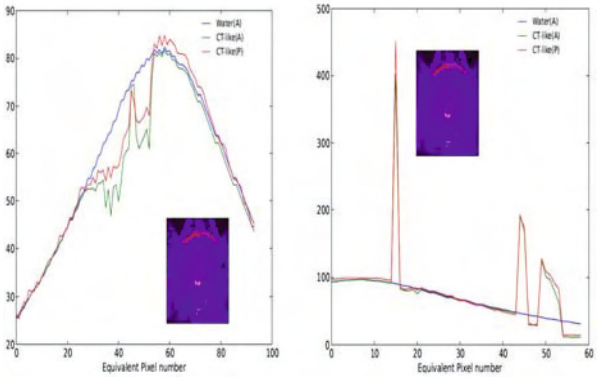

Conclusions: The presented analytical dose calculation algorithm is applicable for any type of heterogeneity. The high calculation speed of the algorithm makes it feasible for use in clinical real time-treatment planning and thus for improving treatment quality.

PO-0967

Loose seeds vs. stranded seeds in permanent prostate brachytherapy: dosimetric comparison of intraoperative plans

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Purpose/Objective: To evaluate and compare the dosimetric parameters of intraoperative treatment plans in prostate seed implants performed with loose seed and stranded seed techniques.
Materials and Methods: Permanent prostate brachytherapy with I-125 seeds as a monotherapy for patients with low and intermediate risk prostate cancer was implemented at our institute in 2009, and since then 147 patients have been treated. The first 79 patients were implanted with loose seeds (seedSelect, Nucletron) and the next 68 patients with stranded seeds (IsoSeed, Bebig). Loose seeds (LS) were delivered automatically with the seedSelectron system, while stranded seeds (SS) were placed into the prostate manually. For treatment planning the SPOT PRO 3.1 (Nucletron) software was used for all patients. The number and positions of seeds were calculated with an inverse dose optimization algorithm (IPSA) in the pre-implant plan. Then, the seeds were implanted under transrectal ultrasound guidance, and their real positions were updated in live planning. The prescribed dose was 145 Gy. Dose-volume histograms were calculated and volumetric parameters were used to evaluate the plans. V100 (%), DHI, D90 (Gy) and COIN were determined for the prostate, while D_{max} (%), D0.1cm^3 (%), D10 (%), D30 (%) for the urethra, and D_{max} (%), D0.1cm^3 (Gy), D2cm^3 (Gy), D10 (%) for the rectum. Means and standard deviations were calculated and compared for both intervention groups.
Results: On average, 54 and 47 seeds were implanted in the prostate with individual median seed activities of 0.49 and 0.56 mCi for LS and SS technique, respectively. The median needle number was 15 and 17, correspondingly. The mean prostate volumes were practically identical (33.4 vs. 33.9 cm^3). The dose coverage was similar (V100: 96% vs. 97%, D90: 167 Gy vs.169 Gy) in the two groups, and the dose homogeneity was identical (DHI: 0.39). The conformity of dose distributions was better for LS (COIN: 0.70 vs. 0.65). Regarding the dose to urethra all dosimetric parameters were significantly lower ($p<0.05$) for LS (D_{max}: 138% vs. 154%, D0.1cm^3: 126 vs. 140 %, D10: 125 vs. 136 % and D30: 119 vs. 128 %). The rectum received less dose with the LS technique (D_{max}: 101% vs. 112 %, D2cm^3: 82 Gy vs. 97 Gy, D0.1cm^3 :127 vs. 143 Gy, and D10: 75% vs. 86%) ($p<0.05$ for all).
Conclusions: In permanent prostate seed brachytherapy the dose to urethra and rectum is less with LS technique compared to SS technique in the intraoperative plans. Moreover, the conformity of dose distