), with a reduction of 0.78% of the hepatic perfusion for each delivered gray. The linear equation that we found had a predictive value in predicting the loss of liver function depending on the delivered dose of 96% ($R^2 = 0.9605$).

Conclusion: We showed for the first time the utility of HBS in evaluating the variation of liver function after SBRT. This analysis shows a functional decrease, which is proportional to the delivered dose, thus predicting the resulting acute toxicity.

Figure 1: Reduction of liver perfusion depending on the radiotherapy dose



2.1_Impact of the radiation dose on the pulmonary perfusion assessed using lung scintigraphy

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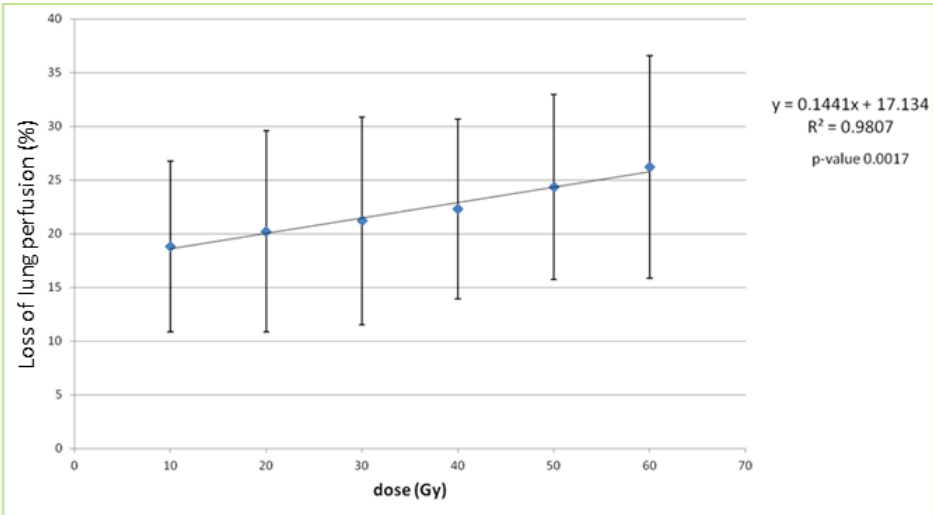
Aim: We evaluated the impact of the radiation dose on the lung perfusion (LP) using lung scintigraphy (LS) performed before and after the treatment in patients (pts) treated for primary or secondary lung cancers.

Methods: Between 06.2014 and 09.2015, 15 pts presenting a primary (n = 11) or secondary (n = 4) lung cancer were treated with radiotherapy +/- chemotherapy (10x3 Gy, 1 pt; 13x3 Gy, 1 pt ; 6x8 Gy, 1 pt; 7x7.5 Gy, 1 pt; 3x18 Gy, 1 pt; 12x4.5 Gy, 1 pt; 5x11 Gy, 1 pt; 30x2Gy 4pts; 33x2Gy, 2 pts; 5x12Gy, 1pt; 12x5Gy, 1 pt). Three pts were treated in a context of re-irradiation. All patients received a LS to evaluate the LP before and three months after radiotherapy, which was co-registered with the planning phase of the simulation CT-scan. For pts treated with hypo-fractionated regimens, the biological equivalent dose at 2 Gy/fraction (EQD2) was calculated (alpha / beta = 10 Gy for acute toxicity). Isodoses (5, 10, 20, 30, 40, 50, 60, 70, 80 and 90 Gy) were drawn. Then, we calculated the activity (MBq) in these volumes before and after treatment.

Results: Linear regression analysis showed a significant reduction in lung function than three months, proportional to the increase of delivered dose (p = 0.0017, Figure 1), with a reduction of 0.14% of the pulmonary perfusion for each delivered gray. The linear equation that we found had predictive value in predicting the pulmonary loss of function of 98% (R^2 = 0.9807).

Conclusion: LS is a good tool for assessing the changes in LP after thoracic irradiation. This analysis shows a functional decrease, which is proportional to the delivered dose, reflecting the functional acute toxicity.

Figure 1: Reduction of lung perfusion depending on the radiotherapy dose.



2.2_Non-resected and R1 resected pancreatic adenocarcinoma: Feasibility and patients' outcome after radio-chemotherapy with high dose external radiotherapy (RT)

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Aims: To evaluate the acute and late toxicities and patients outcome (progression free and overall survival) in a single center retrospective analysis of patients (pts) treated with high dose RT with concomitant chemotherapy (gemcitabine) for non-resected or R1 resected pancreatic adenocarcinoma.

Parients & Methods: Between March 2009 and August 2015, 24 patients, with non-resected locally advanced (18 pts) or R1 resected (6 pts) pancreatic adenocarcinoma, have been treated with concomitant radio-chemotherapy. Four patients presented with cT2-3, 14 with cT4, and 6 with pT3-4. All tumors were proven histologically. Chemotherapy was based on gemcitabine (50 mg/m2 administered twice weekly). Except one patient who received 56 Gy, all patients received >=59 Gy (median dose 60.0 Gy) in standard fractionation, using mainly IMRT technique (58%). The acute and late toxicities were evaluated according to CTCAE v3.0 criteria during and after the treatment.

Results: The median follow-up was 8.0 months (range, 1-42 months). The actuarial overall survival rates at 12, 24 and 30 months were 70%, 39% and 26%, respectively. It was of 42% and 20% for the R1 resected and non-resected patients respectively (p=0.22). A detailed data on progression free survival and loco-regional control will be presented. All patients experienced G1 to G2 acute toxicity except one patient who presented with severe digestive bleeding potentially linked to the treatment. Late toxicities consisted mainly of G1 digestive toxicities.

Conclusion: The present study confirms the feasibility of high dose RT combined with gemcitabine-based chemotherapy in patients with locally advanced pancreatic adenocarcinoma. While the outcome remains unsatisfactory in this disease some patients seem to have benefited from this aggressive therapy which merits to be investigated further.

2.3_Long-term outcome of early stage glottic cancer treated with radiotherapy and/or surgery

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Purpose: To evaluate the long-term outcome of cT1-2 cN0 cM0 glottic squamous cell carcinoma (SCC) cases managed with radiotherapy (RT) or surgical treatment (ST).

Patients and Methods: Retrospective, single institution analysis of early stage glottic SCC patients, treated with either normo-fractionated RT or ST between 1990 and 2013. The primary endpoint was relapse-free survival (RFS).

Results: The median age of patients (n=244) was 65 (range: 36-92) years, with the majority (92%) being male and 81.6% presenting a cT1 stage. The median follow-up was 59 months. Eighty-two percent and 18% were treated primarily with RT and ST, respectively. Thirty-seven percent of the surgically treated patients underwent adjuvant RT. The median RT dose was 68 Gy delivered in 2 Gy per fraction with either 2D/3D-conformal (85%) or intensity-modulated RT. With RT and ST, the 5-year RFS was 83% and 75% (p=.05) for T1 and 62% and 50% (p=.47) for T2 stages, respectively. Multivariate analyses indicate T1 vs. T2 and RT vs. ST as independent prognostic factors for RFS with hazard ratios of .38 (95% CI: .21-.72) and .53 (95% CI: .30-.99), respectively (p<.05). Anterior commissure involvement was neither prognostic nor predictive. Without any significant differences (p>.1) among treatment groups, the 5-year overall and disease-specific survival rates of the whole cohort were 92% and 96%, respectively. The incidence rates of second malignancies were not significantly different between patients treated with and without RT (p=.18).

Conclusion: Despite a possible selection bias, our series demonstrate a better RFS with RT over ST for cT1 glottic SCC. However, comparing our RT results to the previous studies using altered fractionation, we are considering to revise our institutional fractionation policy.

Keywords: glottic cancer, larynx cancer, radiotherapy, surgery.

2.4_Impact of the site of metastasis on prostate cancer-specific survival in patients treated with curative radiotherapy

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Aims Most localized prostate cancer (PCa) patients (pts) will be cured after local treatment; but once PCa develops metastasis, the disease becomes incurable. This study aims to evaluate the impact of the metastatic site on the outcome of PCa pts treated with curative radiotherapy.

Methods The analysis from the IOSI database included 531 cases of localized PCa diagnosed between 2000 and 2014 . All pts were treated with radiotherapy, plus(N=432) or minus hormones (N=99). Metastases were radiologically documented. PCa specific survival (PCaSS) was estimated by the Kaplan-Meier method.

Results Median follow-up and age were 6.1 and 70.3 ys, respectively. Five-year PCaSS was 97.5% (95%CI 95.5-98.6). Sixty-two pts (11.7%) developed a metastasis with a median PCaSS of 42.9 mo (95%CI 27.2-nr) after first metastatic progression. Bone (N=20; 32.3%) and LN/locoregional (N=24; 38.7%) metastases were more frequent with median PCaSS of 32.9 mo (95%CI 18.4-65.4) and not reached (95%CI 39.2-nr) respectively (p=0.0006). Six pts had visceral metastasis only (9.7%; liver, lung, brain) and 12 (19.3%) multiple metastases with median PCaSS of 15.1 mo (95%CI 6-nr). Conversely, median survival from primary diagnosis to first metastasis was not associated with the first site of metastasis (p=0.8222).

Conclusions For PCa pts treated with curative radiotherapy, the survival after metastatic progression depends on the site of the first metastasis. Lymph node metastasis had the most favorable prognosis, suggesting a different tumor biology and implying that treatment be selected considering the first site of metastasis. If the first metastatic sites are lymph nodes, local treatments including stereotactic radiotherapy to the metastatic nodes may significantly slow the rate of progression of the disease.

2.5_Risk Factors for PEG-Dependency and Unplanned Hospitalizations in Patients with Head and Neck Cancer Who Underwent Gastrostomy Tube Installment

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Purpose: To identify any risk factors for percutaneous endoscopic gastrostomy (PEG)-dependency and unplanned hospitalizations in patients with head and neck squamous cell carcinoma (HNSCC).

Methods: All UICC stage III-IVB non-nasopharyngeal/-paranasal/-nasal HNSCC patients (n=218) treated from 2007 to 2012 with postoperative or definitive radio(chemo)therapy in a curative intent were included. Patients received a PEG tube either prophylactic (pPEG) or reactive (rPEG), i.e. after the onset of dysphagia interfering with the ability to eat/drink adequately. Continuation of tube feeding and hospitalizations related to recurrence were censored.

Results: Median follow-up of surviving patients was 42 months. pPEG and rPEG were installed in 86% and 14%, respectively. Pre-treatment grade ≥3 dysphagia was observed in 14% and 0% in patients receiving pPEG and rPEG, respectively ($p<0.01$). Pre-treatment BMI was similar for patients with pPEG and rPEG (25.3 vs. 23.9; $p=0.53$). The median duration of PEG-dependency was 23 and 29 months with pPEG to rPEG ($p=0.62$). Independent risk factors ($p\leq0.01$) were identified with multivariate analyses: cT3 (OR: 2.86), cT4a (OR: 2.99) and baseline dysphagia (ORs: 1.56, 2.29 and 2.87 for grades 0, 1 and 2, respectively) for prolonged PEG-dependency; concomitant use of Cetuximab (OR: 2.13) for any hospitalization events; older age (OR: 1.04) and persisting alcohol abuse (OR: 6.25) for cumulative hospital stay longer than 2 weeks.

Conclusion: Patients with baseline dysphagia and/or cT stage ≥3 are prone to prolonged feeding tube dependency; whereas increasing age, persisting alcohol abuse and/or Cetuximab treatment may be predictive factors for unplanned hospital stays. Patients with these factors may require careful monitoring and proactive measures.

Keywords: head and neck cancer, percutaneous endoscopic gastrostomy, morbidity, hospitalization

2.6_Dose-Escalated Salvage Radiotherapy for Histologically Proven Macroscopic Recurrence after Radical Prostatectomy: Clinical Outcomes and Toxicity Results

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Aims: Salvage radiotherapy (SRT) is a potentially curative treatment for local recurrences after radical prostatectomy (RP). This work aims to retrospectively assess clinical outcomes and toxicity data of patients treated with dose-escalated SRT to histologically proven macroscopic local recurrence.

Methods: We report on a cohort of 28 patients with histologically proven macroscopic local recurrence on MRI and/or CT treated with SRT between 2008 and 2015. A dose of 64-66 Gy (2 Gy/fr) was delivered to the prostatic bed followed by a dose escalation to 72-74 Gy (2 Gy/fr) to the site of macroscopic disease using image-guided IMRT. Patients were treated with a concomitant short-course of androgen ablation. Biochemical relapse-free survival (bRFS) and clinical relapse-free-survival (cRFS) were calculated using Kaplan-Meier method. Baseline, acute and late urinary and gastrointestinal (GI) toxicity rates were reported using CTCAE v4.

Results: Median follow-up was 38 months (8-66). Median pre-RT PSA was 5.6 ng/ml (0.5-24). Ten patients (36%) had biochemical failure (BF) and 3 developed distant metastasis. Median time to BF was 27 months (17-66). The 3-year bRFS and cRFS were 58% and 95%, respectively. At baseline, 2 patients had grade 2 urinary toxicity. Eight patients (28%) developed grade ≥ 2 acute urinary toxicities. Two patients (7%) had grade 2 acute GI toxicities. No grade ≥ 3 acute GI toxicity occurred. Three patients (11%) had grade ≥ 2 late urinary toxicities. No grade ≥ 2 late GI toxicity was reported.

Conclusions: Dose-escalated SRT using image-guided IMRT to histologically proven macroscopic local recurrence offered a reasonable bRFS rate with an acceptable incidence of late toxicities.

2.7_SAFETY AND EARLY EFFICACY OF STEREOTACTIC RADIOSURGERY IN TRIGEMINAL NEURALGIA

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Aims: Stereotactic radiosurgery (SRS) is one of the surgical alternatives for the treatment of drug-resistant trigeminal neuralgia (TN). This study aims to evaluate the safety and efficacy of SRS in a population of patients with TN.

Methods: Between 2011 and 2015, 8 patients presenting with TN were treated using SRS. The frequency and severity of pain, as well as trigeminal nerve function, according to Barrow Neurological Institute (BNI) scale, were evaluated before SRS and regularly thereafter. After immobilization with a Leksell B stereotactic frame under local anesthesia, SRS was planned on iPlan® (Brainlab) with the help of computed tomography (CT) and magnetic resonance (MR) images for targeting and delivered with a Novalis TX™ linac using circular cones. Isocenter was positioned at the root entry zone of the trigeminal nerve. A single 6 mm cone and a mean of 26 arcs (25-27) were used for treatment. The prescribed dose was 90 Gy to the isocenter in one fraction.

Results: The median follow-up time was 1.5 years (0.3-3.1). The median age of patients was 61 years (31-77). The mean time between onset of TN and SRS was 9.3 years (0.5-23.2). Seven patients had 1 or more previous surgical procedures. A total of 5 patients became pain free after a median delay of 90 days (1-130) after the SRS (BNI grade I-IIIa). Three patients developed a mild facial numbness (BNI grade II) and only one patient reported a very bothersome facial numbness (BNI grade IV). No brainstem toxicity was reported. Brainstem doses were: Dmax 18.08 Gy (11.93-28.08), Dmean 0.75 Gy (0.62-0.91) and D(0.1cc) 8.47 Gy (7.32-10.24). Brain doses were: Dmax 73.28 Gy (38.89-89.99), Dmean 0.23 Gy (0.20-0.26), D(5cc) 3.80 Gy (3.34-4.38) and D(10cc) 2.97 Gy (2.74-3.49).

Conclusion: Our data indicates the safety and early efficacy of SRS for the treatment of drug-resistant TN. The rate of late effects were comparable to published series.

3.1_Liquid filled ionization chamber 2D-array for patient specific QA for stereotactic treatment at CyberKnife®.

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Aim: Stereotactic radiotherapy treatments have increased during the past years, arising the needs for specific quality assurance programs and dedicated detectors with higher resolution.
In this study we analyze the feasibility of using the two-dimensional liquid filled ionization chamber array Octavius 1000SRS (PTW-Freiburg, Germany) for patient specific QA for Cyberknife® treatment plans.

Methods: Twenty treatment plans for several anatomical sites have been considered and recalculated in the Octavius phantom. Additionally six static beams with different incidence angles have been measured in order to assess the response of the detector for simple irradiation.
Measurements were performed with the stereotactic 2D array 1000SRS and with the ionization chamber A1SL (Standard Imaging, USA). The doses measured by the central chamber of the 2D array 1000SRS were compared with the A1SL chamber measurements and with the TPS dose calculations.

Results: The measures performed with the A1SL are in good agreement with the TPS calculations. The comparison between the 2D array 1000SRS dose and the A1SL dose results in a correction factor (k_{user}) that has to be applied to the measured 2D dose distribution.
The delivery angles of the beam were recorded to study a potential correlation between the incidences of the beams on the detector and the observed variation of the k_{user}.
When corrected by the average k_{user} the measured 2D dose distributions showed an overall agreement of 1.5%/1.5 mm with the calculated dose distributions (up to 3%/1.5 mm in some cases).

Conclusion: The two-dimensional liquid filled ionization chamber array Octavius 1000SRS has proven a valid instrument for patient specific QA for the CyberKnife® Robotic radiosurgery system equipped with fixed, iris or MLC collimators.

3.2_Evaluating the actual direction distribution of the primary radiation for a Cyberknife-M6 using system log files

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No abstract

3.3_Monte Carlo model of a gantry for proton pencil beam scanning

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Aims: To model the PSI proton scanning gantry (Gantry 2) using a Monte Carlo (MC) tool in order to explore new delivery techniques, such as the use of apertures. Particular attention has been concentrated on reproducing the measured angular and spatial distribution of pencil beams in air.

Methods: Beams have been simulated using TOPAS 2.0.p3, which is built around the MC toolkit Geant4.10.1.p02. The input parameters have been adjusted such that integral depth dose curves and lateral spot profiles measured during commissioning are reproduced. The preabsorber (range shifter) has been modeled as a component in the nozzle. MC dose calculations in water and on patient CT data have been compared both to measurements and to analytical results from the PSI treatment planning system (TPS).

Results: Ranges and widths of simulated pencil beams agree with measurements to within 0.1 mm and 0.2 mm respectively, pencil beam propagation in air (lateral spot profiles) and the range shift due to the preabsorber have been matched with submillimeter accuracy. First comparisons of absolute dose between MC and analytical calculations however show systematic deviations of up to 8 %, whereas calculations on the patient CT show that tissue heterogeneities can lead to localised range differences between the analytical and MC calculations (see figure 1).

Conclusion: A MC model of Gantry 2 has been developed with good agreement to commissioning data and localised discrepancies between analytical and MC calculations have been found. The model is now ready to be used to investigate advanced beam delivery techniques for proton pencil beam scanning.

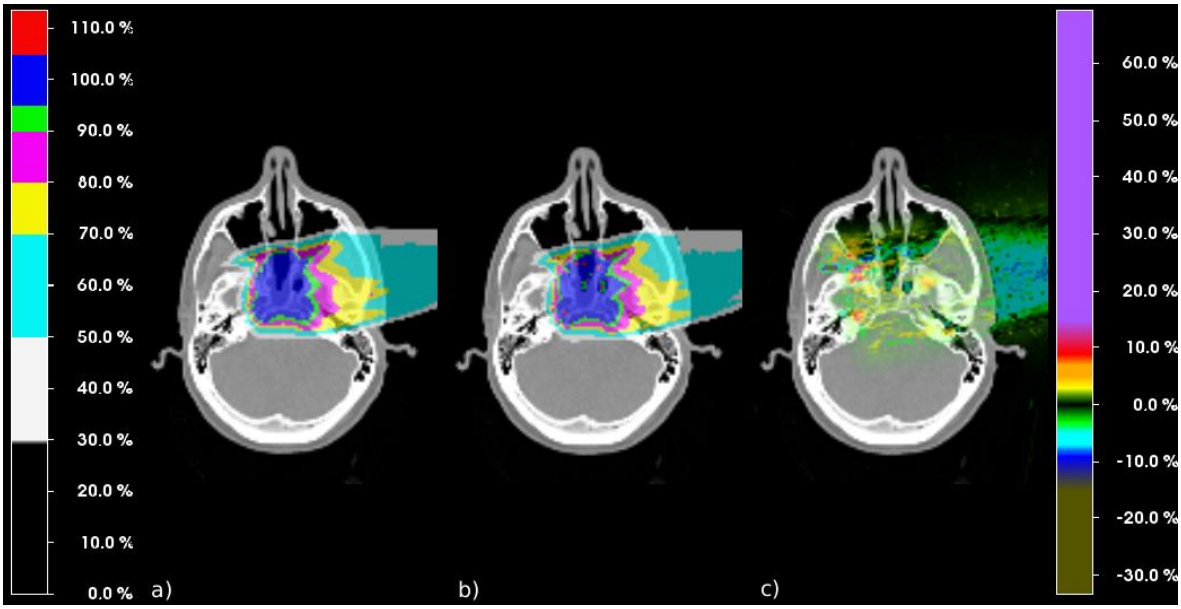

Figure 1 Relative dose calculated using the TPS (a), TOPAS (b) and dose difference TOPAS–TPS (c).

3.4_Dose and energy measurements in radio therapy by a combination of TLD100 and TLD100H

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Purpose: Due to the small size and the tissue equivalent composition TLDs are well suitable for out-of-field dose measurements. However, the photon energy variation of the stray dose lead to systematic dose errors caused by the energy dependency of the TLDs. We present a method to automatically correct for energy variation of the measured photons by combining LiF:Mg,Ti and LiF:Mg,Cu,P chips.
Methods: The energy response of TLD100 and TLD100H compared to ^{60}Co was taken from the literature. For the measurement, a TLD100H was placed on top of a TLD100 chip. With the ratio between the TLD100 and TLD100H dose the mean energy was determined. With the energy, the single correction factors for TLD100 and TLD100H could be found. The in- and out-of-field dose accuracy of the double TLD method for nominal beam energy of 6MeV was determined by an end-to-end measurement. For this, the mean dose of the TLD100 and TLD100H chip was compared to an ionization chamber measurement. Furthermore, Monte Carlo (M.C.) simulations of the mean photon energy for brachytherapy sources and for stray radiation of a treatment machine were compared to the measured mean energies. Finally, the photon energy distribution in an Alderson phantom was measured for different treatment technics applied with a linear accelerator and a cobalt machine combined with a MRI.
Results: The presented method to determine the dose showed an accuracy of 0+/-3% double standard deviation of the mean compared to the ionization chamber. The measured energies were in agreement with the M.C. simulations. For mean energies lower than 0.6MeV, the method systematically overestimated the energy by 0.1MeV.
Conclusion: The method is suitable for accurate in- and out-of-field dose measurements down to a photon energy of 150 keV.

3.5_Comparison of two automated treatment planning solutions for complex head and neck cancer

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Purpose: Volumetric Modulated Arc Treatment (VMAT) optimization is a time consuming process which involves several iteration cycles before an acceptable plan is achieved. Furthermore, quality of VMAT plans is highly dependent on the planner skill and experience. This is true in particular for complex cases such as head and neck (HN) carcinoma irradiated with simultaneously integrated dose levels. In order to improve plan consistency and decrease planning time, automated planning algorithms have been developed. In this pilot study, we compared two commercially available automatic planning systems for HN cancer patients.

Material and methods: A VMAT model was created with a knowledge based, Auto-Planning V9.10 (AP) (Pinnacle, Philips Radiation Oncology Systems, Fitchburg, WI) and a model based, RapidPlan V13.5 (RP) (Eclipse, Varian Medical System, Palo Alto, CA), optimization systems. These two models were used to optimize ten H&N primary radiotherapy plans using an integrated boost concept and three dose levels of 70Gy, 60Gy and 54Gy. Only a single cycle of plan optimization was done for both automated treatment planning systems.

Results: The results from the planning comparison for HN cancer patients showed a better target coverage with AP in comparison to RP and manually optimized plans (($p < 0.01$). RP achieved better dose conformity in comparison to AP ($p < 0.05$). No significant differences were observed for the OARs, except for the pharynx where RP and the manually optimized plans were better than AP ($p < 0.01$) and for oral mucosa were AP performed better than the two other systems ($p = 0.01$). The working time needed to generate clinical accepted plans for the automated TPS was drastically reduced to less than fifteen minutes.

Conclusions: These encouraging results show that highly consistent treatment plans for complex cases can be achieved with an automated planning process, reducing overall plan-generation time.

3.6_Concepts and principles of deformable image registration QA

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Aims: Deformable image registration (DIR) is becoming an essential tool in radiotherapy for processes like multimodal segmentation, dose accumulation, adaptive therapy, etc. If applied inappropriately, DIR may lower the efficiency of treatments and lead to serious injuries. This clearly speaks up for performing a QA program, but there are no official recommendations. DIR QA is hampered by the availability of different types of transformation models and similarity metrics as well as various implementations of these. Moreover most models are not based on underlying physics which makes QA more challenging than for dose planning software.

Methods: The tools proposed for DIR QA can be split into four categories: visual (image fusion, deformation vector maps, voxels tracking), localized (target registration error, critical points, Jacobian), contours and volumes (Dice similarity coefficient, Hausdorff distance, MDT) and test objects (physical, virtual phantoms). However none of these is general enough to be used solely. We have evaluated the suitability of the different QA tools in terms of their usefulness, time consumption, accuracy and ease of realization.

Results: We found that 30% of the tools allow to quantify errors of keys points but at the expense of extra time. The other quantitative tools (30%), more practical, miss a clear localization of errors. The remaining tools are either qualitative or representative of the deformation model. Finally the appropriate choice of tools also depends on the subsequent use of the deformed images.

Conclusion: Our analysis shows that there are multiple ways of implementing DIR QA in the clinics and that they should be clearly defined. We suggest setting up a working group to determine guidelines.

3.7_Comparison of two deformable registration software using an in-house "deformable phantom"

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Introduction: The multimodality image fusion, widely used in radiotherapy to precisely contour the target volumes, opened the field to deformable registration, as significant anatomical and positional modifications may occur between acquisitions.
In this work, a heat deformable 3D phantom, with two rigid well defined lesions, was conceived to quantify the performances of Velocity and Smart Adapt in their ability to segment structures on deformed images.

Material and Methods: The phantom's deformable body (BODY) is made from wax (deformable at 40°C) and includes two rigid elements of Aquaplast (deformable at 60°C) in its extremities. The volumes of the structures were 10,78cc, 18,9cc and 466,8cc respectively for PTV1, PTV2 and BODY. The initial distance between the centers of PTV1 and PTV2 was 10,6cm. At first, it was scanned on its initial form (CTinitial), then undergone two deformations, having one CT imaging for each deformation (CT-1deform, CT-2deform). The PTV2 was shifted from PTV1 1,2cm after the first deformation and 4,7cm after the second deformation. Reference contours BODY, PTV1 and PTV2 were manually contoured on each CT, with 3 physicist drawing PTVs to estimate intra-observer variability. The CTinitial was deformed to CT-1deform and CT-2deform using both SmartAdapt and Velocity. Different metrics were used to compare manual and segmented structures.

Results: In the table below are presented the metrics results as a mean value for PTV1 & PTV2:

Case	Mean Dice (min-max)	Mean distance (mm)	maximum distance (mm)	Mean Volume difference (%)
3 Physicist	0.95 (0.93-0.96)	0.5	4.4	3.5
Velocity	0.83 (0.79-0.91)	1.66	16.5	17.57
SmartAdapt	0.81 (0.66-0.88)	1.86	19.9	9.55

The mean distance (PTVs & BODY), manual versus segmented structures, was 1,2mm and 1,5mm for Velocity and SmartAdapt respectively. On the other hand, maximum errors of 16,5mm and 19,9mm were observed on PTVs.

Conclusions: This first study showed similar performances between the two software. Larger errors were related to larger physical deformations of the phantom. Clinical performances will be tested when effects like tissue/air modifications, low contrast and, large shifts are present.

4.1_Timing of radiotherapy and chemotherapy after breast-conserving surgery for node-positive breast cancer: long term results from IBCSG Trials VI and VII

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Purpose: The aims of the present study were to update the previous report from two randomized clinical trials, now with median follow-up of 16 years, to analyze the effect of radiotherapy timing on local failure and disease-free survival.
Methods and Materials: From July 1986 to April 1993 the International Breast Cancer Study Group (IBCSG) Trial VI randomly assigned 1475 pre/perimenopausal women with node-positive breast cancer to receive 3 or 6 cycles of initial chemotherapy (CT). IBCSG Trial VII randomly assigned 1212 postmenopausal women with node-positive breast cancer to receive tamoxifen for 5 years, or tamoxifen for 5 years with three early cycles of initial CT. For patients who received breast-conserving surgery (BCS), radiotherapy (RT) was delayed until initial CT was completed; 4 or 7 months after BCS for Trial VI and 2 or 4 months for Trial VII. We compared RT-timing groups among 433 patients on Trial VI and 285 patients on Trial VII who received BCS plus RT. Endpoints were local failure, regional/distant failure, and disease-free survival (DFS).
Results: Among pre/perimenopausal patients there were no significant differences in disease-related outcomes. 15-year DFS was 48.2% in the group allocated 3 months initial CT and 44.9% in the group allocated 6 months initial CT (HR=1.12; 95% CI:0.87–1.45). Among postmenopausal patients, 15-year DFS was 46.1% in the no-initial-CT group and 43.3% in the group allocated 3 months initial CT (HR=1.11; 95% CI:0.82–1.51). Corresponding HRs for local failures were 0.94 (95% CI: 0.61–1.46) in Trial VI and 1.51 (95% CI:0.77–2.97) in Trial VII. For regional/distant failures, the respective HRs were 1.15 (95% CI:0.80–1.63) and 1.08 (95% CI:0.69–1.68).
Conclusions: This study confirms that, after more than 15 years of follow-up, it is reasonable to delay radiotherapy until after the completion of standard chemotherapy.

4.2_HIT THE "LUNG" TARGET: IOSI EXPERIENCE

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AIMS: Stereotactic body radiotherapy (SBRT) is a curative treatment for patients (pts) with early-stage non-small cell lung cancer who are not healthy enough to undergo surgery and for pts with oligometastatic disease. The aim of the study was to report clinical results of SBRT in lung cancer.

METHODS: 41 pts and 46 lesions were consecutively treated from September 2011 to December 2015 with VMAT/RapidArc® and Exactrac (BrainLab®) technique to a Biologically Effective Dose (BED_{10}) ≥ 90 GyE. 20 pts were treated for early non small cell lung cancer and 21 pts for metachronous or synchronous lung metastases. 30 pts had histologically proven cancer (21 adenocarcinoma, 9 squamous cell carcinoma) while 11 pts were irradiated without a proven histology but based on highly suspicious PET/CT scans. All the treatments were discussed during a multidisciplinary session. The median age at diagnosis was 71 years (range 52-90). The median volume for PTV was 13.1 cm^3 (range 4.6-70). PTV was obtained merging GTV on 10 phase 4D-TC plus 3 mm margin.

RESULTS: With a median follow-up of 29 (range 3-56) months, overall survival (OS) at 1 and 2 years was 91.8% and 85.7%, respectively. Progression free survival (PFS) at 1 and 2 years was 91.7% and 81.5%, respectively . No significant difference in OS e PFS was registered between pts with primary disease and pts with synchronous or metachronous metastatic lesions (p 0.098 and p 0.520 respectively) and between PTV volumes that were larger or smaller compared to median volume (p 0.2 and p 0.126). Only 2 pts (4.8%) developed late toxicity: 1 pneumonitis and 1 rib fracture.

CONCLUSION:SBRT is feasible and well tolerated. Our experience confirms excellent long term local control rates and is associated with very low acute and late toxicity.

4.3_Prognostic factors in breast cancer (BC) associated with brain metastases (BM)

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BACKGROUND: BC is the 2nd commonest cause of BM. This study aims to define prognostic factors of brain dissemination in patients with limited BC.

METHODS: We retrospectively analyzed 726 pts with non-metastatic BC, treated between 2008 and 2013. Tumour and patient characteristics were correlated to the development of BM, other systemic progression, locoregional failure and survival.

RESULTS: Median follow-up was 40 months. 66% of tumours were luminal, 9% luminal/Her2+, 3% Her2+, 12% triple negative and 10% not specified. Median age was 60 years. DFS at 5 and 10 years was 86% (95%- confidence interval [CI]: 82-90%) and 48% (CI: 34-62%), respectively. OS was 92% (CI: 89-95%) and 62% (CI: 50-74 %), respectively. LRC was 97% (CI: 95-98%) and 91% (CI: 84-98%), respectively. BM- free survival was 97% (CI: 96-98%) and 73% (CI: 60-86%), respectively. Out of 726 patients, 28 developed BM. Their median OS was 41 months. Median time from initial diagnosis to BM was 59. In multivariate (MV) Cox regression analyses, prognostic factors of BM development were primary tumor >T1, carcinomatous lymphangitis (CL) and Her2+ or triple-negative ($p<0.05$). These prognostic factors were also significant for DFS, along with >N1. Percentage increase in progesterone and oestrogen receptor positivity was significantly associated with less BM occurrence ($p<0.0001$). DFS and OS were also significantly influenced by primary tumor >T1, CL and Her2+ or triple-negative BS and hormonal receptor percentage expression.

CONCLUSIONS: The risk of BM in early-stage BC remains low, but our study found a substantial variation in risk by BS, tumour size and hormonal receptor positivity.

4.4_Oligorecurrent nodal prostate cancer: long term results of an elective nodal irradiation approach

S. Tran, T. Falco, G. Lamanna, L. Lestrade, R. Miralbell, T. Zilli

Radiation Oncology, Geneva University Hospital, Geneva, Switzerland

No abstract

4.5_Miss the target in old age breast cancer patients: the experience of the Ticino Breast Unit

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1Radiation Oncology,Oncology Institute of Southern Switzerland, Bellinzona-Lugano [2]Gynaecology Department, Ospedale Regionale Bellinzona e Valli, Bellinzona [3]Centro di Senologia della Svizzera Italiana (CSSI)

AIMS To evaluate the impact of old age on adjuvant radiotherapy (RT) prescription.

METHODS Three hundred eighty-four female patients (pts), more than 70 years old, treated from January 2007 to June 2015 with conservative surgery or mastectomy for breast cancer, have been selected. The median age was 77 years (range 70-96) and pts were divided in 3 subgroups according to age: 70 to 79 years, 80 to 89 years and 90 years and older. Bilateral breast cancers were diagnosed in 20 pts (5.2%) while unilateral in 364 pts (94.8%). Two hundred eighty pts (69.3%) were treated with conservative surgery, 124 pts (30.7%) with mastectomy. A nonparametric $\chi 2$ test was used to compare the subgroups.

RESULTS In the group treated with conservative surgery (280 pts) 165 pts (58.9%) underwent RT, while 115 pts (41.1%) didn't. A statistically significant correlation was observed between age and RT prescription comparing younger subgroup to the others ($p<0.001$). In the group (124 pts) treated with mastectomy, 17 pts (13.7%) received RT while 107 pts (86.3%) didn't, without statistically significant different between age subgroups ($p>0.4$). The treatments for each age subgroup are described in Table 1 and 2.

CONCLUSION The percentage of pts not receiving adjuvant RT after conservative surgery increases with age. We are analysing data to look for a likely correlation between age, comorbidities, patient preference and RT omission.

	70-79y		**80-89y**		**≥90y**		**total**
	N° pts	(%)	N° pts	(%)	N° pts	(%)	N° pts
	189		79		12		280
Conservative surgery	32	16.9	34	43.0	9	75.0	75
Conservative surgery plus sentinel node biopsy	110	58.2	34	43.0	3	25.0	147
Conservative surgery plus axillary dissection	47	24.9	11	13.9	0	0.0	58
Adjuvant RT	135	**71.4**	27	**34.2**	3	**25.0**	**165**
No RT	54	**28.6**	52	**65.8**	9	**75.0**	**115**

Table 1

	70-79y		**80-89y**		**≥90y**		**total**
	N° pts	(%)	N° pts	(%)	N° pts	(%)	N° pts
	78		39		7		124
Mastectomy	10	12.8	7	17.9	4	57.1	21
Mastectomy plus sentinel node biopsy	34	43.6	17	43.6	0	0.0	51
Mastectomy plus axillary dissection	34	43.6	15	38.5	3	42.9	52
Adjuvant RT	13	**16.7**	4	**10.3**	0	**0.0**	**17**
No RT	65	**83.3**	35	**89.7**	7	**100.0**	**107**

Table 2

5.1_Comparison of MLC and couch tracking for SBRT prostate cancer

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Aims: Relaxation of the patient and bowel motion contribute to the uncertainty in dose delivery to prostate cancer patients. Tracking is a promising motion-management method for decreasing the uncertainty in the delivery of the planned dose distribution. Dosimetric measurements were performed in order to characterize and compare the performance of couch and MLC tracking.

Methods: For ten prostate patients, VMAT SBRT treatment plans were prepared. To simulate a moving target, the Delta^4 phantom (Scandidos) was mounted on the motion platform Hexamotion (Sandidos) and operated with five different prostate motion patterns. Dosimetric measurements were taken for all ten patients with all five motion patterns, while no compensation, couch tracking or MLC tracking was applied. The experiment was performed on Varian TrueBeam 2.0 accelerator in the Varian iTools-Tracking mode. The tumor position for tracking was acquired from Calypso (Varian) transponders.

Results: In Fig. 1 boxplots of the Gamma Agreement Indices (GAI) are shown. On the horizontal axis, the different trajectories are listed. Trajectory 5 describes a prostate with practically no motion (Amplitude<1 mm). Both tracking methods showed significantly increased GAI for the trajectories with pronounced motion ($p<0.05$), but slightly decreased GAI for the stable prostate. Overall couch tracking showed significantly higher GAI than MLC tracking ($p<0.05$).

Conclusion: Both tracking methods were able to increase the accuracy of dose delivery. The amount of improvement by tracking depends on the motion pattern of the target. If the target shows practically no motion, the change in performance is negligible. MLC tracking performed worse, probably due to the discrete character of the MLC position for motions perpendicular to the leaves.

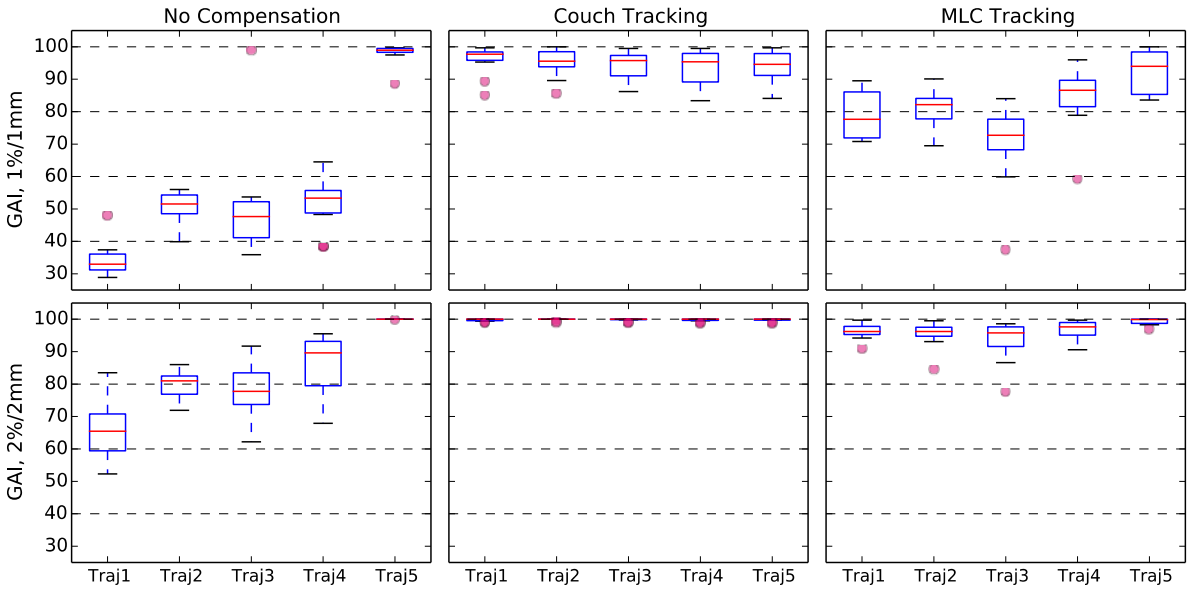

Fig. 1: Boxplots of Gamma Agreement Indices for the different Tracking modalities

5.2_Prospective study on the clinical impact of ^{18}F-fluorocholine (FCH) PET/CT on treatment management in biochemical recurrent prostate cancer: hit the right target for the right patient.

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AIMS: After curative treatment for prostate cancer, biochemical recurrence occurs in 20% to 50% of patients. There is a lack of evidence about the optimal management of this clinical setting. In this regard we performed a study to evaluate the role of FCH PET/CT in biochemically recurrent prostate cancer (brPC), focusing on its impact on treatment management decisions.

METHODS: This prospective monocentric study enrolled 59 consecutive patients who underwent FCH PET/CT for brPC (from 1.2015 to 5.2016). Patient characteristics (age, PSA, stage, prior treatments) were collected. Referring physicians were asked to indicate the hypothetical therapeutic strategy without and with the FCH PET/CT results. A nonparametric χ^2 test was used to compare the change of treatment management based on PET/CT findings.

RESULTS: Mean PSA value before FCH PET/CT was 4.6 ng/ml (range 0.2-20). In 40/59 (68%) cases, FCH PET/CT was positive (8 had prostatic recurrence, 14 had pelvic nodal relapse, 12 had bone metastases with/without lymph nodal recurrence, 5 had both prostatic and nodal relapse and one a suspicious lung lesion). Treatment was changed in 34/40 (85%) patients with a positive FCH PET/CT and in 1/19 (5%) cases with a negative FCH PET/CT. Overall FCH PET/CT findings led to a change in management in 35/59 patients (59.3%; $p<0.0001$).

CONCLUSION: FCH PET/CT strongly impacts on treatment decision-making in brPC by identifying patients who may still benefit from curative treatments, compared to those that instead, despite a low PSA value, are candidates for hormonal therapy and vice versa. In the era of personalized medicine, FCH PET/CT could help in tailoring treatment for brPC patients, giving the right treatment to the right patient and time with a better outcome.

5.3_The breath hold method to reduce the heart dose for left sided breast radiotherapy .

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Aims: Generally performed with 3D-planning, deep inspiration breath hold technique (DIBH) is often used for left sided breast radiotherapy to reduce heart dose. The VMAT technique delivers a precise sculpted dose to the planning target volume (PTV), while sparing dose at the normal tissue surrounding it. Associating VMAT and DIBH might substantially reduce the dose to the heart and also preserve the lungs.

Methods: 19 patients were evaluated with a VMAT-DIBH treatment. Depending on their pathologic stage, 13 patients received local irradiation, 4 a loco-regional irradiation and 2 an irradiation of the 2 breasts. Fractions of 2-2.7 Gy were used for local irradiation and fractions of 2Gy for Loco-Regional irradiation. Eligible patients should be able to breath hold during 25s several times. Treatment plans were optimized with the TPS Pinnacle 9.8 from Philips and consisted of 4-7 arcs of a maximum delivery time of 25s each. Daily positioning was controlled before each treatment with the Elekta Agility 160, with a fast XVI Cone Beam CT in 2 or 3 intervals.

Results: The mean heart dose was reduced at 1.7±0.9Gy for left sided breast and at 2.4±0.9Gy for bilateral breast irradiation with non-existing V20 and V30. The PTV coverage was achieved in all cases with 95% of the volume covered by 95% of the prescribed dose. The ipsilateral lung received a V20, V10 and V5 of 10.4±5Gy, 19.5±6Gy and 33±10Gy, respectively. The controlateral breast received an acceptable mean dose of 1.2±0.8Gy.

Conclusions: The VMAT-DIBH technique is a non-costly method which is easy to implement. A good PTV coverage is achieved with important dose reduction at the heart, while preserving lungs during the breath hold.

5.4_Intraindividual comparison of 11C-Acetate and 18F-Fluorocholine PET/CT and PET/MRI studies for early recurrent prostate cancer after primary treatment

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Aims: To assess the intra-individual performance of 18F-fluorocholine (FCH) and 11C-acetate (ACE) PET studies for restaging of recurrent prostate cancer (PCa), to correlate PET findings with long term clinical and imaging follow-up (FU) and to evaluate the impact of PET results on patient management.

Methods: Thirty-three PCa patients (pts) relapsing after radical prostatectomy (RP) (n=9) (PSA ≤ 3 ng/ml), primary radiotherapy (RT) (n=8) (PSA ≤ 5 ng/ml), or RP + salvage RT (n=15) underwent ACE and FCH PET-CT (n=29) or PET-MR (n=4) studies in a randomized sequence 0 to 21 days apart.

Results: The positivity rate for ACE was 66% (69% for PET-CT and 50% for PET-MR) and for FCH was 60% (59% for PET-CT and 75% for PET-MR). Results were concordant in 79% of the cases (26/33) and discordant in 21% (retroperitoneal, n=5; pararectal, n=1; and external iliac nodes, n=2). After a median FU of 41 months (n=32, one patient lost to FU), the site of relapse was correctly identified by ACE and FCH in 53% (17/32) and 47% (15/32) of the pts, respectively (2 M1a patients ACE+/FCH-), while in 6/32 pts the relapse was not localized. Based on PET results, treatment approach was changed in 13 pts (41%): 11 pts were treated with a curative intent for oligometastatic progression (n=8) or local recurrence (n=3) after RT and/or RP + salvage RT, while in 2 relapsing RP pts the RT plan was modified to include pelvic nodes or to boost a local relapse.

Conclusions: In pts with early recurrent PCa, ACE and FCH showed minor discrepancies, limited to nodal staging and mainly in the retroperitoneal area, with true positivity of PET findings confirmed in half of the cases during FU. Treatment approach turned out to be influenced by ACE or FCH PET-CT studies in more than one third of the pts.

5.5_Potential of computed tomography with iterative metal artifact reduction algorithm for proton therapy of patients with metal implants

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Metal implants introduce substantial uncertainties in proton dose calculation. Such effect could be compensated by manually overriding artifacts' CT numbers or using iterative metal artifact reduction (iMAR) for CT reconstruction. We investigated the potential of iMAR in an experimental scenario.

We simulated a cervical spine chordoma PTV in an anthropomorphic head phantom, which embeds a titanium rod implanted in a cervical vertebra. A single fraction (2 GyRBE) of a clinical IMPT treatment (Fig1, a) was optimized respectively on a CT without and with manual artifact correction, as well as with iMAR based reconstruction.

Residual positioning errors were within 0.6 mm and 1˚ in all directions, for all the deliveries. We compared planned and measured dose distributions using GafChromic films EBT3 inserted in three sagittal planes. The medial plane exhibits the largest differences (Fig1, b-d). In addition, we measured under-dosage of approximately 0.8 Gy for all the deliveries in this plane, possibly due to residual positioning errors combined with dose calculation inaccuracies at bone/air interfaces. For the uncorrected plan the effect of the artifacts resulted in distal over-dosage up to 0.5 Gy. Considering the other two sagittal planes, the differences between calculated and measured dose distributions are comparable.

Based on this preliminary analysis, iMAR shows potential to be used as an easy and fast alternative to manual artifact delineation for proton therapy in presence of metal artifacts.

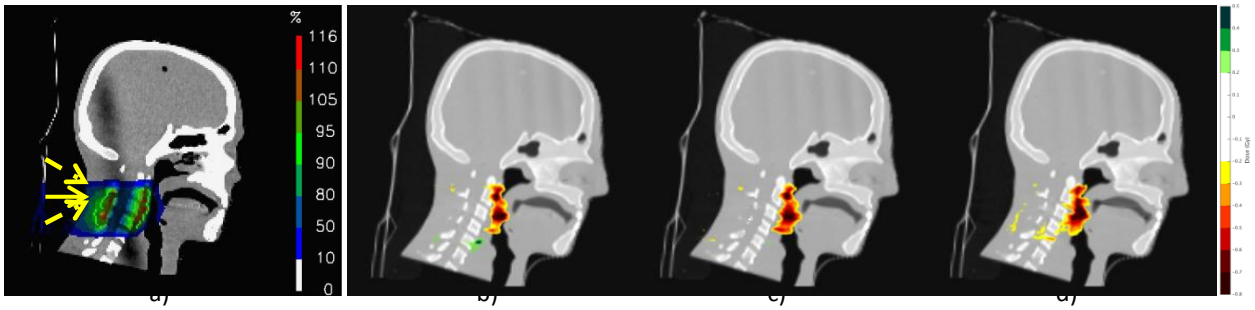

Fig 1 - (a) Sagittal dose distribution and field orientation (one posterior-anterior and two at ±30° from median plane) for the central slice of the phantom. Uncorrected (b), manually corrected (c) and iMAR (d) dose differences between measured and calculated.

6.1_Krebs? Das Krebstelefon ist da mit Wissen und Fürsorge

A Zahno, Leiterin Krebstelefon, Krebsliga Schweiz

No abstract

6.2_Evidenzbasierte Pflege – Entzauberung der Wissenschaft

A Gutierrez, Klinik Hirslanden, Aarau, Schweiz

No abstract

6.3_Natürlich essen während der Strahlentherapie – Vortrag mit Kostproben

E. Fischer, Autorin von Kochbüchern und Essensratgebern, *Wien, Österreich*

No abstract

6.4_Mepitel Film vs standard treatments for the prevention and cure of skin toxicity in postoperative treatment of breast cancer: a phase III study.

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Aims: Verify the clinical efficacy, the patients satisfaction and the costs of a dressing (Mepitel Film) in prevent or reducing the radiation-induced skin reaction (acute and chronic) in breast cancer patients.

Methods: We defined a randomized controlled trial (phase III) to compare two different type of dressing:

- group 1: use of acqueous creams as defined in SASRO guidelines;
- group 2: use of Mepitel Film from the first session of Radiotherapy to at least 1 week after the end of treatment.

Primary endpoint:

- *Clinical* - Incidence of moist desquamation (G2) in the two groups.

Secondary endpoints:

- *Humanistic* - Patient satisfaction scores collected during and after the end of treatment by Visual Analogue Score (VAS) for pain and final questionnaire.
- *Economic* - average total cost of the two treatments (in Swiss Francs).

According to the study of Herst et al. (2014), we expect a proportion of moist desquamation in nearly 20% of patients in the control group vs nearly 5% in the treatment group (Mepitel Film). Therefore a biostatistician calculated the sample size (82 patients in each groups). Eligible and consenting women are randomly assigned to one of two groups. Acute skin reactions are weekly evaluated during the treatment up to nearly one month. Late skin toxicity will be assessed 6 and 12 months after the end of radiotherapy. Radiation toxicity was graded according the RTOG criteria and documented with photos.

Results: The patients accrual has been started on February 2016. We have already randomized 10 patients. The protocol adherence of these early patients was good and we haven't found peculiar problems in their management.

Conclusions: This project, shared by nurses and doctors, is an example of evidence-based practice and use of research for improving the quality of life for patients. Currently, no conclusion can be drawn because the trial is still ongoing.

7.1_Prone breast automatic segmentation of organs at risk including heart and coronary vessels: similarity indexes, contouring times and dose volume parameters

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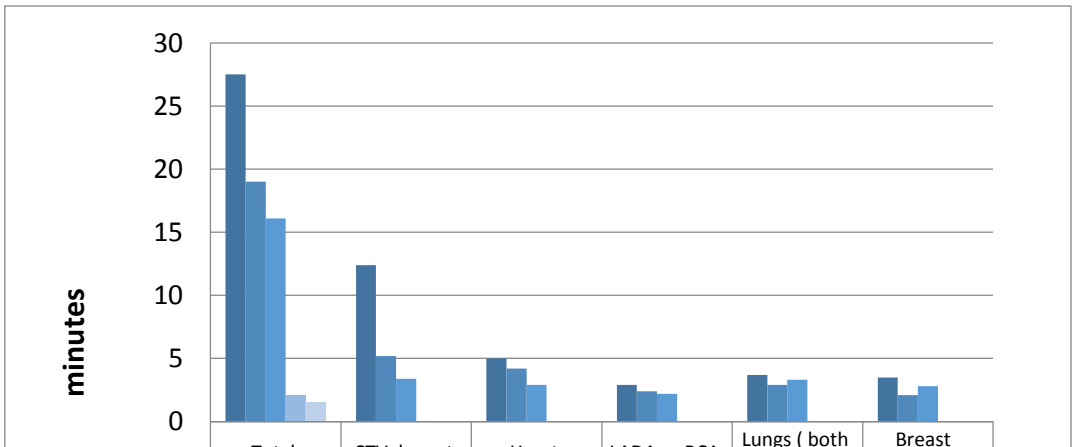
Objective: To investigate the effects of different parameters on atlas sampling for automatic-segmentation (AS) in prone breast cancer planning.
Methods: Two sets of contours of organs at risk (OAR) and CTV were generated using AS on 27 patients (pts) with selected atlas cases to match test pts sampled either stratifying by breast volume (AS1) or by breast cup size and body mass index (BMI), (AS2). The common atlas contained 13 pts, with just one extra for AS2 sampling. The AS structures were then edited by a senior radiation-oncologist (Sr): AS1 Edit and AS2 Edit. All structures were compared to reference manual delineations (MS) done by the Sr to calculate Dice, and other indexes. Contouring/editing times were registered. Finally the AS dosimetric values (mean dose (%), the percentage of dose to 2%, 5% and 10% of structure volume) were analyzed compared to MS.
Results: Respect to AS1, AS2 heart mean Dice and sensibility increased from 0.89±0.03 to 0.91±0.01, and 0.88±0.05 to 0.92±0.04, respectively ($p<0.01$). For the left anterior descending artery (LADA), LADA+1cm margin, the right coronary artery (RCA) and, RCA+1cm margin, even AS2 structures presented a low Dice. Lungs and the contra-lateral breast edited from AS2 were optimal. Edited CTVs were similar. Contouring with AS2 with structure editing was 35% less time consuming than MS for all OAR ($p<0.01$), see Table. When comparing the dose distribution of AS structures versus manual, AS2 decreased the mean dose difference for D10 and Dmean of heart ($p<0.05$) as compared to AS1 and was also able to reduce the standard deviation of LADA, LADA+1cm and, RCA. With the exception of heart for mean doses, structures' editing was necessary to obtain dose distributions similar to MS for most OAR.
Conclusions: Breast cup-size and BMI are more reliable parameters than breast volume to sample the atlas for AS. The AS2 heart may be used unedited to estimate mean doses, while wire-form structures, LADA and RCA, need a larger atlas population to improve Dice values.



	Total	CTV_breast	Heart	LADA or RCA	Lungs (both sides)	Breast contrallater
Manual contour	27.5	12.4	5	2.9	3.7	3.5
AS1 Edit	19	5.2	4.2	2.4	2.9	2.1
AS2 Edit	16.1	3.4	2.9	2.2	3.3	2.8
AS1	2.1	0	0	0	0	0
AS2	1.5	0	0	0	0	0

7.2_Estimation of late effects for MERT and photon plans in radiotherapy of the breast and chest wall

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No abstract

7.3_PET/CT-guided SIB-IMRT Combined with Concurrent 5-FU/MMC for the Treatment of Anal Cancer: a Single Institution Experience

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Aims: To evaluate local control, survival and toxicity in anal cancer patients treated with PET/CT-guided intensity-modulated radiation therapy (IMRT) and concurrent chemotherapy at a single institution.

Methods: From August 2010 to May 2015, 26 consecutive patients with localized squamous cell carcinoma of the anal canal (SCCAC) were treated with IMRT and concurrent 5-fluorouracil/mitomycin-C (5-FU/MMC), and retrospectively evaluated. Initial staging was based on PET/CT and MRI. Radiotherapy (RT) at a dose of 50.4 – 59.4 Gy was delivered with a simultaneous-integrated boost (SIB-IMRT). Endpoints were local control (LC), overall survival (OS), disease free survival (DFS), colostomy free survival (CFS) and toxicity.

Results: Median age was 61 years, 85% were female, and 50% had advanced (stage III) disease. PET/CT was the most accurate imaging modality for nodal staging, having an impact on nodal boost volume delineation and/or RT dose definition in 9/23 patients (39%). MRI was more accurate at identifying T4 disease. RT was delivered at full dose in 96% and 5-FU/MMC in 85% of cases. Only 2 patients (7.7%) required RT breaks. After a median follow-up of 35 months, the 2-year LC, OS, DFS, and CFS were 100%, 100%, 100% and 85%. Acute grade 3-4 dermatitis, proctitis or neutropenia occurred in 73%, 8% and 43% of cases. A total of 4 patients (15%) developed chronic grade ≥ 2 GI toxicity.

Conclusion: PET/CT leads to significant changes in both target volume delineation and final treatment dose in 39% of cases, and should be included as standard staging and planning procedure for any SCCAC patient. SIB-IMRT with 5-FU/MMC is feasible and results in excellent LC and survival outcomes, if all efforts are being made to minimize RT interruptions.

7.4_Radiomics of CT perfusion maps

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Department of Radiation Oncology, University Hospital Zurich, University of Zurich, Switzerland (1) Department of Nuclear Medicine, University Hospital Zurich, University of Zurich, Switzerland (2) Department of Diagnostic and Interventional Radiology, University Hospital Zurich, University of Zurich, Switzerland (3) Department of Nuclear Medicine, University Hospital Bonn, Germany (4)

Aim: This study aimed to test the tumor control predictive value of radiomics features computed on pretreatment CT perfusion maps after a preselection of features in a robustness study regarding perfusion calculation factors.
Methods: 11 patients with head and neck cancer (HNC) and 11 patients with lung cancer were included in the robustness study to preselect stable radiomics features. Data from 36 HNC patients treated with definitive radiochemotherapy was used to build a predictive model based on these parameters. 315 radiomics features were computed for three perfusion maps: blood volume, blood flow and mean transit time. The variability of radiomics features was tested with respect to non-standardizable (noise level and artery contouring) perfusion computation factors using intraclass correlations (ICC). The parameter with the highest ICC in the correlated group of parameters was tested for its predictive value. Final model to predict tumor control was built using multivariate Cox regression analysis with backward selection of the variables. It was compared with a tumor volume-based model.
Results: Ten parameters were found to be stable in both HNC and lung cancer after the correction for inter-parameter correlation. In the multivariate backward selection of the variables, blood flow entropy showed a significant impact on tumor control ($p=0.03$) with concordance index (CI) of 0.76. Control rate at 18 months was significantly lower in patient group with lower blood flow entropy $p<0.1$ (Fig. 1). The new model showed a higher CI in comparison to the tumor volume model (CI= 0.68).
Conclusion: The preselection of variables in the robustness study allowed building a predictive radiomics-based model of tumor control in HNC despite a small patient cohort. This model was found to be superior to a volume-based model.

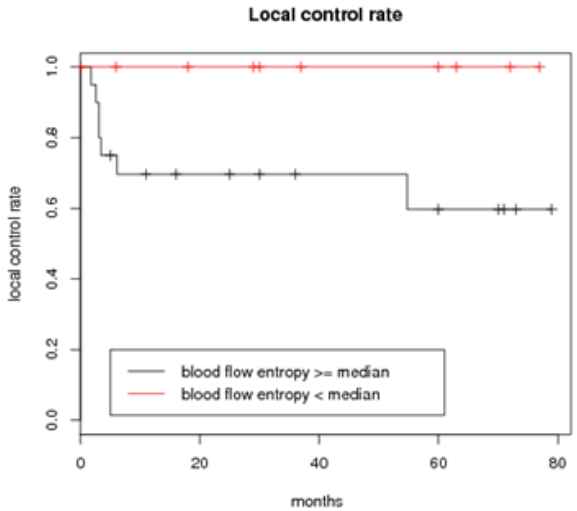

Figure 1. Tumor control rate as a function of blood flow entropy, curves are different at the significance level of 0.1.

8.1_Clinical implementation of an optical surface monitoring system (OSMS®, Varian) in breast irradiation

A.Tini, I. Pytko, S.Lang, C. Winter, M. Guckenberger, C. Linsenmeier

Department of Radiation Oncology, University Hospital Zürich, Switzerland

Aims: The optical surface monitoring system (OSMS®) was implemented in our clinic to improve our daily radiation therapy workflow, to avoid frequent repositioning and unnecessary skin marks on breast cancer patients.

Methods: 32 breast cancer patients, with a total of 513 fractions, were treated using OSMS® and 3D tangential fields. They were positioned supine, on the C-QualTM Breastboard (CIVCO® Medical Solutions). The patients' reference surface was imported from the CT scan to OSMS® and region of interest was selected. 3 different positioning methods were used. 6 patients (124 fractions) were aligned according to the CT and isocenter skin reference marks (group A). 9 patients (124 fractions) were positioned additionally with OSMS® (group B). 4 patients (96 fractions) were directly set up with OSMS® (group C). After aligning the patient, MV imaging and bone match on the chest wall were used to correct for positioning error. The OSMS® deltas acquired before performing the couch shifts were assessed against MV imaging results for every patient to compare the two methods. The average treatment offset based on the OSMS® deltas acquired after performing the couch shifts, was calculated for every patient separately.

Results: The most suitable ROI was found to be the irradiated breast itself, excluding the shoulder and clavicular region, but including a 2 cm margin of chest wall surrounding the breast. Positioning based on OSMS® was in good agreement with the positioning based on MV imaging. The mean 3D deviation between the two techniques for group B and C was 3.3 +/- 2.0 mm and 3.2 +/- 2.0 mm, accordingly. This was superior to positioning based on patient skin marks alone (5.4 +/- 2.8 mm). The average 3D treatment offset based on the OSMS® deltas was 5.6 +/- 2.8 mm (A), 3.3 +/- 1.7 mm (B), 3.6 +/- 1.9 mm (C).

Conclusions: According to our preliminary data-patient positioning based on OSMS® is easy, time efficient and reproducible. Additionally, patient skin marks can be avoided. More data will be collected to confirm these findings. In the future we plan to use the OSMS® system for deep inspiration breath hold techniques and the set-up of extremities.

8.2_Stability In Positioning For Lung Radiosurgery (SBRT) Patients

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Aim: A large number of departments position their lung SBRT patients using some kind of fixation. To be certain that using a frameless positioning in combination with a free-breathing (FB) technique is stable enough to treat lung SBRT patients an intrafraction stability study has been done.

Method: 10 patients were positioned on a wingboard (Unger), in combination with a thin mattress and head cushion. The patients were treated with the current protocol used by Kantonsspital Aarau, 5 fractions of 1100cGy. Before treatment each patient received a 4-D Planning CT and this scan was used to contour an internal target volume (ITV). A Cone-Beam CT (CBCT) was made before every treatment to determine the difference in positioning between Planning CT and treatment. An ITV match was used to define the shifts and the table was then shifted in the right position for treatment. Another CBCT was made after every fraction to determine the movement of the patient during the treatment. An ITV match was again used to determine the intrafraction motion.

Results: The deviation of the patients during the treatment is shown in figure 1. In vertical direction there are 26 fractions (59%) with no intrafractional deviation and a mean deviation of -0,7 mm. In longitudinal direction there are 32 fractions (73%) with no intrafractional deviation and a mean deviation of 0 mm. In lateral direction there are 31 fractions (70%) with no intrafractional deviation and a mean deviation of 0 mm. The mean vector is 1,4 mm.

Conclusion: The intrafraction stability of FB lung SBRT patients wich are frameless positioned using a wingboard is on average 1.4 mm ±1.7. This fulfils our stability requirements.
The range of motion is the biggest in vertical direction with a standard deviation of 1.4 mm, this is the direction of the breathing motion, this could explain the bigger deviation in this direction and it can't be overcome with a FB technique. Another explanation could be that the patients get more relaxed during the treatment because we can see that almost all of them move in the dorsal direction.

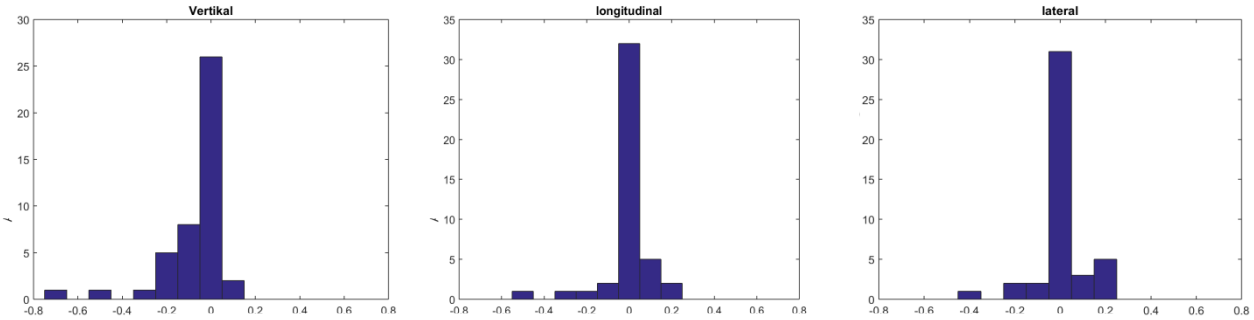

Figure 1 Number of fractions against the deviation in cm, in vertical, longitudinal and lateral direction

8.3_Validation of patient preparation and setup verification in SBRT for liver tumors – Case report.

Panizza D[1], Colleoni P[1], Yordanov K[2], Valli MC[2], Pupillo F[1], Gaudino D[1], Moretto S[2], Rottoli G[2], Presilla S[1], Richetti A[2].

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Aims: To report our initial experience on patient preparation and setup verification for SBRT liver-confined disease.

Methods: We present our patient preparation and set-up verification procedure performed for hepatocellular carcinoma treatment. For the patient immobilization we used a vacuum pillow and an abdominal compression belt, aimed at decreasing the respiratory motion related to diaphragm. CT images were acquired with tailored 4D-CT protocol and with intravenous contrast medium enhancement. During a dry run before the treatment planning, the patient positioning was verified using co-registration between radiographic oblique kV imaging and digitally reconstructed radiography from the planning CT to determine the actual position of the liver volume: we performed a marker-based verification using previous chemoembolization implants as fiducial surrogates. After making a radiographic-based shift an additional kV cone beam CT was done, to confirm the proper position of the organs at risk with respect to the liver on the basis of soft tissue localization. After adapting isocenter, we evaluated the residual liver motion by fluoroscopic acquisition (FA) with the patient in the treatment position.

Results: FA highlighted a residual respiratory liver motion of 6 mm in craniocaudal direction. Imaging analysis showed proper choice of planning target volume margin to account for the residual motion.

Conclusions: The adopted protocol is appropriate and can be implemented in clinical practice for the majority of such patients. In case of inconsistency between planned volume and detected target the procedure should be repeated. Literature analysis of liver SBRT protocols showed that ours approach has the potential for ensuring the effective and patient-friendly delivery.

8.4_Multi radiotherapy modalities treatment for multi targets in malignant pheochromocytoma setting - *Case Report*

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Purpose/objective This case report regards a 46-year-old male patient, known for malignant pheochromocytoma of the left adrenal gland, initially treated by nephrectomy in 2011. He has been metastatic since 2012 and was treated multiple times with surgery and metabolic radiotherapy. A local relapse in 2014 was operated with close margins (R1) and at the time, we gave adjuvant radiotherpay with Tomotherapy with a SIB (simultaneous integrated boost) scheme of 10x3.5/5 Gy. In 2016, the patient presented multiple metastatic lesions (thorax, abdomen, spine and right leg) and there are no treatment options left other than radiotherapy. We wished to determine the adequate CT planning set and treatment techniques suitable for this clinical situation.

Material/methods In total, 15 lesions were defined. For thoracic and abdominal lesions, the PTVs were defined based on an ITV (internal target volume) strategy, where we performed an expirium, inspirium and free breathing CT scan. Because the ITV volume was too large for the thoracic lesions, we decided to perform a CT scan with the ABC system (Active Breathing Coordinator, Elekta). VMAT plans were created using Monaco treatment planning system (Elekta) to treat 4 lesions located in the lungs and liver with the prescription of 5x7 Gy. One lung lesion was located in left inferior lobe near the stomach and esophagus which had both received radiation in 2014 and we decided to treat it by CyberKnife (Accuray) with fiducial tracking. The plan was created with Multiplan (Accuray) to give 8x4 Gy. Tomotherapy plans were created using Tomotherapy treatment planning system (VoLo, Accuray), to treat the lesions located at left chest wall, right gluteus (5x7 Gy), vertebra (5x5/7 Gy), psoas and para-aortic nodes (5x6 Gy). To estimate the composite dose and analyze the OAR (Organ At Risk) tolerance doses, we used Velocity AI software.

Results The OAR tolerance doses were checked using an in-house dose tolerance protocol, inputted into Velocity AI software. The dose to the remaining kidney was kept to a strict minimum with a composite max dose of 4 Gy and a mean dose of 0.74 Gy. We determined that the treatment was possible and the patient was treated on all of his lesions.

Conclusion This case represented a very complex clinical/technical situation. The workload and time used were important. We accepted to treat because of the clinical context and the fact that we were able to treat with precision.

Key-words: re-irradiation, composite plan, precision, pheochromocytoma

8.5_Hypofractionated stereotactic radiotherapy feedback for the treatment of liver tumors using Backup Gating and Auto Beam Hold

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HUG Radio-oncologie Genève

Introduction: The objective is to share a treatment technique of hypofractionated stereotactic body radiation therapy for liver tumors using the TrueBeam ™ (Varian Medical Systems).

Materials and Methods: Between May and December 2015, six patients were treated for liver cancer with SBRT in Geneva University Hospital. Two types of lesions were radiated: hepatic metastasis of digestive cancer and primitive tumors. The treatement consisted of 45Gy, in three 15Gy doses. The liver is located in a highly active area of the body, therefore breathing and peristalsis must be considered. We used two systems to prevent error in the dose distribution. The first tool we used to improve accuracy was radio-opaque markers (visicoils) which were implanted in the liver before the simulation. The second tool used for this treatment was the CT4D. The goal was to perform computer tomography pictures synchronized with a system that allows us to measure the breathing movement. At the end of the exam, we saved the breathing curves for each phasis of the breathing. Capturing patient thorax movement is essential to producing a breathing curve. We used a block that we placed on the patient's abdomen so the camera could measure the breathing movement represented by the movement of the block. This system is called Real-time Position Management (RPM, Varian). This system is synchronized with the CT scan and the irradiation is initiated. Before the irradiation it is important to detect a regular breathing rythme so as to be the most accurate. At the end of the irradiation the computer reconstructs the images for each phase represented by the same point for each curve. The threshold of tolerance depends on the amplitude of the breathing curve.

Results: This results in 50% decrease in average duration positioning and treatment between the 1st, 2nd and 3rd session (58, 28 and 27min respectively). The respiratory curve is not constant from one session to another. Sometimes the algorithm of the ABH does not detect visicoils although they appear to be in the correct position.

Conclusion: We reached our objective, which was to treat a moving target in optimal conditions. In a localisation such as the liver, movements can distort the dosimetric prevision. If the patient breathes inconsistently, this treatment may not be possible. In order to get the most reproducible breathing curve, it is essential to find the most comfortable position for the patient. We still need to work on the technique we use to record the breathing curve so that it is as accurate as possible.

9.1_Implementation of a complete time-effective dosimetric verification system for the commissioning and routine verification of Multiple Metastases Element (BrainLab)

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RadioOnkologieZentrum, KSA-KSB, Kantonsspital Aarau, Aarau

Aim: The Multiple Metastases Element by BrainLab (MME) is a stereotactic planning system that uses multiple inversely optimised single isocenter dynamic conformal arcs (SIDCA), to treat up to 10 brain metastases. The traditional verification system of film dosimetry and small volume detectors (ionization chamber, diamond detectors, etc), is not only cumbersome and very time consuming, but also becomes technically impractical when the number of lesions to be verified increases (>3). A combination of Portal Dosimetry (PDIP, Varian) and an independent 3D dose recalculation of the plan (Mobius 3D), (PD_Mob), has been the chosen method to commission MME.

Method: 5 patients (2, 3, 7, 9, and 10 metastases respectively) were planned with the MME software and dosimetrically verified with a previously validated (20 PTVs and 64 arc beams) PD_Mob system. The 31 MME lesions ranged from 0.3 to 7.4 cc, with an average value of 1.9±1.4 cc.

Results: Mobius showed an average gamma passing rate of 99.7±0.9% (3%, 1mm) within the PTVs, and the 32 required arc fields were analysed with the Varian PDIP software leading to an average gamma passing rate of 99.2±0.8% (2%, 1mm, absolute normalisation, MLC+0.3mm analysis area). The physics verification and machine QA time has dropped by a factor greater than 2, from around 180-225 min with EBTfilm/diamond chamber system to some 80-115 min with PD_Mob, for a single lesion, with a rapidly increasing favourable trend towards the PD_Mob system when the number of lesions increase.

Conclusion: An alternative to the traditional EBT_DC verification system that allows complete verification of a multiple stereotactic brain metastasis plan with up to 10 lesions has been successfully implemented with a significant reduction in the Physics and machine time.

9.2_Benchmarking an automated planning tool for multiple brain metastases against an established multiple isocentre dynamic conformal arc technique

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Radio-Onkologie-Zentrum KSA-KSB, Kantonsspital Aarau

Aim: A new commercial planning tool (Multiple Metastases Elements, MME, BrainLab) dedicated to automatically producing plans for multiple brain metastases, using a single isocentre and multiple inversely optimised dynamic conformal arcs, is compared with the multiple isocentre dynamic conformal arc (MIDCA) technique used until now (iPlan, Brainlab).

Method: 8 patients treated with a number of lesions varying from 2-9 were planned using both the MIDCA method and the new single isocentre MME tool. The plans were evaluated using typical indices to assess plan quality (Paddick conformity index, CI, gradient index, GI), V12Gy, the low dose spread, V5Gy, as well as the planning time and the treatment delivery time.

Results: Mean CI was found to be similar using both tools (CI_{MME} 0.70±0.08, CI_{MIDCA} 0.6±0.12), as was GI (GI_{MME} 3.9(±0.9), GI_{MIDCA} 3.5(±0.7)). The normal brain tissue dose V12Gy showed little difference between the techniques. The mean low dose spread was 10 -15% greater for MME than for MIDCA. The typical treatment time depends primarily on the total number of arcs used (MIDCA: 6-27, MME 4-9). The total monitor units delivered is significantly lower for MME plans (2.5 to 4 times lower).

Conclusion: Both planning tools achieved conformal plans with steep dose fall-off, however the MME plans were more efficient both in terms of the time taken to plan and also the time needed to deliver the treatment. As the number of lesions increases the plan optimisation becomes challenging with MIDCA and can result in variable plan quality. In this case, the MME plans have a tendency towards improved CI, GI and low dose spread. When combined with an efficient plan verification method, this tool should make radiosurgery of multiple metastases a viable treatment approach.

9.3_High dose-per-pulse electron beam dosimetry – A saturation model for the Advanced Markus ionization chamber

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Aims: Similar to other ionization chambers, the Advanced Markus saturates during measurements in high dose-per-pulse (D_p) beams. The aim was to model how the chamber saturates as the D_p is increased, and to compare it to calculations using two-voltage-analysis (TVA), the Boag models, and the Burns and McEwen (B&M) equation.
Methods: Two independent methods were used: 1) Varying the output of the linear accelerator (linac) and measuring its relative effect on chamber response at different source-to-surface distances (SSD). 2) Simultaneous dose measurements, chamber together with dose rate independent Gafchromic™ EBT3 film, in beams with varying D_p (10^{-4}-10^{1} Gy), by varying the linac gun grid tension (controls output) and the SSD.
Results: The chamber saturation increased (ion collection efficiency decreased) as the D_p increased. The Boag models agreed with the data, but only for a low polarizing chamber voltage (U=50 V). The TVA method and the B&M equation only agreed with the data at low D_p values (≤10^{-2} and ≤10^{-1} Gy, respectively). An empirical model of the saturation was found by fitting a logistic function to the data (Figure).
Conclusions: The Advanced Markus ionization chamber saturates but remains functional for dose measurements in beams with high D_p values, if the saturation is taken into account. The limitations of the tested saturation models motivate the use of an empirical model for measurements in high D_p beams. The model depends on the D_p and the polarizing chamber voltage.

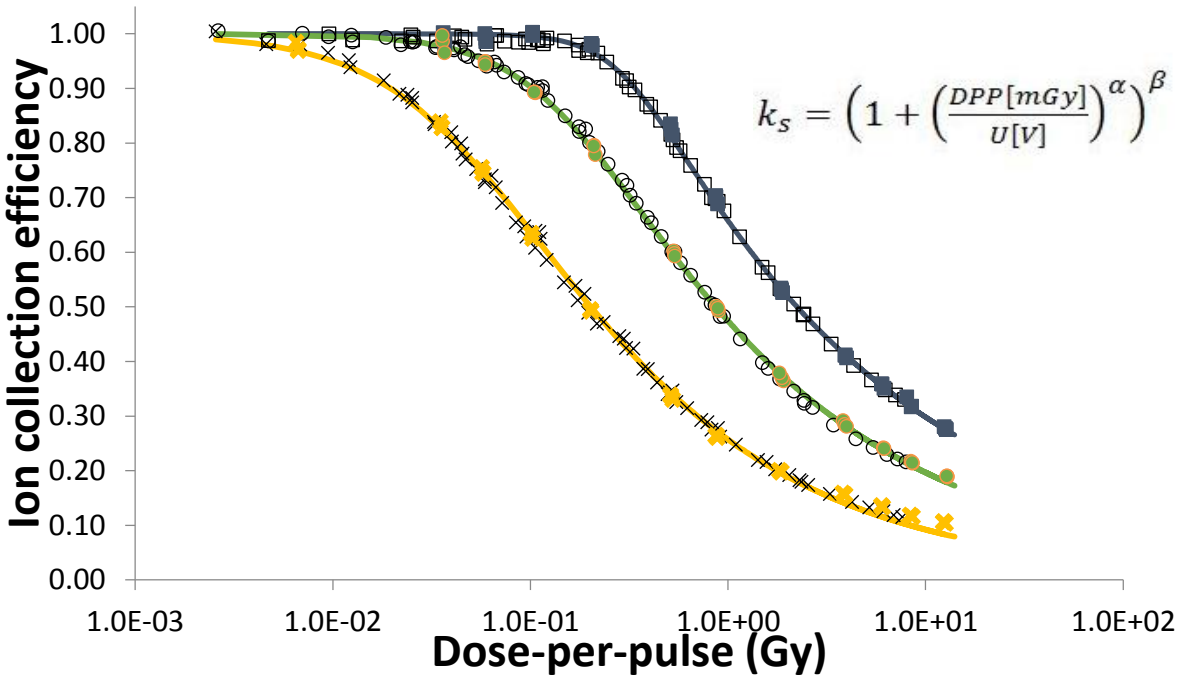

Figure: The ion collection efficiency ($1/k_s$) as a function of the dose-per-pulse according the two measurement methods (1-open, 2-filled symbols), and the logistic function (lines) fitted to the data points, for a polarizing voltage (U) of 50 (crosses), 150 (circles), and 300 V (squares).

9.4_Electron dosimetry with Gafchromic EBT3 films: energy and dose-rate dependence

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The aim of this study was to assess the suitability of Gafchromic EBT3 films for absolute dosimetry in the beam of a prototype high dose-per-pulse linac able to deliver electron beams with dose-rate ($\dot{D}$) up to $8 \cdot 10^6$ Gy/s. To this purpose, we evaluated the overall uncertainties in EBT3 dosimetry as well as the energy and dose-rate dependence of their response.

Uncertainty sources in EBT3 dosimetry were analyzed using irradiations at a clinical radiotherapy linac. Energy dependence was investigated with the same machine by comparing calibration curves acquired at different beam energies (4, 8 and 12 MeV). $\dot{D}$ dependence was probed at the prototype, for $\dot{D}$ ranging from $7 \cdot 10^3$ to $8 \cdot 10^6$ Gy/s. This was first performed by studying the correlation between doses measured by films and the charge of electrons measured at the exit of the machine by an induction torus. Films were also compared to independently calibrated thermo-luminescent dosimeters (TLD) that have been reported as being $\dot{D}$ independent.

We showed that uncertainty below 4% (k=2) can be achieved for doses between 3 and 17 Gy. Results also demonstrated that EBT3 films did not display any detectable energy dependence for electron beam energies between 4 and 12 MeV. Excellent consistency between films and TLD was obtained over the entire $\dot{D}$ range attainable at the prototype linac confirming the absence of any dose-rate dependence within the investigated range. This aspect was further corroborated by the linear relation between the dose per pulse measured by films and the charge per pulse measured at the linac exit.

Our study shows that EBT3 films can be used for absolute dosimetry in pulsed electron beams with high dose-rate. The measurements are associated with an uncertainty below 4% and are dose-rate and energy independent.

9.5_Comparison of photon MLC and cut-out collimated electron beams for standard electron treatments

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Aims: For the collimation of electron beams, the photon multileaf collimator (pMLC) is an alternative to patient specific molded cut-outs to optimize clinical workflow. In this work, the dosimetry of pMLC and cut-out collimated electron beams are compared for standard electron treatments.

Methods: For comparison, depth dose curves and dose profiles are measured for electron beams delivered with cut-out collimation and a source to surface distance (SSD) of 105 cm and with pMLC collimation with SSDs of 70, 80, 90 and 100 cm using the same field size at water surface (4.2 x 4.2 cm^2 and 9.8 x 9.8 cm^2). The measurements are performed in water for all available energies of three Varian treatment units (Clinac23iX, Novalis Tx and TrueBeam). Dose distributions of single electron field plans were compared for six clinical breast cases using the Varian eMC 13.6 and an in-house Monte Carlo algorithm for dose calculation of cut-out and pMLC collimated electron beams, respectively.

Results: Dose differences and distances to agreement in the relative depth dose curves are within 3% / 3 mm for all beam setups. The penumbra of the dose profiles are larger for pMLC than for cut-out collimation and increases remarkably with increasing SSD. For all the investigated clinical cases, a comparable dose homogeneity and a slightly worse dose conformity is achieved with pMLC collimation and an SSD of 70 cm compared to cut-out collimation.

Conclusion: The results suggest that pMLC collimation of electron beams with an SSD of 70 cm is appropriate for standard electron treatments. However, an SSD > 70 cm is only appropriate if compromises in the dose conformity in lateral direction can be accepted.

10.1_The role of the MET receptor tyrosine kinase in tumor resistance to radiation therapy: a phosphoproteomic approach

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Aims: Accumulating data suggest that aberrant MET signalling confers tumor resistance to DNA damaging agents (DDAs), potentially through the modulation of key players of the DNA damage response (DDR) machinery. However, the molecular pathways underlying the MET-DDR link remain currently unknown. Therefore, the major aim of this project is to identify the key players involved in the MET-DDR crosstalk, which could serve as predictive phosphosignatures. Moreover, we aim to investigate MET addiction further, as oncogene addiction constitutes the rationale behind newly developed anticancer therapies and little is known of the molecular mechanisms responsible for this phenomenon.

Methods: We performed a targeted proteomics approach based on Selected Reaction Monitoring (SRM) in order to monitor phosphorylation changes of 120 candidate proteins in nine MET-positive cellular models upon MET inhibition (METi), alone or in combination with ionizing radiation (IR).

Results: METi and IR appear to regulate the phosphorylation status of a subset of analyzed proteins in a synergistic manner in MET-addicted cellular models. Moreover, METi alone seems to control the phosphorylation status of key players of DDR signaling pathways in MET-addicted cell lines. Remarkably, not only crucial regulators of DDR-related processes, but also key nodes of a plethora of other cellular processes seem to be regulated in MET-addicted cellular models upon METi.

Conclusion: In-depth data analysis allowed us to identify predictive phosphosignatures that characterize MET-addicted *vs*. not MET-addicted cellular models, are descriptive for their phenotypic response to METi, alone or in combination with IR, and have the potential to shed light on the molecular mechanisms of the phenomenon of oncogene addiction.

10.2_Involvement of MET signaling in the HIF-1α pathway

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Aims: Poor oxygenation is a common biologic feature involved in aggressive manifestations of solid tumors. Hypoxic areas of tumors have been reported to overexpress the MET tyrosine kinase, a high affinity receptor for hepatocyte growth factor (HGF). As both MET and hypoxia are determinants that affect cellular responses to DNA damaging agents, we aimed to elucidate the effect of MET inhibition on MET-overexpressing tumor cell lines under hypoxic conditions.

Methods: MET-overexpressing cancer cell lines were exposed to a hypoxic environment (1.5% O_2) and MET was inhibited by a highly specific pharmacological inhibitor. Transcription of genes of interest was assessed by qRT-PCR and expression of proteins by western blotting or immunohistochemistry. A 3D *ex vivo* model consisting of organotypic xenograft tissues was used to confirm the *in vitro* observations.

Results: MET inhibition reduces the protein levels of the key hypoxic regulator HIF-1α and its targets. Receptor targeting seems to interfere with translation of HIF-1α through reduction in phosphorylation of the eukaryotic translation initiation factor eIF4G1. This phenomenon can be observed not only in 2D cell line cultures, but also in a 3D *ex vivo* model.

Conclusion: We have identified a link between MET and HIF-1α signaling which is likely to be important in tumor progression. Interruption of this pathway using MET inhibitors may contribute to antitumor activity of these agents in hypoxic malignancies, leading potentially to better therapeutic outcomes.

10.3_Regulation of the Oncogene Carnitine Palmitoyltransferase 1C under Hypoxia involves HIF1-alpha and p53

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Institution: Department of Radiation Oncology, Inselspital, Bern University Hospital, and University of Bern, Switzerland

Aims: We identified carnitine palmitoyltransferase 1C (CPT1C) as a novel p53 target gene. In addition we found that CPT1C acts as an oncogene by promoting cell survival under hypoxia and tumor growth *in vivo*. The mechanism by which CPT1C shows this strong phenotype is uncertain. In this study, we focus on investigating the regulation of this gene upon hypoxia.

Methods: Mouse embryonic fibroblasts (MEF) from wildtype and p53 null mice as well as MEFs depleted of the hypoxia-inducible factor 1 alpha (HIF1 alpha null) were treated with hypoxia (1.5 % or 0.2 % oxygen) or hypoxia-mimicking agents (100 µM cobalt chloride or 1 mM DMOG). RNA and protein expression was measured by quantitative PCR and western blotting, respectively.

Results: CPT1C expression was upregulated in a time dependent manner under severe hypoxia (0.2 % oxygen), a condition in which both pathways, HIF1 alpha and p53, were activated. This CPT1C upregulation was dramatically attenuated in HIF1 alpha null MEFs and was completely abolished in p53 null MEFs. However, expression of CPT1C was not affected under conditions in which only HIF1 alpha was activated, i.e., either mild hypoxic condition (1.5 % oxygen) or treatment using hypoxia-mimicking reagents.

Conclusion: Our results suggest both HIF1 alpha and p53 are required for the proper activation of CPT1C under hypoxia. Given the carcinogenetic properties of CPT1C, the knowledge gained from this study will give us a better understanding on CPT1C's role as oncogene.

10.4_Dose-Rate Effect of Novel Radiation Technologies: Relevance for the Clinical Use

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Aim: There is increasing evidence that modulation of dose-rate and delivery time can effect tumor cell survival. The clinical significance of this observation and the underlying molecular mechanisms are still unclear. In this study we hypothesize that decreasing delivery time or increasing dose-rate in radiation therapy leads to a significant change of the molecular response using the multicellular tumor spheroid (3D) model leading to a more pronounced activation of cell death signaling pathways.

Methods: Experiments were performed comparing different 3D tumour cell models and several genetically modified human cancer cell lines (e.g.HCT116 $p53^{+/+}$ and HCT116 $p53^{-/-}$). The spheroid integrity and growth was monitored using optical microscopy, the cell viability examined by acid phosphatase assay.

Results: To optimize the 3D cell culture model for our purpose we tested 3 different systems: Nunclon Sphera surface coating-low attachment flasks, agarose-coated microtiter plates and the Freiburg matrix. HCT116 cells did grow as spheroids in all methods but only using agarose-coated plates we are able to generate spheroids with a stable morphology and of equal size. Currently we are validating the spheroid tumour model by performing flow cytometry and immunohistochemistry using different antibodies relevant in the DNA-damage and repair pathway, and hypoxia.

Conclusions: Using agarose-coated plates provides spheroids with a stable morphology and of equal size. This 3D cell system using agarose-coated microtiter plates will now be used to validate our hypothesis that cancer cells treated with different dose rates and dose intensities will show a difference in cell signalling and cell death pathways.

11.1_Prevention of acute dermatitis with Noviphenone®, a proprietary Camellia Sinensis extract, in female patients with breast cancer undergoing adjuvant radiotherapy

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[2] ClinResearch LTD, Aesch, Switzerland

[3] Novelpharm AG, Schlieren, Switzerland

Purpose: To evaluate the effectiveness of Noviphenone® for the prevention of acute dermatitis (AD) during adjuvant radiotherapy (RT) for breast cancer (BC).

Methods: Between November 2014 and January 2015, 20 patients who had been operated on for BC and receiving adjuvant RT were enrolled in this open-label, prospective mono-centric study. Patients were allocated to application of Noviphenone® gel 2.5% 7 days prior to RT, 1 hour before each RT session and Noviphenone® 0.4% lotion on the irradiated fields after each session twice daily as well as 4-8 weeks thereafter or longer if needed. The primary end points were time to AD ≥ grade 2 (G2) and time to recovery from G2 events. Secondary end points were frequency of RT interruption and stop, complications, required intervention and tolerability of preventive gel and care lotion. Outcomes of these 20 prospective data sets were compared with data of 100 retrospectively collected data sets derived from medical records.

Results: The time to AD of ≥ G2 was significantly prolonged with the use of Noviphenone® (Min-Max: 7 to 99 days vs. 30 to 95 days; P=0.0138). The hazard ratio was 2.33 (95% CI: 1.15, 4.72), demonstrating a more than 50% decrease in the risk of AD ≥ G2 event. There was a trend to faster recovery from AD of G2 in the group treated with Noviphenone® (22 vs. 24 days; P=0.0779). No differences for secondary endpoints were detected between the two groups.

Conclusions: The primary objective of the study was met. The Noviphenone® group was statistically superior in terms of time to ≥ G2 event. Noviphenone® was effective for the prevention of AD ≥ G2. Patients who undergo adjuvant RT for BC should be evaluated in a randomized phase III trial using Noviphenone® for prevention of AD.

11.2_ITV, MidV, gating or tracking - what to use when?

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Purpose: Respiratory lung tumor motion is most often addressed with an ITV approach to ensure tumor coverage. But tumor motion can be mitigated with other motion management techniques, namely with mid-ventilation (MidV), gating or tracking concepts, raising the question: What to use when?

Methods: A planning study with 20 lung cancer patients (tumor motion: 5-28 mm) was performed. Tumor volumes were contoured on the 4DCT phases and target volumes (TV) were delineated: For the ITV concept, the tumor volumes of all respiratory phases were combined, for gating 3/10 phases at end of inhale, for tracking and MidV 1/10 at the mid-position. TV-to-PTV margin was 5 mm, except for MidV concept which used probabilistic PTV margins. SBRT treatments were prepared for all cases with 3*13.5 Gy to the PTV inhomogeneously prescribed to the 65% isodose line. Afterwards, 4D dose calculations were performed to estimate the dose to the moving tumor. The dose to 95% of the GTV (D_{95}) and D_{max} were reported. Lung doses (D_{mean} & V_{20Gy}) were compared with Wilcoxon tests. Spearman correlations of dose benefits with tumor motion and volume were calculated.

Results: The 4D calculations showed significant ($p<0.05$) increase in D_{max} for ITV and MIDV concept than planned, higher D_{95} for ITV and gating and lower D_{95} for MidV and tracking (Fig. 1). Lung doses were significantly reduced by all techniques compared to ITV. Correlations of dose benefit with tumor motion were found for gating and tracking, while the MidV concept showed correlation to tumor volume.

Conclusion: Regarding 4D dose calculations, gating gives the most reliable tumor coverage, while tracking shows the highest benefit in lung dose, which is more pronounced for higher motion amplitudes, and allows for shorter treatment times than gating.

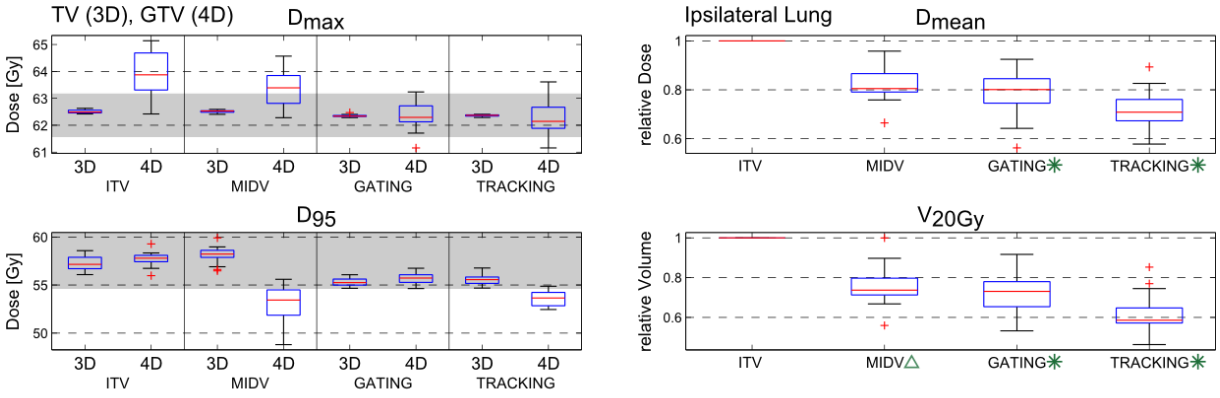

Fig. 1: Left: 3D and 4D dose parameters of target volumes for the different techniques. Shaded areas show dose constraints of 3D plans. Right: Dose parameters of ipsilateral lung for different techniques, individually normalized by ITV values. Star: Correlated to motion amplitude. Triangle: Correlated to tumor size.

11.3_Combination of Stereotactic Radiotherapy and Targeted Therapy: Patterns-of-care Survey among Swiss and German Clinics.

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Aims: Stereotactic Radiotherapy (SRT) is increasingly used in the metastatic tumor situation. As metastasized patients often receive targeted therapy, both therapies are increasingly indicated at the same time. For example, it is recommended by the NCCN Guidelines to treat patients with non-small cell lung carcinoma with Erlotinib and local therapy. However, it is largely unknown whether and how SRT should be combined with targeted therapy. The aim of this study was to investigate how SRT-experienced clinics in Switzerland and Germany combine both therapies.

Methods: A survey was handed out at the German DEGRO Stereotactic meeting in December 2015 and was sent to all Swiss clinics performing SRT at the beginning of 2016. The survey obtained information about the experience of performing SRT in the metastatic situation, how targeted therapies were combined with SRT, if there were any contraindications to a combinational therapy and if the SRT or targeted therapy dose was reduced. The targeted therapy asked for were new immunotherapies and tyrosine-kinase inhibitors.

Results: 27 clinics took part in the survey, of which the majority (n=16) were university hospitals. SRT for metastases was performed since 2008 (median, range 1997-2016), a median of 140 (range 5-1100) SRTs were performed since then. Vemurafenib (33%), Bevacizumab (26%), Erlotinib (11%), Sorafenib (7%) and Ipilimumab (4%) were considered a contraindication for combinational therapy. Bevacizumab was never given simultaneously to SRT, other targeted therapies were given simultaneously to SRT in 7-52% of clinics. The majority of hospitals paused targeted therapy 1 week before and after SRT. Only one clinic reduced the SRT dose when combined with targeted therapy.

Conclusion: Although there is limited evidence for safety and efficacy of a combinational treatment of SRT with targeted therapy, it is regularly performed. The way clinics combine these two therapies varies widely. To gain more knowledge about combinational treatments, a retrospective and prospective multicenter trial is needed.

11.4_Clinical commissioning of MR-Only Prostate treatment planning workflow

G. Bolard, S. Bulling, N. Hejira
Clinique de Genolier

Purpose:To quantify the effect of MR-only treatment planning on dose distributions for prostate cancer for the clinical validation of MR-only workflow.

Methods: For pre-clinical validation of the MR workflow, where five-value stratified synthetic CT (Magnetic Resonance for Calculating Attenuation (MRCAT) algorithm, Philips Ingenia 3.0T), are used for dose calculation instead of CT, we (1) converted conventional 12-bit CT scans to five-value stratified CT and (2) applied the measured geometric distortions (deformation vector field measured with a dedicated phantom) from the MR scanner to the CT scans of 10 patients to quantify the effect on dose to target and organs-at-risk (OAR) for IMAT prostate plans. For the clinical validation, we calculated the gamma index of the 3D dose distribution for MR-only and conventional CT dose calculations for the same patient.

Results: Five-value perturbed CT and conventional CT dose distributions were equivalent. No difference was observed for DVH-parameters for standard CT compared to five-value CT with MR distortion vector field applied. DVH-parameters were generally higher for five-density CT/CT dose calculations; PTV mean dose was 100.5% compared to 100% for CT-based plans. For rectum the effect of CT HU histogram reduction on the mean dose and D2cc was not significant (rectum Dmean_CT=31.2 Gy, rectum Dmean_5valCT=31.6 Gy). MR-only compared to CT 3D dose distribution 3D gamma analysis (1mm/2%) pass rates were >95%, except for one patient (92%) in the 50% and 90% isodose volumes.

Conclusion:Synthetic CT dose distributions are equivalent to CT for OARs and slightly overestimate the dose to the target. The differences due to the simplified CT composition and deformation are small. 3D gamma analysis (1mm/2%) pass rates for MR-only dose distributions compared to CT are >95% for comparable organ filling at both scans.

11.5_Radiotherapy infrastructure and human resources in Switzerland – Present status and its projected computations for 2020

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Aims: The study evaluates the present status of radiotherapy (RT) infrastructure and human resources in Switzerland. Projections for 2020 were computed taking into consideration the changes in the future RT practices, with a gradual emphasis on the practices of state-of-the-art RT techniques.
Methods: The guidelines of ESTRO-QUARTS and IAEA were adapted to estimate the requirements for teleradiotherapy (TRT) units, radiation oncologists (RO), medical physicists (MP) and radiotherapy technologists (RTT). The databases used for computation of the present gap and additional requirements are (a) GLOBOCAN for the cancer incidence and its types (b) Directory of Radiotherapy Centres (DIRAC), IAEA for existing TRT units (c) human resources from the recent ESTRO-HERO survey and (d) radiotherapy utilization (RTU) rates for each cancer sites, published by Ingham Institute for Applied Medical Research (IIAMR). With a gradual transition from 2D and 3D conformal RT techniques to IMRT, IGRT and SRS/SRT, an increased time factor of person-hr/patient for RO (3 times), MP (2-2.5 times) and RTT (1.5-2 times) were considered for contouring, plan evaluation, treatment execution, supervision and monitoring. These have been individually taken into consideration to compute the projections for 2020.
Results: In 2015, 30999 of the 45903 cancer patients would have required RT. By 2020, this would increase to 34041 for the 50427 cancer patients. Switzerland presently has an adequate number of TRTs but a deficit of 57, 14 and 36 ROs, MPs, and RTTs respectively. By 2020, an additional 7, 72, 22, and 66 of TRTs, ROs, MPs and RTTs would be required. In addition, a realistic dynamic model for calculation of the staff requirements due to anticipated changes in the future RT practices has been proposed. This could be tailor-made and individualized for any RT centre.
Conclusions: By 2020, the increase in cancer incidence would reflect in a 9.8% increase in patients requiring RT. This study should assist the stakeholders and health planners to design appropriate strategy for meeting future RT needs for Switzerland.

11.6_Reducing treatment delivery times in prostate cancer robotic SBRT

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No abstract

P01_Fatal hemorrhage due to an aortoesophageal fistula after neoadjuvant chemoradiation in locally advanced esophageal cancer – a case report

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Aim: Chemoradiation (CRT) is an established treatment for locally advanced esophageal cancer (EC) [1]. However, locally advanced disease with malignant esophageal stricture or tumors invading neighboring structures (T4) are associated with poor outcome and the risk of development of esophageal fistula during treatment [2]. We present a case of fatal bleeding due to a newly developed aortoesophageal fistula after neoadjuvant CRT in EC.

Methods: A 54-year-old female patient with newly diagnosed squamous cell carcinoma of the middle esophagus cT3 cN3 M1 (solitary renal metastasis) G2 was referred to our clinic for neoadjuvant CRT. There was no evidence of organ invasion by PET-CT scan and endoscopic ultrasound. The patient underwent neoadjuvant CRT according to the CROSS protocol [3]: RT: 41.4 Gy in 23 fractions, concomitant chemotherapy: paclitaxel and carboplatin weekly.

Results: Neoadjuvant CRT was completed according to the planned protocol. However, the patient presented with severe hematemesis one day after completion of CRT which eventually led to death due to circulatory failure. Autopsy revealed an aortoesophageal fistula within the necrotic tumor as cause for the fatal hemorrhage.

Conclusion: Invasion of thoracic structures such as the aorta, trachea and bronchi is commonly observed in locally advanced EC [4]. Consequent esophageal perforation is associated with an inferior median survival of only two months [5]. While treatment-related arterioesophageal fistula are found in 15-18% of T4 tumors, aortoesophageal fistula are rare (8%), but often result in fatal bleeding [2, 6]. Our case demonstrates that an aortoesophageal fistula after CRT may even occur in locally advanced EC without evidence of invasion of neighboring structures at pre-treatment staging.

References:

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P02_Fluence painting for breast patients with magnetic metal-ports

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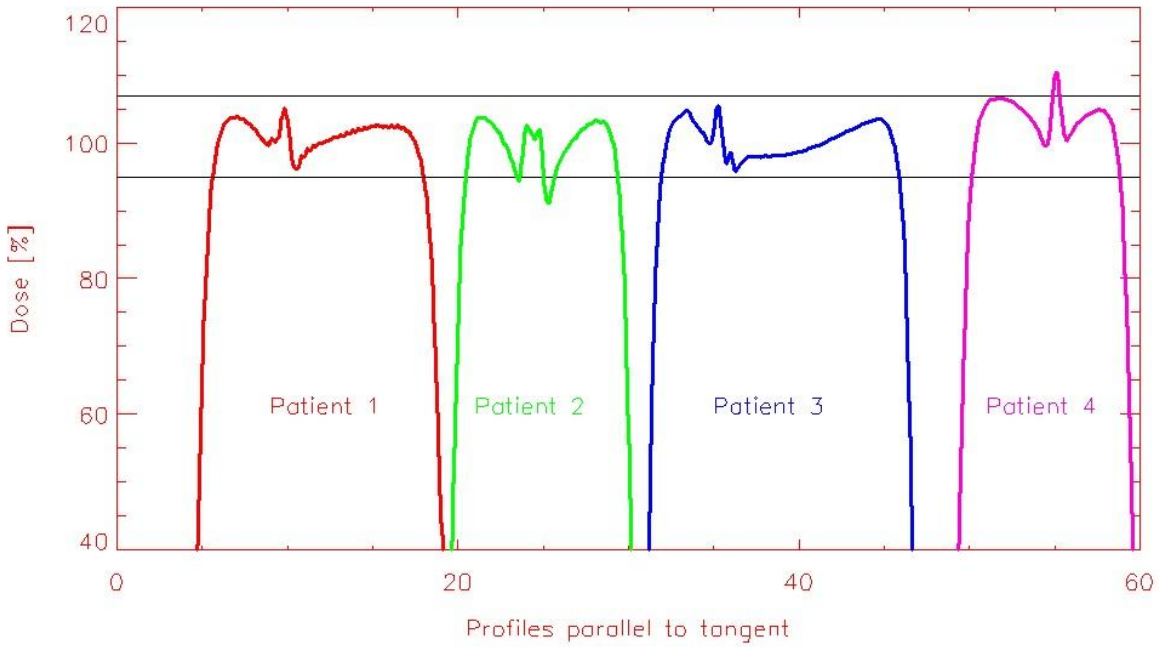
Aims: Tissue expanders with an internal magnetic metal port have been increasingly used for breast reconstruction in post-mastectomy patients who receive radiation therapy. In previous work it was shown that PTV coverage was significantly lower distal to the expander, independently of the assigned expander CT value. Here we report on a treatment technique to compensate for the under dosage of the PTV due to metal ports.
Methods: Prior to treatment planning a realistic CT value was assigned to the metal port. Deep inspiration breath hold was used for treatment with two field tangential forward planned IMRT fields (irregular-surface-compensator). After calculation of the surface compensator the fluence of both treatment fields was increased by 10% in the projection of the magnetic metal port. Four patients were treated with this technique. Dose was verified for each treated patient by measuring exit dose with diodes. To determine the robustness of this technique with respect to positioning uncertainties for one patient the isocenter was shifted by 5 mm in three spatial directions and the resulting dose distribution was analysed.
Results: The treatment plans with the modified fluences for the four patients resulted in a dose coverage according to ICRU guidelines (95% < D < 107%, see figure) including the dose in and at the edges of the metal port. The resulting deviations due to a isocenter shift in the PTV-DVHs were quantitatively the same for a patient with and without a metal port, respectively.
Conclusions: The presented method to treat breast patients with magnetic metal ports is safe and robust. Treatment planning is simple and it is possible to achieve dose distributions according to ICRU guidelines.



P03_Case report: radio-supersensitive oligometastatic lung cancer

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Background: Metastatic non-small cell lung cancer is associated with a poor prognosis and palliative chemotherapy is the mainstay of treatment. However, long-term survival has been observed in oligometastatic patients treated with local therapies to all sites of metastatic disease.

Case report: A 60-year-old man was diagnosed with a cT4N0M1b adenocarcinoma of the lung (right upper lobe) presenting a 6 x 8 cm bone lesion in the os ilium. The situation was deemed palliative and the patient received palliative chemotherapy started in May 2012. Because of heavy pelvic pain due to the bone metastasis with prominent soft tissue extension into the left pelvis and progressive destruction of the left os ilium, the lesion was treated with radiotherapy (RT) with a dose of 36Gy in 12 fractions. After RT and one year of chemotherapy, partial remission was seen in computed tomography. During a subsequent treatment-free interval the tumour in the right upper lobe increased 14 months post chemotherapy and was then treated with palliative radiation therapy with 46Gy in 23 fractions resulting in a partial remission (RECIST criteria). Because of FDG avidity in the PET-CT only in the right upper lobe five months after RT, an upper lobe resection was performed without evidence of vital tumour cells in the pathological examination. In May 2016, four years after diagnosis, the patient is still in complete remission with no evidence of disease neither in bone nor in lung.

Conclusion: The management of oligometastatic lung cancer is not standardized. This case report is an example for very good response to radiotherapy in oligometastatic lung cancer. To our knowledge this is the first reported case describing an oligometastatic lung cancer seemingly cured with radiotherapy in palliative intent. The cause why some tumours are super-radiosensitive and others not is still a matter of debate. A potential database of radio-supersensitive tumours might be the foundation for the identification of predictive molecular markers for RT in the management of lung cancer.

P04_Hyperthermia and proton irradiation in unresectable soft tissue sarcoma: First patients treated under "HYPROSAR" study protocol

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Aims: Unresectable soft tissue sarcomas (STS) present a therapeutic challenge due to their poor radio and /-or chemo sensitivity. Local hyperthermia (HT) at 39-43°C along with proton irradiation (PT) could be a possible therapeutic alternative as these combine a thermo-radiobiological and physical dose distribution advantage over the conventional photon radiotherapy (RT) alone. We present herein the first two patients treated with this novel proton thermoradiotherapy (PTHT).
Methods: "HYPROSAR", a phase I/II study (*ClinicalTrials.gov NCT01904565)* of HT and PT was launched recently to examine the feasibility and safety of this therapeutic approach in unresectable STS. The first two patients recruited in this study had unresectable STS of the left lower leg. In view of the involvement of the neurovascular bundles, both were advised above-knee amputations. However, both refused amputation and were therefore recruited for the HYPROSAR study. HT was delivered using RF waves at 100 Mhz, once a week following PT. PT was delivered to a dose of 70 -72 Gy (RBE) delivered at 2.0 Gy (RBE)/fraction, 5 days/week for 7 weeks.
Results: Both patients tolerated the treatment very well with no significant acute or late morbidity. The local tumour showed a near complete response as evident on serial MRI images. At a follow up of 5 and 14 months, they are able to carry out normal indoor and outdoor activities without any notable functional impairment.
Conclusions: To date PT and HT has not been reported as a therapeutic modality in any neoplastic conditions. Our first experience in two consecutive patients of unresectable STS with this novel treatment of PTHT shows that the approach is safe, feasible and effective, resulting in functional limb preservation with near total tumour control.

P05_Robustness of dose volume concepts for treatment of prostate cancer between 1995 and 2015

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Aims

Dose volume concepts for treatment of prostate cancer had been changed several times in our clinic in the last 20 years. The influence on tumor control (TCP) and normal tissue complication (NTCP) were evaluated.

Methods

On one 3D CT image of a standard prostate cancer case, the CTV and organs at risk are contoured. Based on the CTV, four different volume concepts for the PTV used between 1995 and 2015 were reconstructed. For each volume concept treatment plans were created with a technique and a dose prescription that corresponded to the volume concept applied in those years (table 1).

Plan	Technique	Number of plans	IGRT / Uncertainty	PTV Volume	Calculation Model MLC leaf width	Prescribed dose / Normalization
1 (1995)	**3DCRT** (4-field)	2 series	**skin marks** U1: 6mm ventral / 4° L-R axis U2: 6mm dorsal	15 mm around CTV. Seminal vesicle excluded after 45 Gy	PBC / 1 cm	72 Gy / 1.8 Gy V95%=PTV
2 (2000)	**3DCRT** (4-field)	3 series	**skin marks** U1: 6mm ventral / 4° L-R axis U2: 6mm dorsal	15 mm around CTV, from 55.8 Gy 10 mm and from 68.4 Gy 5 mm. Dorsal always 5 mm less	PBC / 1 cm	75.6 Gy / 1.8Gy V95%=PTV
3 (2005)	**IMRT** (5-field)	SIB	**daily portal image (bones)** U1: 3mm ventral / 4° L-R axis U2: 3mm dorsal	**Large volume** (68.4 Gy): Superior, inferior : 15 mm, Left, right, ventral: 10 mm, Dorsal 5 mm **SIB-volume**: 5 mm in all directions, except dorsal: 0 mm	AAA / 0.5 cm	76 Gy / 2 Gy V95% = PTV
4 (2010)	**IMRT** (5-field)	one PTV	**daily portal image (marker)** U1: 2mm ventral / 2° L-R axis U2: 2mm dorsal	Superior, inferior, ventral: 10 mm, left / right : 8 mm, dorsal: 6 mm	AAA / 0.5 cm	78 Gy /2Gy V100% = CTV
5 (2015)	**VMAT** (two full rotations)	one PTV	**daily portal image (marker)** U1: 2mm ventral / 2° L-R axis U2: 2mm dorsal	Superior, inferior, ventral: 10 mm, left / right : 8 mm, dorsal: 6 mm	AAA / 0.5 cm	78 Gy / 2 Gy V100% = CTV

Table 1: Reconstructed treatment plans and IGRT methods used

The TCP of the prostate was calculated for three different risk groups proposed by Levegrün [1], the NTCP of the rectum as proposed by Rancati [2] (rectal bleeding grade 2 or 3 within 18 month), and the NTCP of the bladder as proposed by Zhu [3] (LENT-SOMA grade 2 or higher after 4 years).

To test the robustness of the treatment plans against uncertainties stemming from a variation in rectum filling between the individual treatment fractions, different shifts and rotations were applied to the treatment plans. The magnitude of uncertainty was chosen in relation to the associated IGRT method. (table 1).

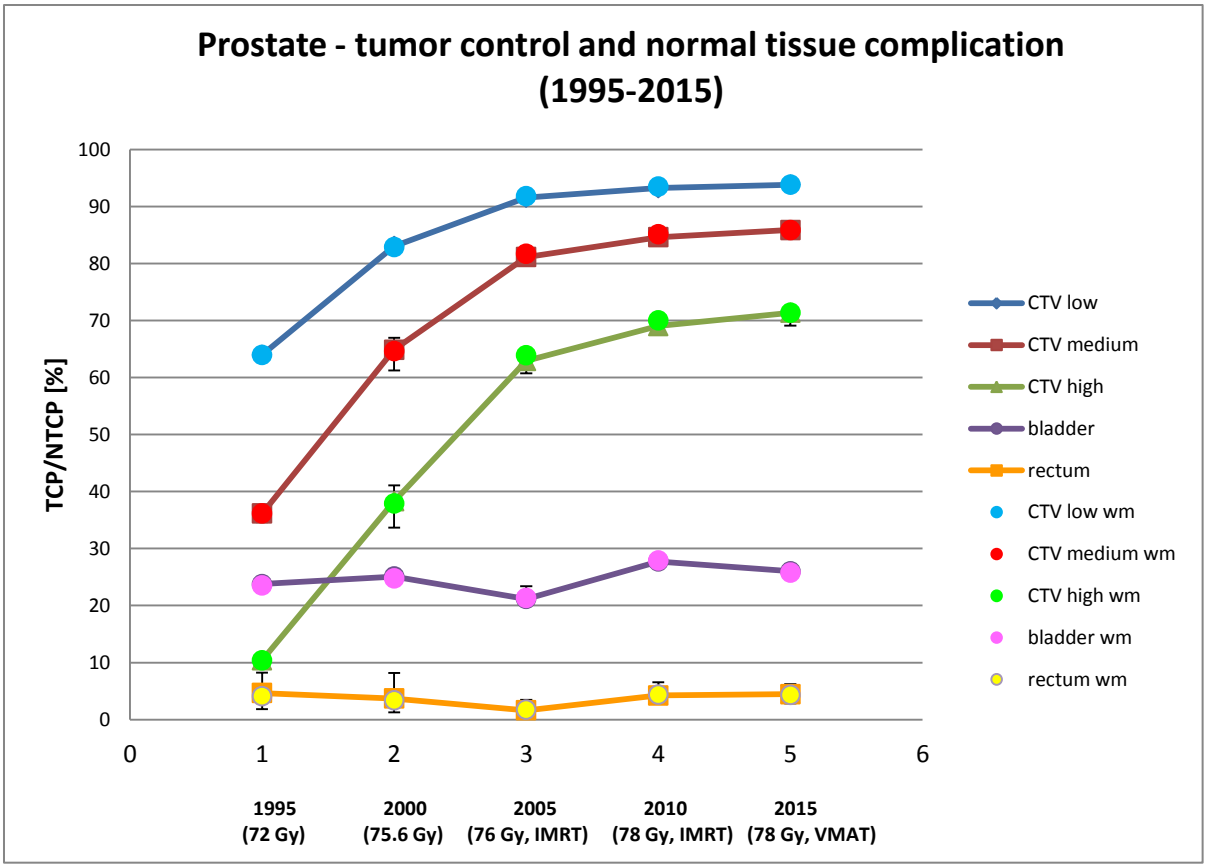

Figure 1: TCP and NTCP for different dose-volume/IGRT concepts

Results

Figure 1 shows the TCP and the NTCP for the five different dose-volume / IGRT concepts. The TCP increased significantly with dose for all three risk groups. In contrast, the NTCP for rectum and bladder could be kept almost constant. The results obtained with simulated uncertainties due to changing rectum filling (dots "wm") do not differ noteworthy from the results without simulated uncertainties.

Conclusion

Despite increasing the prescribed dose to the CTV from 72 to 78 Gy, which increased the TCP, the NTCP for the bladder and rectum could be kept constant. For all volume concepts that we used over the last 20 years, the robustness was preserved by adopting IGRT methods simultaneously. We can conclude that we have hit the target savely all over the years.

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P06_Comparative analysis between second-generation MLC and variable aperture collimator in robotic SBRT for liver tumors

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OBJECTIVE: The second-generation multi-leaf collimator (MLC2) for Cyberknife was recently introduced. We compared plan qualities and dose-parameters, which are relevant in clinical routine use of robotic liver SBRT, generated using MLC2 and variable aperture collimator (VAC).

METHODS: Planning scans of the first 10 patients with one to three liver lesions treated in our clinic with VAC to 25-30Gy in 3 to 5 fractions with Cyberknife were retrieved. Treatment plans were generated with MLC2 and VAC within Multiplan 5.3, using previously applied doses and fractionation. Dose prescription: to 67-70% isodose. Optimization objectives: clinically applicable treatment plans, PTV coverage ≥97%. Dose constraints to OAR defined according to Grimm et al. 2011 (1). For MLC2 plans, the optimization script was chosen as similar as possible as for VAC plans. The following parameters were analyzed: minimum, mean and maximum dose of PTV, liver, liver-GTV and OAR, Nakamura conformality index (nCI), homogeneity index (HI), treatment time (setup time 15min and 60sec. imaging interval) number of beams and monitor units (MUs) per fraction. Statistical analysis: STAT/SE 14.1, using t- test to compare plan quality metrics. Statistical significance level: $p<0.05$.

RESULTS: MLC2 plans did not differ in conformality ($p= 0.87$) and homogeneity ($p=0.33$). nCI was 1.17 ± 0.06 and 1.17 ± 0.05 and HI was 1.43 ± 0.06 and 1.43 ± 0.00 for the MLC 2 and VAC plans respectively. No difference in mean dose to the PTV ($p= 0.9543$). OAR dosimetric parameters did not differ ($p>0.50$). Mean MUs per fraction for the plans were 6830 (MLC2) and 7018 (VAC), respectively ($p= 0.86$). There was a significant difference for the minimum dose to PTV in MLC2 plans ($p<0.01$), number of beams (MLC2 55 vs. VAC 161 beams, $p<0.0001$), and delivery time (median time MLC2 43min vs. IRIS 59min, $p< 0.0001$) regardless of single versus multiple lesions.

CONCLUSION:: MLC2 treatment plans are of similar quality as the VAC system with faster treatment times and fewer beams for the clinical use of robotic liver SBRT.

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P07_A dosimetric review of three radiosurgery planning techniques for single brain metastases.

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Aim: The platforms for planning and delivery of primary and postoperative radiosurgery (RS) for single brain metastases in our institution have changed as technology has been upgraded. We conducted a retrospective comparison of the quality of the plans produced using three techniques.

Methods: 19 plans for non-coplanar IMRT (KonRad, Siemens) for a 2.5mm add-on microMLC (Siemens) were compared with 12 VMAT plans (Eclipse, Varian) for 5mm MLC (Truebeam, Varian) and 17 dynamic conformal arc plans (iPlan, Brainlab) for 2.5mm MLC (Novalis STx, Varian/Brainlab). Isodose volumes were generated from the KonRad and Eclipse dose distributions (Velocity, Varian) from which the gradient and conformity indices could be derived.

Results: The mean PTVs were 39.14±15.25 cm^3 for Konrad (5 postop) and 31.87±28.67 cm^3 for Eclipse (9 postop) both with historical 3 mm margins, but only 1.96±2.07 cm^3 for iPlan (1 postop, 1 mm margin). Gradient indices for KonRad were 3.7±0.67, Eclipse 3.46±0.76 and iPlan 3.02±0.46. The conformity indices were 0.84±0.18, 0.85±0.1 and 0.7±0.07 respectively. There were statistically significant differences in mean V12, V9, V6 and V3 between IMRT and VMAT plans ($p<0.02$).

Conclusions: Clinically acceptable RS plans could be achieved with all techniques. Low dose spread (V3-V9) and risk of radionecrosis (V12) were greatest on static IMRT plans, which may reflect the field arrangements. These patients received hypofractionated RS (25-30Gy/5fr) and no toxicity was observed. IMRT and VMAT plans achieved the best conformity however the iPlan DCA plans achieved the best gradient indices. This may be a function of the much smaller target volumes as well as the prescription isodose, and has enabled the implementation of single fraction RS for small brain metastases.

P08_Future Perspectives in Bladder-Preservation Therapy: A Critical Analysis of Phase 2 and 3 Trials of the ClinicalTrials.gov Database.

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No abstract

P09_Defining the incidence and treatment of skull base metastases in breast cancer: case report and selective literature review.

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Objective: Bone metastases are one of the most common sites of recurrent disease in breast cancer patients and typically arise in the vertebral spine or extremities. Skull base metastases (SBM) are relatively rare. Based on 2 recent cases of SBM, we evaluated the literature to better define the incidence and management of this presentation in breast cancer patients.

Materials and Methods: We present two patients with a past history of breast cancer and SBM. One patient developed anosmia, the other complained about sinusitis and pain in the left maxillary sinus. After several courses of antibiotics and analgesics, imaging eventually demonstrated a suspicious mass in the skull base. A biopsy confirmed the histological diagnosis of breast cancer metastases. After staging with PET-CT, one patient presented with a suspicious ovarian lesion, which was operated on laparoscopically and confirmed a breast cancer metastasis. The other patient showed no evidence of further disease. Both patients with SBM were irradiated with a curative dose using a highly conformal technique. One patient remains free of recurrent disease after two years of follow up; the other patient is currently under treatment. A search of the PubMed database for “base of skull metastasis and breast cancer” was performed. The search was repeated with “and radiotherapy”.

Results: We identified 43 articles concerning SBM and breast cancer. By adding “and radiotherapy”, 14 articles remained. According to the literature, SBM are rare and typically arise secondary to breast, lung or prostate cancer. Various treatment methods, including surgery, radiotherapy, systemic agents or a combination, have been used. Limited data is available regarding radiation dose, technique and outcome in breast cancer patients with SBM. Improvement in symptoms following radiotherapy has been documented.

Conclusion: SBM secondary to breast cancer are rare. However, awareness of the skull base as a potential metastatic site in breast cancer is important, as early detection and treatment is crucial to improve patient outcome, and to alleviate and control disabling symptoms.

P10_Geometric Differences in Target Volumes Using Two Delineation Strategies Based on Soft Tissue and Lung Windowing in Head and Neck Cancer: Missing the Tip of the Iceberg?

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Aims: To evaluate the geometric differences between two delineation strategies for head and neck tumors neighboring air cavities.

Methods: Based on our standard institutional protocol, primary gross tumor volumes (GTV) and clinical tumor volumes (CTV) of 14 pre-treated patients were contoured using standard soft tissue windowing (SW) used in the head and neck region. A second strategy based on the same volumes but with an extension to include the parts which became visible through lung windowing (LW). Triangular meshes (TMs) for all volumes were exported using the Eclipse Research Scripting API 13.6. An analysis-tool written in Python 3.5 was used to handle the TMs and to calculate surfaces, volumes and the Hausdorff-distance's (HD) between the two different sets (**Figure 1**).

Results: Mean differences (LW-SW) in GTVs and CTVs were 3.12 (95% CI: 2.3-3.95) and 6.52 (95% CI: 4.36-8.68) cm^3, respectively (p values <0.001). Mean 3-dimensional HD for GTVs and CTVs were 5.66 (95% CI: 4.87-7.91) and 9.32 (95% CI: 7.1-10.25) mm, respectively. Mean 2-dimensional HD for the same structures in axial plane were 4.74 (95% CI: 3.78-7.04) and 5.2 (95% CI: 4.51-8.95) mm, respectively. All mean differences were more prominent in laryngeal vs. non-laryngeal primaries ($p<0.05$).

Conclusion: Our contouring strategy modified by LW showed differences towards the air cavities neighboring the tumors. We will further evaluate its dosimetric impact in terms of potentially significant under-dosage of these air-tissue surfaces.

Keywords: head and neck cancer, radiotherapy, target volume, contouring

P11_Hemangiosarcoma after breast conserving therapy – re-irradiation & superficial hyperthermia

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Introduction: Possible radiation induced hemangiosarcoma of the skin (HSS) after breast conserving therapy (BCT) is a rare disease (0.04%) and has unfavorable prognosis. Not many treatment options exist: mainly surgery (radical mastectomy, wide resections with/without plastic reconstructions) are recommend. Nevertheless a high incidence of 50 – 56% of local recurrence is reported, 25 -30% present distant metastasis at first diagnosis. Re-irradiation (re-RT) combined with superficial hyperthermia (HT) could increase local control of this disease.

Methods: 4 patients are analyzed in this retrospective analysis. All hat former BCT from 2003 to 2006. 4.5 to 5.5 years later HSS developed, all patients were first treated with surgery. In case of recurrence additional resections were performed in 2 patients. 2 had already received after 1st R_1/R_2-resection postoperative re-irradiation & hyperthermia. 2 treatment schedules were used: 1st: 13 x 3 Gy 4x/week and 5 – 6 microwave HT 2x/week (1 patient). 2nd: 5 x 4 Gy 1x/week always combined with wIRA HT (3 patients).

Results: 2 patients presented multiple skin manifestations. CR was obtained in all treated regions (4 patients). PD outside occured in 2/4 patients, which were retreated with re-RT + HT (same regimen), this 2 patients finally died due to distant metastasis. 2 patients are living with NED (4.5 y resp. 2 y). Side effects: G1/G2 skin reactions in 2 patients.

Discussion: Little is known about best local treatment, re-irradiation with limited doses combined with hyperthermia seems to be a good option. Further evaluation of re-RT&HT is needed. Registration in a rare cancer network would allow to achieve more information about the best treatment strategies.

Key words: hemangiosarcoma of skin, re-irradiation, superficial hyperthermia

P12_Lung SBRT clinical practice review and rib fracture risk factors analysis

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Background: Chest SBRT has been routine clinical practice in our department for more than 2 years. One recent rib fracture event motivated us to retrospectively review our clinical outcome and treatment parameters in thoracic SBRT and to compare it to the literature

Purpose: Review lung SBRT clinical practice and evaluate different treatment parameters associated with chest wall complication events.

Materials and Methods: Between April 2014 and March 2016, 35 patients were treated with SBRT (5x11/12Gy, 8x7.5Gy), 19 were treated for lung lesions or received significant dose to the chest wall. We retrospectively reviewed chest wall toxicities, in particular rib fractures, and analysed significant dosimetric parameters.
After treatment completion, every patient had clinical and radiological follow-up at 3 months, 6 months and then annually by high resolution CT-scan. Toxicities were graded according to CTCAEv3.

Results: Only 1 rib asymptomatic fracture was observed in 19 patients (8x7.5Gy prescribed dose on a lesion in contact with the rib). Overall follow-up was 2-23 months, Mean age 72yo (58-86 yo), 10/19 M/F, Average size 26mm, Chest wall distance 0-68mm, Avg $Dmax_{rib}$ 35Gy (17-62Gy), Avg BED_3rib 84Gy (36-210Gy), Avg EQD_2rib 50Gy (22-126Gy). Clinical outcomes were very good with 95% (18/19) local control and 5% (1/19) >G1toxicities at most recent follow-up.

Conclusions: Thoracic SBRT is effective and well tolerated. Radiation induced rib fracture is well known in literature, but the described rib fracture event has uncommonly happened despite a mildly hypofractionated treatment schedule.

Such events remain rare in our daily clinical practice. Incidence of rib fractures in retrospective studies seem to be somewhat higher and correlated to various clinical and dosimetric parameters (chest wall distance, D_{max}, age, sex,). In our small cohort, tolerance to thoracic SBRT was good in the majority of patients but will require longer follow-up and will help us to standardise our clinical protocols. Prospective data collection is underway.

P13_Combined stereotactic body radiotherapy and immune checkpoint inhibition – initial clinical experience

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AIM. Preclinical data as well as several clinical reports suggest that radiotherapy may enhance systemic anti-tumor immunity when administered in combination with immune checkpoint inhibitors. One potential mechanism is increased tumor antigen release, which may eventually lead to abscopal responses. We report our first clinical experience with the combination of stereotactic body radiotherapy (SBRT) and immunotherapy (IT).

METHODS. Among 252 patients receiving SBRT treatment between 2014-2015, 9 patients with malignant melanoma (n=8) or non-small cell lung cancer histology (n=1) were identified who received palliative SBRT after progression under IT (n=8) or MEK inhibition (n=1). SBRT was applied in 3-7 fractions with a median BED of 43.2 Gy (28-67.2 Gy)to intrapulmonal (n=4),intrahepatic (n=3), splenic (n=1) and nodal (n=1) lesions while IT was continued.

RESULTS. With a median follow-up of 6.6 months, local control was achieved in 78% and all but one patient remained alive. An abscopal effect was observed in one patient in a non-irradiated lymph node 2 months after SBRT with continued IT. A second patient had no distant recurrence at 13.4 months after SBRT and IT for a solitary melanoma metastasis. Overall, median progression-free survival was 3.3 months, but new metastases were only observed in 4 patients. A grade 3 pancreatitis occurred 6 months after infrarenal SBRT (pancreas not irradiated) and a grade 2 hepatitis 3 months after SBRT.

CONCLUSION. Abscopal response and stable disease were observed in patients with low systemic tumor burden, but patients with very advanced disease showed early radiological progression. Results from prospective studies are eagerly awaited to determine the extent of potential synergisms and the toxicity profile of combined SBRT and IT.

P14_Locally Advanced Prostate Cancer (T3/T4) Treated by Radiation Therapy and Hyperthermia: A Case Report

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Aim: Management of high-risk prostate cancer represents a major therapeutic challenge and consists usually of external radiotherapy (RT) along with androgen deprivation therapy (ADT). Hyperthermia (HT) with RT has also been found to be an effective modality in various single arm studies in locally advanced prostate cancer.

Method: A 68-year-old man ECOG=0, presented with locally advanced prostate cancer, stage cT3-4cN1cM0, Gleason score 7b and PSA 11.1 ng/mL. MRI showed a 3.9x2.8cm tumor in the prostate with local invasion into surrounding soft tissues, seminal vesicles along with some suspicious pelvic lymph nodes. Following discussion in our urology multi-disciplinary tumorboard, he was offered ADT, Goserelin for 6 months during which, after 3 months, he was referred for local pelvic HT along with concurrent RT. The patient received 50Gy to the prostate including the seminal vesicles and pelvic lymphatics (CTV) followed by a boost of 24Gy to the prostate/tumor volume (GTV). Concomitant with RT, he also received 6 weekly HT sessions (BSD 2000, Sigma-Eye applicator). During HT sessions, a tumor temperature of 41-43°C for 60 minutes was recorded using an intravesical thermometer placed in the prostatic urethra.

Result: Combined HTRT was well tolerated with no significant acute or late toxicities. MRI at 6 months following RT showed a significant reduction in tumor size to 11x8mm with no evidence of pelvic lymphadenopathy or invasion of the seminal vesicles. The current PSA value has dropped to 0.2 ng/mL, indicative of a possible complete tumor response.

Conclusion: The case illustrates that thermoradiotherapy can be an effective modality in locally advanced prostate cancer therapy. This needs to be evaluated further through a well designed randomized study.

P15_Radiobiological Modeling to Predict Clinical and Toxicity Outcomes in Early versus Late Salvage Radiotherapy after Prostatectomy

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Aim: Prostate cancer patients are referred for late salvage radiotherapy (LSRT) for macroscopic local recurrences despite evidence favoring adjuvant and early salvage (ESRT). We compared normal tissue complication probability (NTCP) and tumor control probability (TCP) in patients treated with ESRT versus LSRT.

Methods: We assessed 10 LSRT cases treated with 64Gy to the prostate bed plus 10Gy boost to the macroscopic lesion (2Gy/fr). The same 10 cases were used to create plans to the prostate bed with 64Gy (2Gy/fr) (ESRT). NTCPs for rectum and bladder (grade $\geq$ 2 late) were calculated using a biological evaluation software (Varian Medical Systems). We tested a Poisson-based TCP model (3-yr biochemical control, BC) recently available in literature*. A pre-RT PSA of 0.2 ng/mL and the actual pre-RT PSA were used in the ESRT-simulation and LSRT groups, respectively. Mann-Whitney test was used for comparisons (p=.05).

Results: Median pre-RT PSA in the LSRT group was 2.9 ng/mL ($\pm$4). Median GTV was 6.3 cm^3 ($\pm$5.6). Median 3-yr BC in the ESRT and LSRT groups were 84% and 86% ($\pm$14), respectively (p>.05). LSRT had a 3-fold increase in bladder NTCP compared to ESRT. LSRT presented a higher rectal NTCP compared to ESRT (1.8 vs. 1.3; p=.04).

Conclusion: Although no differences in TCP were seen, limitations of the TCP model must be acknowledged. LSRT showed a higher NTCP due to higher doses to the bladder and rectum. Clinicians must be aware of a potential loss in the therapeutic ratio when choosing LSRT over ESRT for patients with high-risk of local recurrence.

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P16_Palliative radiotherapy towards end of life – benefit versus burden

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Introduction: Radiotherapy (RT) is an effective method to alleviate symptoms in patients (pts.) with advanced cancer. Towards the end of life palliative cancer patients are more prone to be treated as inpatients due to the interdisciplinary complexity of the symptoms. Many pts. receive RT in the final weeks or months of life. We retrospectively analyzed our inpatients treated with palliative RT with emphasis on effect, toxicity, treatment abortion and correlation between treatment time and survival.

Material and Methods: *Patients:* All pts. treated with a palliative intent from 01/2013 to 12/2014 were included (n=185). Median age was 65.2 years. Most common treatment indications were bone metastases (39.5%), brain metastases (18.4%), and spinal cord compression (18.4%). Most pts. suffered from NSCLC (25%). *Radiotherapy:* 70% of pts. were treated using 3D conformal technique, 28% using RapidArc technique. The most frequently used schedule was 10x 3Gy (54,6%). Single dose was given in 4.8% of pts.

Results: Mean time (MT) of hospitalization was 19.5 days (d). 78% of pts. were ≥ECOG 2. MT from first consultation to planning CT was 3.3 d. MT from CT to first RT was 4.6 d. Average treatment time was 13 d. Treatment abortion rate was 18.4%. 62% of pts. had no or grade I acute toxicity. Improvement of symptoms during hospitalization was seen in 62%. Mean follow-up was 3.52 months. 4/185 pts. are still alive. Mean survival after end of RT was 3.38 months. Relation of duration of RT versus remaining life time was 0.25 mean. Relation of time from first consultation till end of RT was 1.30 mean.

Conclusion: Estimation of prognosis poses still a challenge. Shorter fractionation schedules should be used more often in patients towards end of life to alleviate symptoms while avoiding too much burden.

P17_Palliative short course Total Skin Irradiation with Helical Tomotherapy for Primary cutaneous T-cell lymphoma

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Aim: To present the clinical outcomes of an 84-year-old patient affected by a mycosis fungoides (MF) treated with total skin irradiation (TSI) using helical Tomotherapy (HT)with a palliative schedule of 4 Gy in 2 fractions.

Methods: The patient presented a symptomatic MF (clinical stage: T2aN0M0B) since 2010. He presented several comorbidities (relapsing skin carcinomas of the face, treated with surgery; chronic coronary disease, treated in 2011 with a stent placement; severe multifactorial polyneuropathy, strongly affecting his mobility). For the MF, he had already received several cycles of physical and medical therapies (PDT, methotrexate, topical corticoids, interferon), with a limited efficacy. In 08.2014, the patient presented a blastic transformation of MF, treated with a gemcitabine-based chemotherapy until December 2014. Before TSI, his performance status was scored as 2 according to the ECOG performance status scale. At the moment of the first consultation, he was receiving ineffective prednisone 20 mg/day and topic applications of a moisturizing cream 3 times/day. He presented a severe itch, strongly affecting his daily activities and his sleeping, evaluated with the 5D itching scale (IS, Table 1). We decided to treat him with a palliative schedule of 4 Gy delivered in 2 fraction with HT.

Results: Table 1 shows the results of the treatment in terms improvement of the 5D-IS.

Conclusion: The technique we have developed for that specific patient gave good clinical results, letting us think that it could represent an alternative to electron TSI.

Table 1: 5D-itching scale

Anatomical site	**5D-IS** **Before treatment**	**5D-IS** **at 5 months**
Head and scalp	6/10	3/10
Face	6/10	0/10
Thorax	7/10	1/10
Back	8/10	1/10
Abdomen	7/10	2/10
Upper Arms	7/10	3/10
Thighs	5/10	0/10
Points of contact with clothes	5/10	0/10

PR01_Radiation Therapy of a pulmonary metastasis at the Cyberknife: Tumortracking vs. Fiducialtracking

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No abstract

PR02_Immobilization Device for External Beam Radiotherapy of the Penis

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AIMS: It is technically challenging to irradiate the whole penis or parts of the penis while sparing most of the normal tissue and the testicles. Therefore, we have designed a device that places the penis in an upright position to facilitate the treatment with lateral opposing photon fields.

METHODS AND MATERIALS: A device for the ease of positioning the penis has been designed. The device consists of two Perspex plates for fixing the penis in position for radiation treatment. Grooves in the plates allow the penis to be aligned into an anatomically optimal and comfortable positon. The gap between the plates provides room for part of the scrotum's skin. The Perspex plates also act as buildup material to achieve a homogeneous dose distribution for 6MV lateral opposing fields.

RESULTS: Two patients with carcinoma of the penis and one with a penile metastasis were successfully treated with the device. The setup reproducibility was good and patients had acceptable acute treatment reactions. The device helped reduce the volume of normal tissue being irradiated. In addition, the combination of lateral opposing treatment fields, with image-guided technique, enabled the accurate positioning of either the whole or partial penis for radiation treatment.

CONCLUSION: The use of the Perspex-plates device has allowed the efficient positioning and the successful treatments for penis carcinoma and penis metastasis patients. Minimal skin dose (outside the PTVs) has also been achieved. Moreover, the use of IGRT has effectively provided verification of the PTV for each treatment fraction. Consequently, this device has been adopted as the standard setup method in our department for future penis carcinoma cases.

PR03_Integration of computed tomography iodine contrast in radiation oncology department.

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Aims: Computed tomography with intravenous injection of iodine contrast (CTIV) is used to enhance the contrast of tumors, different tissues, vessels and organs. CTIV in radiation oncology allows radiation oncologists and technologists to improve the delineation of the clinical target volume (CTV) and organs at risk (OAR). We present a report on how to integrate CTIV into a radiation oncology department. Objectives and needs will be compared to those of routine diagnostic imaging.

Materials and Methods: 98 CTIV have been made since the opening date in June 2013. Specific injections and acquisitions protocols were created, after internal multidisciplinary agreement, according to the needs of radiation oncology and the treatment localisation (head and neck; thorax; pelvis; abdomen).

Results: The injection of iodine contrast in the same patient treatment position can improve the PTV and OAR delineation, by contrast enhancement and by optimal image fusion of native and contrast CTs in the planning process. Each acquisition is preceded by a native helix scan used as reference for treatment planning. Every CTIV is done during the same imaging sequence and in 2 phases: a late-phase and arterio-venous phase. This allows for the most up to date oncologic imaging before treatment.

Conclusions: Radiation Oncology requires acquisition and injection protocols suited to its needs and specifications. Using CTIV increases the technologists and radiation oncologists engagement and the patients care.

PR04_Comparing Accuracy and Stability of Two Immobilization Methods for Patients with Upper Leg Sarcomas

Day, J and Mashintsova, M

The purpose of this study was to evaluate the accuracy and stability of sarcoma immobilization devices used to treat patients with upper leg sarcomas at our clinic. The comparison was made between setups using a custom molded Vac Lok^{tm} (Varian) and a standard generic setup using cushions under the knees and a foot rest to immobilize the feet. The values of on-board shifts performed after imaging were retrospectively collected from patient records who had undergone treatment for upper leg sarcomas. The results displayed that Vac Lok^{tm} immobilization produces increased variance in the vertical and lateral directions, while standard cushions resulted in greater variance in the longitudinal direction. In addition, the mean shifts were statistically greater in the longitudinal direction for the conventional setup . This indicates that Vac Loks^{tm} do not necessarily result in more accurate and stable set-ups, and should not be used exclusively as the standard choice of setup.

PR05_How to improve patient cooperation to the radiotherapy treatment?

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Aim: Poor patient compliance is also RTT's responsibility. Therefore, in our study we tried to provide an environment that stimulates patient adherence to the treatment. This includes the information given to the patient by the technician.

Methods: During a period of over two years, we gathered 238 surveys given to ambulant patient that were starting the radiation treatment. The form had four questions that pointed out the needs of information about the patient's path in order to create a document that could satisfy the essential knowledge about the different aspects of the treatment.

Results: We received back 223 forms (93.7%). We observed that 58.8% of the patients felt that they had received complete information. 14.7% felt they received partial information and 26.5% felt that they did not receive any information. 78.9% of the 238 patients appreciated the documentation and found it useful to comprehend their treatment path through the different steps.

Conclusion: The study shows that 63 of 238 patients did not have any information about radiotherapy before our "patient centered paper project". 188 of 238 patients appreciated our paper documentation that built confidence and encouraged them to comply with the treatment.

PR06_Evaluation of optimal modulation factor for Tomotherapy head and neck carcinoma treatment plans.

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Aim: To study the impact of modulation factor (MF) on head and neck (H&N) carcinoma Tomotherapy treatment plans with simultaneous integrated boost (SIB) and determine the optimal MF for this type of treatment plans.

Method: 10 patients with H&N carcinoma were planned on Tomotherapy TPS HD version 2.04 with the following parameters: Field Width (FW) = 2.5 cm dynamic jaw, Pitch = 0.287 and 150 iterations. MF was set to 2.0, 2.4, 2.8 and 3.0. Prescription doses for PTV1 and PTV2 ranged, respectively, from 52.8 Gy to 54.4 Gy and from 66 Gy to 70.04 Gy. The quality of the plans was evaluated through the homogeneity index, the conformity index and coverage of PTVs. Treatment time and doses to organs at risk (OAR) were also considered. Finally, the optimum MF was compared to MF of 2.0 initially used routinely.

Results: For most patients, a MF of 2.8 optimizes the PTVs coverage and reduce the dose to OAR without having a significant impact on the treatment time. On average, the homogeneity of the coverage for the PTV1 is increased by 2.14% and the PTV2 by 10.87%. The dose to the spinal cord is reduced by 3.85%. The impact on the treatment time remains low with an average increase of 1.37% (half of the cases had the same time).

Conclusion: For patients with H&N, a MF of 2.8 optimizes the quality of the plans. This value has been adopted as standard value in our institution. However, in some cases, a MF of 3 may also have a positive impact on the plan without increasing treatment time. Unlike what is published in the literature, our study shows that a factor of 2.4 produces very often a sub-optimal plan in terms of doses to OAR but guaranty an unchanged treatment time.

PR07_Submillimeter intrafraction motion: bite block versus BrainLAB mask system

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Aim: The BrainLAB three point mask system is used in our institution as an immobilization device for the radiosurgical treatment of brain metastases. Occasionally, patients with claustrophobia are unable to tolerate an immobilization mask. To verify whether a bite block system can be used as a replacement for the BrainLAB mask system, the intrafraction movement using these two stabilizing systems was compared

Method: Eight patients (26 fractions) were set up using the bite block and individual occipital cushion (Medical Intelligence) and three patients using the BrainLAB mask system (18 fractions). All patients were positioned online using CBCT. At the end of each fraction a CBCT was performed to define the intrafraction motion. The vector of the difference in x, y and z planes between the two CBCTs is defined as the intrafraction motion.

Results: Intrafraction motion was within 0.6 mm for both the BrainLAB mask system and the bite block (table). The average time between the two CBCTs was 12.05 min for patients with the Brainlab mask system and 13.02 min for patients stabilized using the Biteblock.

Bite block

	Average [mm]	St.Dev. [mm]	Max. [mm]	Min. [mm]
Vertical	-0.13	0.37	1.00	-0.70
Longitudinal	0.04	0.40	0.50	-1.00
Lateral	0.07	0.29	0.50	-0.70
Vector	0.56	0.28	1.12	0.00

BrainLAB mask

	Average [mm]	St.Dev. [mm]	Max. [mm]	Min. [mm]
Vertical	-0.21	0.16	0.00	-0.50
Longitudinal	-0.06	0.30	0.40	-0.60
Lateral	-0.12	0.24	0.20	-0.60
Vector	0.43	0.21	0.81	0.17

Conclusion: Both masks showed comparable performance in term of intrafraction motion. The biteblock is a reliable alternative for patients who cannot tolerate the mask.

PR08_EVALUATION OF BLADDER AND RECTAL PREPARATION IN PROSTATE CANCER PATIENTS DURING RADIOTHERAPY COURSE

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Aims: To evaluate the variation of bladder and rectal volumes through CBCT in educated patients (pts) with toxicity correlations

Methods: Pts were trained by our nurses to prepare themselves with regard to: -rectum: a clyster an hour before radiotherapy session ; -bladder: intake of 300 ml of water right after clyster; -follow a low-fiber diet; -Weekly evaluation of weight, general conditions and tolerability. A series of 12 pts with prostate cancer and presence of gold fiducial markers were investigated through biweekly CBCT to evaluate the volume variations of bladder and rectum during radiotherapy (RT).

Results: Our data demonstrate that the volume of bladder can change during RT from **-35%** to **+ 53%** and rectal volume from **-22%** to **+ 27%** with respect to the planning CT. 6 patients showed a regular bladder filling with only minimal variations, maximum volume: range **8% -30%** minimum volume: range **12%-23%**.The other 6 pts had important variations with a peak between **-55%** and **+152%** Rectal changes were regular in 8 patients with a maximum volume between **6%** and **25%** and minimum volume between:**9%** and **23%**.The peak of rectal variations was less important, from **-45%** to **72%**. These results are correlated with the acute toxicity,5 patients had proctitis and diarrea during radiotherapy and only 2 had residual rectal toxicity at 6 weeks after RT. 10 patients showed pollachiuria, 9 nicturia, 7 disuria during radiotherapy and 7 had residual bladder toxicity at 6 weeks after RT.

Conclusion: Despite the methodical training by our nurses and good compliance from the patients, the bladder volume undergoes major changes during RT while the regular use of clyster could improve the preparation of the rectum. However, given the amount of patient-training, we expected better results in terms of a more reproducible bladder volume. We are consequently considering a review of our educational program of patients.

PR09_Patienten Edukation bei Prostata Bestrahlung: Schonung der Risikoorgane bei Prostatabestrahlung unter VMAT

Fabian Perren, Nita Gutierrez, Christian Von Briel, David Blumer; Radiotherapie Hirslanden Klinik Aarau

Ausgangslage: VMAT (Rotationsbestrahlung) ist eine grundsätzliche Technik zur Schonung der Risikoorgane bei der Prostatabestrahlung. Für die Planung und die tägliche Bestrahlung ist es wichtig, immer die gleichen Bedingungen in den Risikoorganen Rektum und Blase vorzufinden.

Ziel: Damit eine Schonung der Risikoorgane Rektum und Blase gewährleistet werden kann, ist es von bedeutender Wichtigkeit, dass der Enddarm entleert und die Blase gefüllt ist. Als weitere Voraussetzung gilt es, den Patienten im Voraus eingehend aufzuklären.

Vorgehen: Zur besseren Schonung der Risikoorgane ist eine gezielte Patientenaufklärung vor dem Planungs-CT sowie der Bestrahlung unumgänglich. Die Aufklärung erfolgt durch den Arzt und die Pflege. Die Kontrolle am Planungs-CT wird durch die MTRA durchgeführt. Vor der Bestrahlung wird täglich ein CBCT zur Lagerungsüberprüfung und Kontrolle der Risikoorgane angefertigt. Bei leerem Rektum oder voller Blase können entsprechende Massnahmen ergriffen werden.

Schlussfolgerung Die Methode ist einfach und praktikabel. Patienten werden aktiv in der Behandlung eingebunden. Sie sind entspannter aufgrund der genaueren Informationen vor der Behandlung, was positiv auf die Lagerungsgenauigkeit auswirkt.

PR10_Calypso® system for prostate tracking during treatment: Geneva experience.

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AIM: Since January 2016, we use the Calypso® system (Varian Medical System) to treat prostate patients (pts) with DynamicEdge™ gating. Following we present our first clinical experience with this system.

METHODS: Before its use, daily, we perform a QA of the system with the QA-fixture phantom to verify the concordance of Calypso®-TrueBeam isocenter. Then we install each pts on the table with its own physical restraints and position the array system and start using Calypso®. Ten pts (1 with Parkinson disease) have been treated: 1 for pelvic lymph-node+prostate, 3 for prostatic bed and, 6 for prostate. All pts are positioned supine with a Combifix™ (knees and feet immobilized) on the dedicated Kevlar table top. They were all implanted using a trans-perineal procedure. Calypso has been used for positioning pts, for monitoring cone beam computed tomography (CBCT) acquisition for initial positioning and finally for tracking pts' treatment.

RESULTS : Up to now, no complications due to transponders implant or transponder migration were registered. All pts were tracked during the treatment. Treating using Calypso® enabled us to see small movements of the target during irradiation and also to correct the position when necessary. When pts' anatomy (empty rectum and full/empty bladder) reproduced simulation conditions, only 5 more minutes were necessary to treat comparing to a non-Calypso® system treatment.

CONCLUSION: Calypso® is easy, fast to use especially if simulation conditions are reproduced. Trans-perineal implant is safe, allowing a correct and stable transponders' position. A good pts selection (anatomy) prior to implant allowed us to work in the localization volume of the array and thus to track all patients.

PR11_A simple technique of voluntary deep inspiration combined with VMAT for left breast treatment.

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Aims: The breath hold (BH) technique is well known and widely used to reduce heart dose for left sided breast radiotherapy. There are 2 common techniques in use: conventional 3D radiotherapy in a voluntary deep inspiration breath hold (vDIBH), and automated gated respiratory systems. We developed in our facility a very simple method to combine VMAT and vDIBH without special breath hold equipment.

Methods: 23 patients were selected on their ability to hold their breath more than 25s. The simulation was performed in 2 CT scans: the first one in normal breathing to determine the isocenter and the second one in DIBH for the delineation and calculation. VMAT plans were done with the TPS Pinnacle 9.8, and treatments delivered with the Elekta Agility 160. An IGRT in DIBH was performed in 2 times for positioning. The DIBH position during imaging and treatment was checked by 2 video cameras placed on both sides of the patient to monitor laterals tattoos with a tolerance of 3 mm.

Results: The positioning of the patient was done in DIBH with a precision of ± 1mm. IGRT showed a displacements average of 3 ± 1mm in all directions. The treatments could be delivered with 4 arcs of maximum 25s each, which is a reasonable breath hold duration for all the patients. The heart mean dose was 2 times less, compared to a free breathing VMAT treatment.

Conclusions: Combining VMAT and DIBH is a very efficient technique to reduce the heart dose, and easy to implement without any additional costs.

PR12_ Validation of CT scan doses of a SPECT/CT measured by CTDI phantoms

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CTDI and/or DLP are major radioprotection parameters since they indicate the effective dose received by a patient during medical examinations mainly radiological or nuclear medicine exams. They are also used in epidemiological studies for radiation protection. They are calculated by the facility supplier and are part of the assurance quality.

The aim of this work was to verify the validity of low dose CT scan irradiation obtained by the SPECT/CT with Bright View XCT Philips. CTDI is measured with the CTDI set for CT dosimetry of PTW, according the collimated protocol especially developed by the SPECT/CT manufacturer. A beam collimator is used in order to measure the integrality of the beam with the ion chamber (scatter tails). Some factors are applied to result in CTDI100. Then weighted CTDI and volume CTDI are calculated (Pitch=1).

Finally the measured CTDIvol doses were compared with the preprogrammed CTDI. The difference between the measured and displayed value is less than 25%. Comparison with the measures done in the same conditions but with another CDTI phantom set used by the manufacturer shows the same value at ± 1%.

Validation of the CTDI value for this CTDI measurement protocol (nominal kV, mAs) is crucial since the CTDI displayed on the GUI for the others protocols are estimated from it. It means an adjustment according the mAs value, the number of sequence, and the modality of current (continuous or pulsed current).

The order of magnitude of CTDI remains reliable and CTDI / DLP can be compared to NRDs.

Thanks to Fabrice Jeanneret and Stéphane Montandon are Philips Healthcare employees, Gland, Suisse for their collaboration

PP01_TRANSIENT THERMAL BIOLOGICAL DOSE-EQUIVALENT (TTDE) – APPROACHING SYNERGISM AND TIMING OF HYPERTHERMIA-RADIOTHERAPY (HT-RT)

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Purpose: To compare combined HT-RT treatments, different dose concepts have been developed (e.g. iso-dose concepts by Cumulative Equivalent Minutes or temperature - dependent beta-term in the linear-quadratic law). However, a comprehensive framework regarding the dynamics of tumour response is still missing, especially for varying conditions of timing, fractionation and dose rates. Therefore, we propose a novel approach by using a transient dose equivalent.

Materials and Methods: A transient biological dose equivalent should quantify a relevant, measurable biological effect based on physical input parameter (temperature, radiation dose) and cover relevant transiency (rise according damage production rate, decay according repair rate). The latter point can only be validated by performing experiments with varying dose rate or spacing between heating and RT fractions and by acquiring time-resolved data. The feasibility for applying a transient dose concept was demonstrated for RT by the analysis of survival data in vitro and COMET data in-vivo from biopsy material of treated animals. In this in silico - study, an Arrhenius-based bio-physical model for calculating a TTDE is used. We investigated first-order kinetics – based TTDE especially for temperatures between 42- 45°C, where the activation energy for protein inactivation jumps.

Results: Calculations of the TTDE exhibit saturation when approaching 43°C. The saturation becomes more pronounced when adapting activation energy and pre-exponential factor of the Arrhenius law. Higher temperatures will not lead to higher TTDE due to this saturation effect.

Discussion and Conclusions: The thermal effects above 43°C are not covered by a TTDE based on a single biological effect. The effects above 43°C may be explained by changed speed of protein repair due to e.g. a second-step modification of proteins or an additive cell killing process in addition to the synergistic effect of heat and radiation. The findings suggest that a TTDE related to a single biological process can only be applied in a narrow temperature range.

PP02_Monte Carlo Calculations Supporting Patient Plan Verification in Proton Therapy

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Patient's treatment plan verification covers substantial amount of the quality assurance (QA) resources; this is especially true for Intensity-Modulated Proton Therapy (IMPT). The use of Monte Carlo (MC) simulations in supporting QA has been widely discussed, and several methods have been proposed. In this paper, we studied an alternative approach from the one being currently applied clinically at CNAO. We reanalysed the previously published data, where 9 patient plans were investigated in which the warning QA threshold of 3% mean dose deviation was crossed. The possibility that these differences between measurement and calculated dose were related to dose modelling (Treatment Planning Systems (TPS) vs. MC), limitations on dose delivery system, or detectors mispositioning was originally explored, but other factors, such as the geometric description of the detectors, were not ruled out. For the purpose of this work, we compared ionisation chambers' measurements with different MC simulation results. It was also studied that some physical effects were introduced by this new approach, for example, inter-detector interference and the delta ray thresholds. The simulations accounting for a detailed geometry typically are superior (*p*-value around 0.01) to most of the MC simulations used at CNAO (only inferior to the shift approach used). No real improvement was observed in reducing the current delta ray threshold used (100 keV), and no significant interference between ion chambers in the phantom were detected (*p*-value 0.81). In conclusion, improved agreement between measurement and MC calculations in most cases was observed with the proposed method. But in other cases, position uncertainty represents the dominant uncertainty. The inter-chamber disturbance was not detected for the therapeutic protons energies, and the results from the current delta threshold are acceptable for MC simulations in IMPT.

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PP03_Virtual bolus for breast volumetric arc therapy (VMAT) planning: which size?

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Aims; Use of VMAT planning is increasing for breast cancer radiotherapy. In conventional radiotherapy (3DRT), the gantry leaves are opened in the air to compensate for breathing and potential changes in breast size during treatment. Due to gantry rotation during VMAT treatment, a virtual bolus (having the same density as the breast) must be added for calculation. The size of this virtual bolus varies, depending on the facilities, from 0.5 to 2 cm. In this study, we tried to determinate the best bolus size for optimal VMAT calculation.

Methods: To determine breast movement during normal breathing, 7 patients had a 4D-CT scan (Brilliance 64, Philips). The distance from the table to the top of the breast in transversal planes wes measured in the TPS Pinnacle from Philips for all phases (0% to 80%). The change of the breast size during treatment was analysed for 20 patients, using the positioning imager (cone beam computed tomography (CBCT)) throughout treatment, taking into account the difference between the first and last treatment. All dosimetries were systematically re-calculated without the virtual bolus.

Results: The average displacement during the breathing was 3±0.2mm, and the average breast expansion measured 4±0.2mm. The virtual bolus to use for calculation is then 7mm for free breathing VMAT, and 4 mm for breath hold VMAT. All the dosimetries re-calculated without the virtual bolus did not show major differences, which validates the bolus size applied.

Conclusions: The expansion to use for the calculation in the TPS has been measured precisely. The planning optimisation is then more accurate, especially if the breast does not swell during treatment, as in the majority of cases.

PP04_Clinical implementation of TomoTherapy Total Skin Irradiation developed on the basis of a *in-phantom* dosimetry strategy.

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No abstract

PP05_Plan optimisation with two treatment planning systems- worth the effort?

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Aim: Since 2015, iPlan (Brainlab) has been the TPS of choice at KSA for cranial radiosurgery. A dynamic conformal arc (DCA) technique has been implemented for both fractionated and single fraction stereotactic treatments. As the department currently uses Aria (Varian) as an R&V system, plans created in iPlan must first be exported to the Varian environment before the plan can be delivered for verification and patient treatment. This study investigates whether an extra VMAT optimisation and dose calculation in Eclipse contributes to plan quality, when compared with DCA plans for patients with a single PTV.

Method: The SRS plans for 10 patients treated with DCA were retrospectively optimised using the PR Optimiser in Eclipse. The beam arrangements (start/stop angle, table kick and collimator angle) were copied directly from the clinical plan. Resulting DVHs were compared for VMAT and DCA plans. Conformity and gradient indices (CI & GI), normal tissue V12Gy/ V20Gy and V5Gy, as well as critical structure doses were recorded.

Results: VMAT plans showed an improvement in CI compared to the DCA plans (mean CI 0.82±0.07 vs. 0.68±0.06), but the GI was worse (mean GI 4.6±0.74 vs. 2.87±0.21). For VMAT plans with PTV volumes over 6cc, the normal tissue dose (V12Gy or V20Gy) was less than that of the DCA plans. For PTV volumes under 6cc, VMAT showed no benefit for normal tissue dose, except in the case of an irregularly shaped PTV.

Conclusion: The ease with which one can create and visualize a treatment plan with multiple non-coplanar arcs is a major advantage of iPlan. We have found that the additional calculation and verification time necessary for VMAT plans would only provide potential benefit in cases of irregularly shaped PTVs, PTV volume over 6cc or where OAR dose is critical.

PP06_Implementation of a Standard of Treatment for LINAC-Based Stereotactic Radiotherapy of Intracranial Tumors

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Aims: until a few years ago, the stereotactic treatment of cancer patients was mostly possible for intracranial sites, where the exact positioning and dose delivery was achieved with the help of stereotactic frames screwed to the skull of the patient. With the development of Image Guided Radio Therapy (IGRT) and the Flattening Filter Free (FFF) mode at high dose rates, the delivery of ablative doses of radiation to localized malignancies widened the application range and became nearly non-invasive. Our aim has been the implementation of a standard protocol for intracranial stereotactic treatments.

Methods: at the Kantonsspital-Winterthur (KSW) more than 20 patients were treated with stereotactic method the past year for single or multiple brain metastases using a Varian TrueBeam™ Linear Accelerator delivering a 6FFF photon beam. The tumour, as well as the organs at risk, were delineated on a 2 mm slice thickness planning CT fused with a MRI [1]. A 2 mm margin was added to account for uncertainties [2]. For small target volumes, with diameter between 0.5 cm and a maximum 4 cm, one single fraction of 18 Gy or 20 Gy prescribed to 80 % isodose was delivered. For larger tumour volumes a fractionated scheme of 6x5 Gy prescribed to 80 % isodose was chosen instead. In these procedures, highly-advanced and non-invasive immobilisation techniques are used to ensure sub-millimetre accuracy, particularly for multiple lesion treatment with one isocentre.

Results: we have seen that the use of two full-coplanar or five half-non-coplanar modulated ArcTherapy photon beams yields to treatment plans that best protect surrounding healthy tissue, providing isotropically sharp dose gradients. Various factors such as the conformity index (CI), the brain volume treated with a dose larger than 10 Gy (V10) or 12 Gy (V12), the dose to various organs at risks, as well as various planing uncertainties and dosimetric parameters were assessed in order to select the best treatment plan. In all cases the Winston-Lutz test is performed on a EPID before each stereotactic treatment as standard for radiation isocenter verification. For dose verification we used ArcCHECK (SunNuclear) together with Film dosimetry and/or Epica. The dose at isocentre shows to be within 3%. The Gamma-Index analysis for ArcCHECK is above 95% (2mm 2%) and at least 90% for Film dosimetry (1mm 5%).

Conclusion: by testing and verifying different solutions for each step of the stereotaxic procedure we were able to define a robust protocol that guaranty the accuracy and the reliably of our stereotactic treatments.

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PP07_Benchmarking of abdominal CT protocols using a Channelized Hotelling Observer

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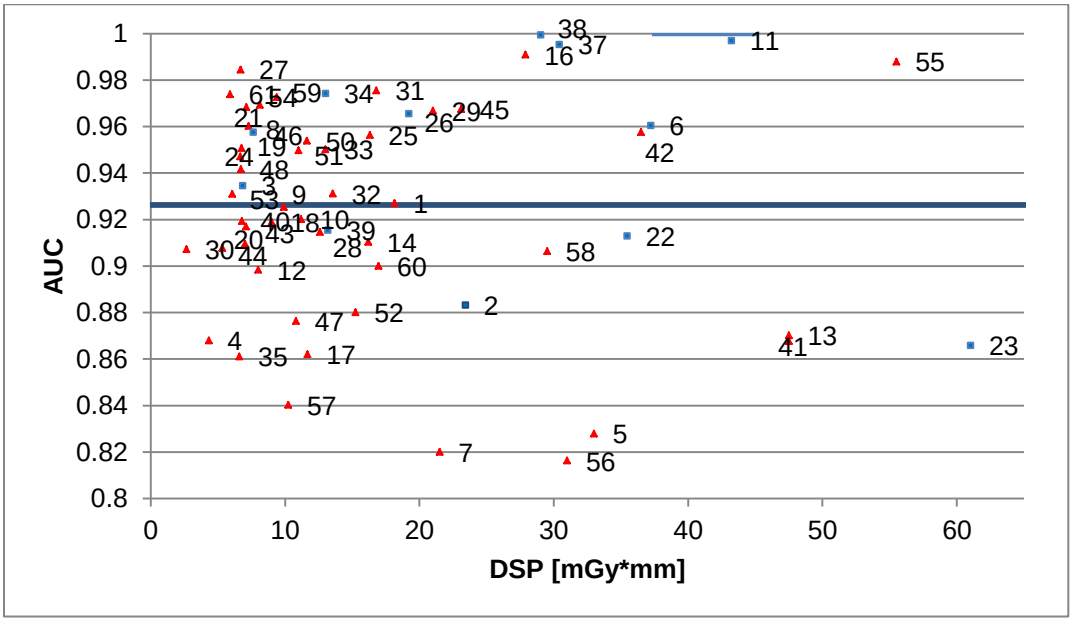
To ensure that radiation dose reductions in abdominal CT protocols do not impair the detection of low-contrast structures, an anthropomorphic abdominal phantom containing 4 spheres of 5 and 8mm in diameter with a contrast of 10 and 20HU was scanned on 58 CT machines in Switzerland. The phantom was scanned using the local CT protocol for liver lesions, producing 40 images per target (diameter/contrast). A subsequent acquisition was performed to obtain 150 images of background noise only. Objective image quality was assessed using a Channelized Hotelling Observer with dense differences of Gaussian channels. The figure of merit (FOM) used was the area under the ROC curve (AUC). Due to the use of various reconstructed slice thicknesses, the product of the $CTDI_{vol}$ and slice thickness (dose-slice thickness product, DSP) was used as a radiation dose metric. The reconstructed slice thickness varied from 2 to 5mm. 79% of the CT machines used an iterative reconstruction (IR) algorithm. No significant difference in objective image quality was noted between FBP and IR. The DSP varied from 2.6 to 61 mGy.mm. For the 5mm-20HU target, the AUC varied from 0.82 to 1.0. Nevertheless, 49% of the CTs gathered around an AUC range of 0.86–0.98 for a DSP range of 5–20mGy.mm. The majority of institutions performed well when dealing with the detection of liver lesions; however six CTs appeared as outliers with a relatively high dose level and limited AUC scores. Thus, the limited spread in objective image quality was associated to a large spread in the chosen dose indicator. In the future, a FOM which represents an expected level of low contrast detectability should be determined to ensure that the change of the acquisition or reconstruction parameters do not impair the diagnostic image quality.

Figure : Area under the curve for the category 5 mm/20 HU as a function of dose-slice thickness product.



PP08_Dose verification using the Delta4 system for InCise2 MLC plans on a Cyberknife-M6

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Aims: Performing dose verification with the Delta4 (D4) system (ScandiDos) is well established for linac-based radiotherapy. This is not true when using a Cyberknife (Accuray) where, typically film-based dose verification is applied. The aim of this work was to test the feasibility to use the D4 system for dose verification in stereotactic body radiation therapy (SBRT) using a Cyberknife-M6 equipped with the InCise2 MLC.

Methods: In order to perform measurements without linac pulse signal, the Tomotherapy option within the D4 software was used. Absolute calibration of the D4 phantom was performed using a 10x10 cm^2 field shaped by the MLC. Five fiducials were attached to the D4 phantom in order to be able to track the phantom before and during measurements. For eight SBRT treatment plans (two liver, two prostate, one lung, three bone mets) verification plans were recalculated on the D4 phantom using MultiPlan. Data was exported from MultiPlan and was adapted in order to be compatible with the D4 software. The measured and calculated dose distributions were compared using the gamma analysis of the D4 system.

Results: All SBRT plans were successfully measured with the D4 system. In the mean, 98.0±1.9%, 95.8±4.1% and 88.4±11.4% of measured dose points passed the gamma analysis using a global dose deviation criterion of 3% (100% corresponds to the dose maximum) and a distance-to-agreement criterion of 3 mm, 2 mm and 1 mm, respectively, and a threshold of 20%.

Conclusion: Dose verification of SBRT plans using the D4 system on a Cyberknife-M6 is feasible. Measured dose distributions of SBRT plans showed clinically acceptable agreement with the corresponding calculated dose distributions.

PP09_Evaluation of the InCise2® MLC for the Accuray M6 Cyberknife®

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Aim: The M6 CyberKnife® is a dedicated tracking system for stereotactic treatments of relatively small tumours. For larger lesions, the time of treatment significantly increases due to the needs of larger number of beams targeting the tumour. Recently, Accuray released a new multileaf collimator (MLC) for the M6 CyberKnife®. The smallest field size of the MLC is 7.5x7.7mm^2 at SAD 800mm, thus it is more suitable for large target volumes. The aim of this study is to evaluate the new MLC for the M6 Cyberknife (Accuray, USA) and the impact of its use on treatment time.

Methods: Acceptance and commissioning measurements were performed and the model was validated by means of end to end test and comparisons between TPS calculations and ion chamber measurements. Several plans have been calculated with fix and IRIS collimator and MLC in order to evaluate the pros and cons of the MLC.

Results: Evaluation of the MLC allowed us to note that the dose distributions obtained with the MLC are at least as good as the ones obtained with IRIS collimator. At equivalent (or better) dose distribution quality, the treatment time could be reduced (up to 20% for some cases such as prostate).

Conclusion: The MLC InCise2 is complementary to the other type of collimation available on the CyberKnife. We have shown that the fix collimators are well suited for very small tumours. For larger tumours the iris collimator gives good results with less time because no collimators changes are needed). The use of the MLC even decrease delivery time and produce more homogeneous dose distributions.

PP10_Head and Neck knowledge based planning model toward RapidPlan clinical use

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Aim: The knowledge based planning process RapidPlan (RP) from Varian aims to generate patient tailored objectives to input in the inverse planning optimization process. Data from high quality plans are used to build models for estimating DVH ranges where the specific DVH of a structure will most likely land according to the plans knowledge. The head and neck model generated at Humanitas is here described.

Methods: 83 clinical plans of patients presenting advanced head and neck cancer were selected to train the model. The dose prescription was 69.96Gy and 54.45Gy in 33 fractions simultaneously delivered to the boost and elective volumes. Plans were RapidArc (RA) with 2 to 4 arcs, 6MV. The organs at risk (OAR) selected for the model were: spinal cord, brain stem, parotids, oral cavity, larynx, thyroid, mandible, submadibulars, constrictors, eyes. The model quality was evaluated with the Model Analytics tool. The objectives in the model included mainly line objectives, with priority values generated by the model. For other 10 patients the best RA plans according to the standard procedures, and RP plans were generated. Comparison of the plan quality was assessed.

Results: Timewise RP revealed to be faster than the standard procedure, where numerous optimization structures were delineated, while not for RP: planning time dropped from 90 to about 20 minutes. Dosimetrically all the OAR with RP were planned with lower doses than the standard procedure, and the different were significant in most of the cases: as an example the percentage difference of the oral cavity mean dose was of about 20%, with $p<0.05$. Targets coverage and homogeneity were similar, in most cases RP improved homogeneity.

Conclusion: the generated head and neck model was considered ready for clinical use.

PP11_Flattening filter free beam profile analysis using two different normalization methods

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Aim: Flattening filter free (FFF) beams present a profile peaked on the beam central axis (cax), unsuitable for flatness and symmetry description that usually characterize standard beam profiles (FF). Definitions of *unflatness* and *slope* have been recently proposed, requiring a preliminar suitable FFF profile normalization. Two main normalization processes as far published are: the *inflection point* IP (Pönish 2006, Med Phys 33:1738), and the *renormalization factor* RF (Fogliata 2012, Med Phys 39:6455). In both formalisms the FFF dose fall-off at the field edge is superimposed with the corresponding FF profile. The present study aims to compare FFF specific profile parameters using the two normalization procedures, for 6 and 10MV FFF beams of a Varian TrueBeam.

Methods: The cax normalization value N was evaluated for the *IP* method as $N=D_{cax}\cdot(D_u/D_f)$, where D_{cax} and D_f are the doses on cax and at the IP of the penumbra region for the corresponding FF beam, D_u is the dose at the IP of the FFF beam. The N value was evaluated for the *RF* method by using the fit dependent on the field size FS and depth: $N=(a+b\cdot FS+c\cdot depth)/(1+d\cdot FS+e\cdot depth)$, where a, b, c, d and e are the fitting parameters, here taken from the published data. Unflatness and slope parameters from profile curves were computed.

Results: Unflatness and slope parameters resulted similar when computed using the two different normalization formalisms. The small differences were not significant. As an example, unflatness for a $20x20cm^2$ field was 1.248 at d_{max} and 1.317 at 30cm depth with the RF, while within 1% with the IP method.

Conclusion: The two normalization methods are both suitable for subsequent FFF profile description. The *RF* procedure, with the published fitting parameters is easier to use.

PP12_Implementation of TomoEDGE in the independent dose calculator CheckTomo

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Aims: CheckTomo is an independent dose calculation freeware for tomotherapy, relying on a water-based model of the dose deposition. After Accuray released the TomoEDGE Dynamic Jaws treatment modality for Tomotherapy devices, we upgraded CheckTomo to incorporate this feature in its calculation engine.

Methods: To account for the varying width and off-axis shift of dynamic jaws fields, the nominal field profile was multiplied by a penumbral filter and the dose calculation grid was shifted. The penumbral filters were obtained by dividing the edge field profiles by that of the corresponding nominal field. They were sampled at widths 1.0, 1.8 and 2.5 cm at isocentre in the edges of the 2.5 and 5 cm treatment field. The upgrade version was tested on 30 patient treatments planned with dynamic jaws using Gamma index.

Results: The gamma pass rate averaged over 10 abdomen plans was 95.9%, with tolerances of 3 mm/3%. For 10 head and neck plans, the mean pass rate was 95.9% for tolerances of 4 mm/4%. Finally, misplacement and overdosage errors were simulated. In each tested cases, the 2 mm/3% gamma pass rate fell below 95% when a 4 mm shift or 3% dose difference was applied.

Conclusion: These results are equivalent to what CheckTomo achieves in static jaws cases. In terms of dose calculation accuracy and errors detection, the upgraded version of CheckTomo is as reliable for dynamic jaws plans as the former release was for static cases.

PP13_A planning study between different techniques for boosting the tumor bed in breast cancer

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Introduction: Boost radiotherapy to the tumor bed has been to significantly decrease the risk of local tumor recurrence [1,2].Numerous publications have investigated the accuracy of using different approaches for breast boost treatment [3,4]. However, to the best of our knowledge no study currently evaluated the different techniques using high treatment planning optimization and thus, some techniques performance was either over or under estimated. Herein, we revaluated some breast boost treatment techniques with treatment-optimized case-by-case and using adequate metrics to achieve a significant inter-comparison.

Methods: 10 women with breast cancer were selected. Left and right breast cancer localizations were equally present. The planning CT of the breast region in Deep Inspiration Breath Hold setting was done using Big Bore CT (Philips Healthcare). CTV and PTV were defined as follows: CTV=GTV+5mm, PTV=CTV+5mm. The prescribed dose was 5x10Gy after a whole breast treatment(25x2Gy). The main objective for all techniques was to cover 100% of the CTV and 95% of PTV and also achieve an acceptable dose distribution heterogeneity (-5% to 107%, ICRU 50 & 62). All treatments were planned using the following techniques: Volumetric Modulated Arc Therapy(VMAT), Dynamic Arc(DA), 3D-Conformal Static Fields(3D-CSF) and Electron beams(EB**).**

Results: table 1 summarizes different comparison metrics. Covering 100% of the CTV as objective was achieved for all treatment techniques. However, best coverage and spatial overlap concerning the PTV were obtained using VMAT. The VMAT was found to be dosimetrically superior to the other techniques in terms of D_{max}, D_{mean} and $D_{1\%}$. Table 2 shows all Dosimetric data analyzed for OARs.

Conclusion: Boosting the tumor bed with optimized VMAT or DA maybe preferred to the other techniques; even if the complexity of the optimization and treatment time may be a little bit higher. OARs dose sparing, may be achievable with an optimized VMAT treatment plan may allow for a potential long term toxicity risk reduction.

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PP14_Evaluation of the "Delivery Analysis™" software for patient's specific quality assurance on tomotherapy

*V. Vallet**Fehler! Textmarke nicht definiert.**, M. Schopfer**Fehler! Textmarke nicht definiert.**, R. Moeckli**Fehler! Textmarke nicht definiert.***

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Aim: Patients specific QA is time consuming and as it compares dose measured and calculated in a homogenous phantom it does not allow detecting the root cause of a QA failure. To overcome these issues new QA tools are developed using log files of the linear accelerators. "Delivery Analysis" (DA) (Accuray, USA) is a software that allows the analysis of how the dose has been delivered to the patient thank to transmitted dose measured with the on-board detector of Tomotherapy units (accuray, USA). It allows the user to take decisions for e.g. replanning when the delivery becomes not adequate. The aim of this study was to evaluate the use of DA in patient QA procedures in order to get rid of an external detector for such controls.

Methods: Ten treatments plans for several anatomical sites have been considered. For each plan a standard QA was calculated and measured with Octavius phantom and 2D-array detector (PTW, Germany). These plans were also run on the machine without phantom and their log files retrieved and analyzed by DA.

Results: QA done with the Octavius and 2D-array always gave good agreements between the measured and calculated dose. Running the plan without phantom, retrieving and analyzing the log files were fast and easy. Preliminary results show that DA could be used for patient QA. However additional work has to be performed in order to correlate the DA results with the ones obtained with the standard technique.

Conclusion: New QA tools based on machine log files are promising. They will allow faster QA and help to find root cause of QA failure. We evaluated DA on our tomotherapy units and found that it could be used for patient QA. However, additional work has to be performed to find correlation between the results of our standard QA and the one of the DA.

PP15_Prone versus supine position for left breast irradiation: a technical and dosimetric comparison

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AIM: To evaluate the technical challenges and potential dosimetric benefits of breast radiotherapy (RT) in prone (PP) versus supine position (SP).

METHODS: We analyzed a patient treated with RT on left breast. A computed tomography (CT) virtual simulation was performed in SP using a Civco Posirest™ with both arms raised above the head, while in PP a Qfix Access™ device was used. In SP the CT was acquired using respiratory gating (RG) too. The prescribed dose to PTV2 (50 Gy/25fx) and PTV1 (10 Gy/5fx) was delivered by two tangential 6MV photon beams. Targets' coverage were assessed by means of V95% and V105% of prescribed dose. Doses to heart, left anterior descending coronary artery (LAD) and right breast were evaluated according to maximum (dose to 0.03cc, Dmax) and mean dose (Dmean); we analyzed Dmean and V20Gy for left lung.

RESULTS: The PTV1 coverage was comparable between SP, both in free-breathing (FB) or RG, and PP. The PTV2 coverage was better for SP in FB (V95% was 94% vs 87%) even if a lower homogeneity was obtained. Heart and LAD Dmax were higher in SP in both FB and RG. Left lung V20Gy and Dmean were 0.03% and 0.4Gy for PP while 20.2% and 11.1Gy in SP (FB), 22% and 11.8Gy in SP (RG). Right breast received a higher Dmax and Dmean in PP although with low doses [**Table 1**]. The patient positioning time increased in case of PP, due to patient difficulties in arranging on the device and the required daily imaging for checking the setup accuracy.

CONCLUSION: Prone setup allows a better organ at risk sparing, favouring a lower dose distribution to heart, LAD and ipsilateral lung. This setting could be a good solution in patients with large pendulous breast. Nevertheless it requires a careful patient selection, due to patient's compliance, and a long team's learning curve.

Table 1

	PRONE Setup	SUPINE FB Setup	SUPINE RG Setup
HEART			
D Max (Gy)	17.9	49.9	43.3
D Mean (Gy)	1.2	6.5	1.7
LAD			
D Max (Gy)	13.1	49.7	20.5
D Mean (Gy)	5	30	6.4
CONTROLATERAL BREAST			
D Max (Gy)	6.3	3.7	3.4
D Mean (Gy)	0.30	0.17	0.16
IPSILATERAL LUNG			
D Max (Gy)	30.8	54.5	53.7
D Mean (Gy)	0.4	11.8	11.1
V20(%)	0.03	22	20.2

PP16_Radiomics in mesothelioma – Is it possible?

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Aims: The inter-observer variability (IOV) in delineation of malignant pleural mesothelioma (MPM) is large, which makes radiomics analysis difficult. Here we investigated the influence of the IOV on radiomics features in CT and PET images.

Methods: 11 MPM patients, who underwent pretreatment CT scans with and without contrast agent as well as a PET scan were included in the study. Gross tumor volume (GTV) was drawn on the CT images with and without contrast, twice for each patient by two radiation oncologists. Radiomics features were calculated with the in-house software. In total, 10 shape parameters and 315 texture parameters were calculated per contour. IOV of the radiomics features was investigated using a two-way, consistency, single-measure intra-class correlation (ICC) with acceptance level of 0.8. The stable parameters across all patients were grouped with hierarchical clustering. For the final set, from each cluster, only the parameter with the highest ICC was chosen.

Results: For the shape parameters, the ICC analysis yielded the following three parameters with ICC > 0.8: 'volume', 'compactness 1' and 'maximum diameter'. For each of the 11 patients, the texture parameters were calculated for the contrast and non-contrast GTV-contours on the CT and PET images. The fraction of stable texture parameters per image modality is presented in Table 1. These parameters are least prone to different contouring and are suited for further investigation. The cluster analysis resulted in 3 to 7 groups of correlated parameters depending on image modality. The parameters with the highest ICC of their cluster are given in Table 1.

Conclusion: Radiomics in MPM seems to be possible, however only with a significant reduced amount of radiomics parameters (depending on the imaging modality between 5 and 30% of parameters were stable).

PP17_Increased Heat Penetration With Adapted Antenna Configuration In Superficial Hyperthermia

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At the Kantonsspital Aarau superficial tumors are heated to temperatures of 41-43°C to exploit the thermal enhancement effect of hyperthermia when combined with radiation therapy. The heat is administered with antennas radiating electromagnetic waves at 915MHz. The frequency limits the 50% heat penetration depth to 2cm

Aim: In this case presentation we show a method to heat deeper lying chest tumors with a lower frequency at 100MHz and therefore improved penetration depth.

Method: For a patient with a painful breast tumor metastasis in the sternal area a combination of hyperthermia and radiation therapy was planned. The size of the metastasis was 16cm x 11cm x 4cm and previously irradiated with 40Gy. Due to the extent of the tumor beneath the skin a new method for heating was considered. The 100 MHz antenna used is part of an annular antenna array (SigmaEye applicator, Pyrexar, Salt Lake City, UT, USA) used to treat deep lying tumors in the pelvic region. For the suggested antenna arrangement effective heating depth (EHD) and effective field size (EFS) measurements were performed in a muscle tissue equivalent phantom

Results: The muscle equivalent phantom material measurements showed it was possible to reach an EHD of 4.0 cm and an approximate EFS of 10cm x 15cm as shown in Figure 1. During patient treatment maximum tempertaures of 42.5°C were measured at 2.5cm tissue depth. The treatment was well tolerated by the patient and no adverse reaction took place during the course hyperthermia sessions.

Conclusion: Using the 100 MHz SigmaEye hyperthermia treatment applicator in an adapted antenna arrangement offers the possibility to heat large superficial areas extending up to 4.0cm into the tissue. These deeper tissue areas could before not be heated with the conventional 915 MHz superficial hyperthermia applicators. However the use of this possibility is limited by the geometry of the SigmaEye applicator and patient positioning within it.

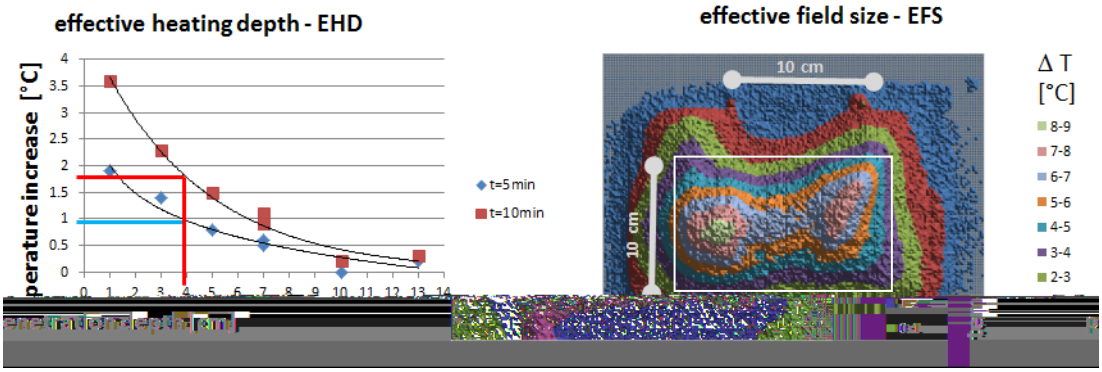

Figure 1: Effective heating depth, EHD and effective field size, EFS (right) for a single antenna pair radiating at 100MHz. EHD is defined as 50% of the temperature change at 1cm depth shown here for two power pulses of 5 and 10 minutes duration (left side). EFS defined as the area of 50% of the maximum temperature at 1cm tissue depth is shown on the right

PP18_Fast and accurate technique for liver tumour segmentation on non-contrast enhanced CT images

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Introduction: Automatic hepatic tumour segmentation is a crucial step for diagnosis and surgery planning. Several methods have been proposed but still hard to implement and time consuming[1,2,3,4]. Most approaches were only tested on images with hypodense tumours. Hypodense tumours show up in CT scans as darker than the surrounding liver, as opposed to hyperdense tumours. Only a few algorithms were tested on datasets containing both hyperdense and hypodense tumours[5]. This study presents a new fast semi-automatic technique to segment both hypodense and hyperdense liver tumours on non-contrast enhanced CT images with less interaction from user.

Methods: non enhanced contrast CT images were obtained from MIDAS database (http://hdl.handle.net/1926/587). CT images were transformed from grey space to CIE LAB space by applying pseudo multispectral colour transformations matrix. The CIE LAB image contrasts were enhanced by applying Root Square Function (RSF) that iteratively enhances the texture intensity spatial distribution(homemade algorithm). The result image channels were classified using an enhanced K-mean clustering. Resulting texture label maps were again classified by labelling the connected regions and lesions were extracted using a complementary image post processing. The algorithm pipeline and results are showed in Fig. 1.

Results: The preliminary results of the proposed algorithm showed a good agreement between the ground truth and the segmented tumour volumes. The mean relative difference computed for 3 patient data was equal to -13% (± 0.5). The image contrast is well improved (6 times higher) and tumour lesion appears sharper when applying the RSF enhancements.

Conclusion: The proposed approach looks promising and shows a high potential to improve liver tumour segmentation results by extracting a maximum of image information from a CT images using pseudo-multispectral transformations, contrast enhancement and an adapted fast, iterative and unsupervised K-mean clustering. The algorithm still needs further improvements and optimizations.

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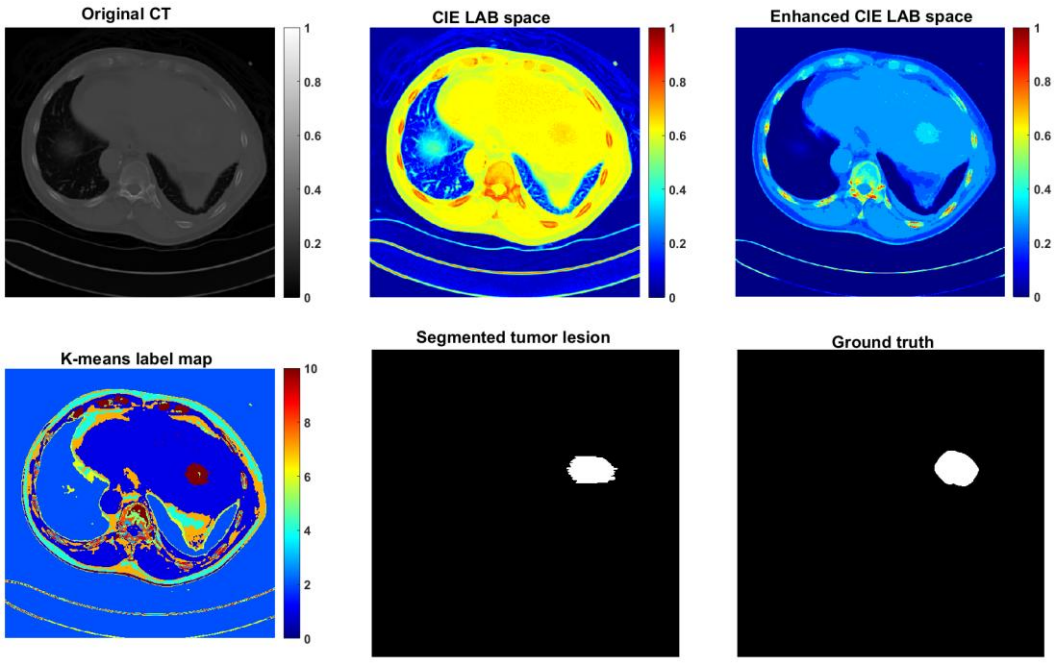

Figure 2: liver tumour segmentation pipeline using the proposed method

PP19_Optimization for dynamic trajectory radiotherapy: Feasibility Study

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No abstract

PP20_Interplay Effects in Tangential Breast IMRT

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Aims: Dosimetric interplay effects may occur when treatment volumes move during a dynamic MLC treatment: the dose to parts of the target volume may be higher or lower than in a stationary treatment. We investigated tangential IMRT plans for breast treatment to find out what magnitudes of over- and underdosage we would have to expect for single treatment fractions, and whether these interplay effects compensate each other when several fractions are irradiated.

Methods: Enhanced dynamics wedge (EDW) and IMRT (1 and 2 carriage groups) breast plans were measured with a PTW Octavius 2d-array on a CIRS 008PL Dynamic Platform. Sine functions and asymmetric functions (unequal inhale and exhale times) with periods T (1s, 3s, 6.5s, and 10s) and an amplitude of 5mm, were used to move the detector (SDD = 124cm) to measure the interplay dose distributions, which were compared to measurements with stationary targets.

Results: For individual fractions of the one-carriage-group IMRT plan, the range of the dose errors increased from +/-1% for T = 1s (root mean square error, RMSE = 0.3%), to +/-6% for T = 10s (RMSE = 2.4%). Averaged over 4 fractions (equally separated start phases), the error kept between +/-1% for all T, with an RMSE of about 0.3% (Figure 1). In comparison: the 30°OUT-EDW plan's single fraction error range was +/-2%; averaged over 4 fractions: +/-1%. For the 2-carriage-group fields, the maximum dose differences reached +/-10% for individual fractions. Averaged over 4 fractions: +/-1%, independent of T.

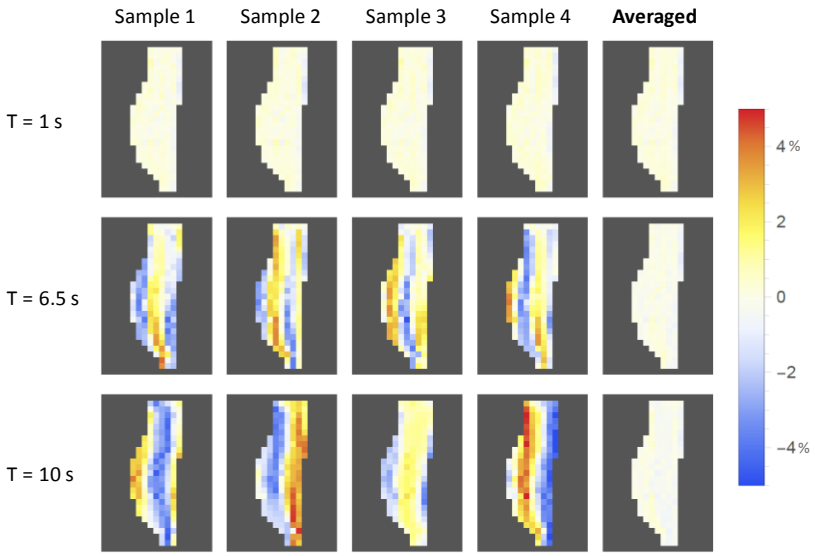

Figure 3: Effects of target movement (peak-peak value 10 mm, period T) on the dose for a 1-carriage-group IMRT field: samples were taken by starting the irradiation at different, equally separated, start phases of a sinusoidal 2d-array detector (SDD = 124 cm) movement. Pixel size: 8 x 8 mm^2

Conclusion: Although it is likely that interplay effects average out for fractionated treatments, care must be taken in order to decide whether over- or underdosage in certain parts of the target of more than 10% in a single fraction is acceptable.

PP21_Multiple brain metastases planning solutions with single isocenter: dosimetric comparison between dedicated treatment planning.

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Aims: To investigate the feasibility of a novel dedicated treatment planning solution, to automatically target multiple brain metastases with a single isocenter and multiple inversely-optimized dynamic conformal arcs (DCA), and to benchmark it against volumetric modulated arc therapy (VMAT) approach.

Methods: Recently published clinical data demonstrated a benefit in treating multiple brain metastases (more than four) with stereotactic radiosurgery. We selected one patient with 10 brain lesions with volume range 0.5-9.68 cc. The treatments ware planned with both VMAT and the novel Brainlab brain metastases (BM) software. The Varian Eclipse system uses arcs with a VMAT optimized delivery whereas the BM software selects among 3 and 7 optimized arcs to deliver the prescribed dose, using a hybrid conformal arc technique (non-IMRT). The plans were compared by Paddick conformity (CI) and dose gradient (GI) indices, by volumes receiving 5Gy (V5), 10 Gy (V10) and 12 Gy (V12) as function of metastases number. We also evaluated time needed for planning.

Results: The brain metastases software tool generated plans with similar CI (0.57 ± 0.07) and improved gradient (mean GI = 3.2 ± 1.2). The health brain tissue exposure in terms of V5, V10 and V12 was comparable to values obtained with VMAT plans. The planning time was (225 ± 60 s) for BM and (687 ± 140 s) for VMAT.

Conclusions: The automated brain metastases planning algorithm software improves dose gradients, provides satisfactory dose distribution with a good conformity index and organs at risk sparing. Reduction of time for optimisation with a similar organ at risk safety and calculation seems to favour the BM software.

PP22_Detection of Activated Linac-Components by NaI-Gamma-Spectrometry

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Aims: Radioactive components are a result of nuclear reactions in high energy (> 8 MV) linear accelerators (Linacs). Free-measurement of these parts may be difficult: depending on Linac design, different isotopes can appear in the individual parts. In this work the feasibility to identify these isotopes with NaI-γ-spectrometry is investigated.

Methods: Parts of three used Linacs (Varian) have been stored for 2, 5, and 7 years, to allow for decay of short lived isotopes. Measurements were performed with a handheld γ-spectrometer with a 2 inch NaI-crystal (Canberra) and compared to the results of conventional dose rate monitoring.

Results: Even the parts with ≥ 5 years storage time could not be completely free-measured. The dose rate for some of these parts was still 0.2-0.4 µSv/h. The remaining activation could be attributed to Co-60 ($T_{1/2}$=5.3a) by measurement of the γ-lines (1173 keV and 1332 keV) with the NaI-spectrometer within two minutes. For Linac parts with two years storage time, the nuclides Mn-54 ($T_{1/2}$=312d) and Co-57 ($T_{1/2}$=272d) could be identified additionally by measurement of the γ-lines at 122 keV and 835 keV, respectively.

Conclusion: Nuclides that cause activation of Linac parts can be identified with very high sensitivity by NaI-γ-spectrometry. This holds even for parts that are close to the limit for free-measurement, i.e. 0.1 µSv/h dose rate above background. Co-60 is a major problem in some parts and requires long storage time before disposal. This nuclide can be detected with high sensitivity and the free-measurement of the remaining parts is very reliable with this method. The method is also feasible for the detection of short-lived isotopes.

PP23_Performance evaluation and feasibility for multi-criteria optimization of a column generation based direct aperture optimization

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Aims: To investigate the performance and the feasibility for multi-criteria optimization of a column generation based direct aperture optimization (CG-DAO) for photon IMRT, MERT and mixed beam radiotherapy (MBRT).

Methods: A CG-DAO capable to simultaneously optimize electron and photon apertures was developed within a Monte Carlo beamlet based treatment planning process using the photon multileaf collimator to shape electron and photon beams. For performance comparison, photon IMRT, MERT and MBRT treatment plans are generated for an academic and a head & neck case using the CG-DAO, a simulated annealing based direct aperture optimization (SA-DAO) and a gradient descent based fluence map optimization (FMO). Treatment plans for the academic case are navigated on the approximated pareto surface generated by a multi-criteria extension of the CG-DAO (MC-DAO). The objective function value (OFV) and DVHs were compared to CG-DAO generated treatment plans with the same dose constraints as of the navigated plans.

Results: For all treatment techniques and cases, the OFVs of CG-DAO generated treatment plans with at least 50 apertures are comparable with SA-DAO generated plans and converge with increasing number of apertures to the OFVs of FMO generated plans. The OFVs of CG-DAO generated treatment plans are lower than of navigated MC-DAO plans. However, for all comparisons investigated, the difference in plan quality based on the DVHs is minor.

Conclusion: The CG-DAO is suitable for optimizations of IMRT, MERT and MBRT treatment plans and is feasible for multi-criteria optimization. This work was partly supported by Varian Medical Systems.

PP24_Towards independent dose calculation for the CyberKnife M6 system

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No abstract

PP25_Radiotherapy data are conformal to Benford's Law. Implication for research and practice

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Aim: Benford's Law states: "In many sets of numerical data the first significant digit (FSD) is not uniformly distributed, but follows a logarithmic distribution expressed with formula: $P\{d\} = \ln(1+1/d)/\ln(10)$ where P(d) is probability and d is FSD". We conducted an analysis of two numerical radiotherapy(RT)-specific datasets (DS).

Methods: Two datasets were used to verify conformity of numerical RT dose data with Benford's distribution. Treatment plans of 10 patients with head and neck cancer (DS1) and manually reported doses for organs at risk (OAR) (min, max and mean for chiasm, brain stem, lenses, cochlea's and optical nerves) of 98 patients with glioblastoma were used (DS2). FSD distribution was calculated for both datasets.

Results: DS1 dose distribution was conformal with Benford's law, for every individual patient plan and for all plans summed together. Relative frequency of FSD for all plans is shown on Fig.1. In DS2 1901 values were analyzed (19.2% missing data). FSD values for single OAR are heterogeneous and only few showed tendency towards Benford's distribution. Accounted together, FSD distribution conforms well to Benford's law and no higher next single digit had a higher relative frequency than previous one (Fig.2).

Conclusion: Numerical data in radiation oncology conforms to Benford's law. This property may have practical applications such as data integrity or quality assurance, as already utilized in other industries.

PP26_A comparative study of two model observer calculation methods to evaluate CT image quality

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Aims: Model observers are becoming increasingly popular in CT image quality quantification as a tool to assess image quality while optimizing radiation dose. Recently, a new approach to estimate the performance of Channelized Hotelling Observers (CHO) has been presented by Wunderlich A. et al. (2015) [1]. The proposed method has been shown to give good estimates of infinitely-trained CHO performance even for few images.

Methods: We compared the presented method to the common procedure which consists of thresholding the decision statistics followed by trapezoidal integration to estimate the Area Under the Receiver Operator Characteristics Curve (AUROC) for varying channel numbers. The comparison was based on CT-images acquired on a Toshiba Aquilion and a GE LightSpeed 16 with the CCT191 MITA IQ Low Contrast Head Phantom (The Phantom Laboratory, inc.). A total of 24 series with three different dose levels (45 mGy, 55 mGy and 65 mGy) were evaluated; regions of interest were created with the signal centered on one of the four small rods.

Results:

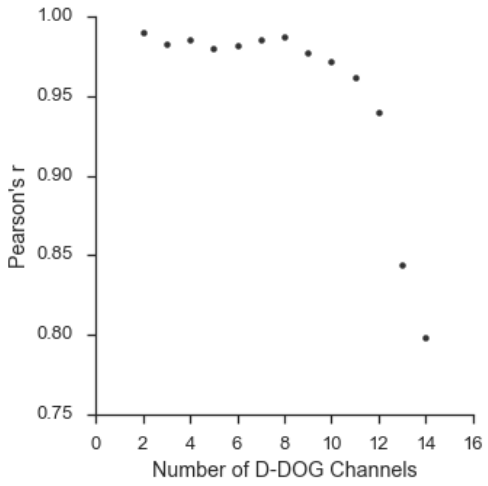

Figure 4: Preliminary Pearson's r of AUROC-values obtained for both methods depending on the number of channels of Dense Differences of Gaussians (D-DOG).

Agreement between both methods in terms of Pearson's r was shown to be dependent on the number of channels used to generate the decision statistics (c.f. Figure 1). This result is expected as the proposed point estimator suffers from bias depending on the number of channels [1]. For a small amount of channels, differences between both methods are negligible.

Conclusion: In cases with few images and channels, we recommend employing the Channelized Hotelling Observer calculation proposed by Wunderlich et al. (2015) due to the good point estimate of the infinitely-trained CHO and the well characterized confidence intervals [1].

PP27_A Novel Attachment System for Cutouts in Kilovoltage X-ray Beam Therapy

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Customized shielding in superficial and orthovoltage therapy is a common procedure to spare healthy tissue. Nevertheless inaccuracies during the replacement of cutouts may arise if the same applicator is required to treat different patients or target volumes (TV) immediately one after the other.

In our department most of the cutouts have a straight-edged shape. Our in-house frame-based system can be used to attach and remove the cutouts to the applicator in an easy and fast manner. It is important to note, that the mounted frame must not interfere with the radiation field. Hence, the frame has an identical size as the used applicator. VELCRO® strips were deployed as an attachment modality between applicator, frame and cutout.

The developed attachment system increases the distance of the applicator to the patient skin by non-negligible 8.8mm. This has to be taken into account by a correction factor. The inverse square law (ISL) is not valid for low energy x-rays because of the interaction x-rays with air in this energy range. A comparison of measurements and calculated values by the ISL show a maximum deviation ±4.9% (≤50keV) and ±1.5% (>50keV) for our set-up.

The attachment system ensures a high reproducible accuracy to irradiate multiple TV in a row with the same applicator but with different frames and cutouts.

PP28_To evaluate different matching processes for the application of deformable registration of preoperative PET-CT to help delineate the tumor bed for whole-breast irradiation after breast-conserving surgery

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AIM Using Velocity© (Varian Medical System) as a deformable image registration (DIR) tool, we evaluated two fusion protocols between preoperative PET-CT (PrePET-CT) and post-surgery simulation CT (SimCT) for tumor bed (TB) delineation in whole-breast irradiation.

METHODS Five patients (pts) were identified having PrePET-CT and a SimCT all in supine position, arms over the head, except for one pts PrePET-CT. To measure the quality of DIR, anatomical structures were contoured on PrePET-CT and SimCT images: body, nipple+25mm margin (PRV-NIP), axillary vein, clavicular head. Two DIR protocols were tested: A "multi-step" protocol (rigid manual vertebral and sternum fusion ending with a deformation in a region of interest (ROI)) and a structure guided deformation (SGD) using the union of the body in the ROI without lung and the PRV-NIP. Dice, mean and maximum distance between structures surfaces and the PrePET-CT TB (50% SUV uptake structure) overlap volume (%) respect to the manual TB drawn on SimCT by a single physician are used to quantify results.

RESULTS The "multistep" protocol lead to insufficient PRV-NIP matching results, with Dice lower than 0.2. Results were best using the SGD (see table), excluding the pts with arms position differing between images. TB mean overlap volume was 48% (range 42-58 %).

CONCLUSION Velocity© can give a good DIR result if properly guided even when there is missing tissue (lumpectomy). Next step will evaluate the use of PrePET-CT TB information to reduce intra-observer contouring variability.

Structure ***N=4 pts***	**Axillary vein**	**Clavicular head**	**PRV-NIP**
Dice Mean (range)	0.5 (0.16-0.77)	0.79 (0.67-0.84)	0.79 (0.64-0.88)
Mean Distance (range) (mm)	3.1 (1.1- 6.0)	1.5 (1.2-1.8)	4.4 (2.3-7.6)
Maximum Distance (mm)	22.9	9.6	26.8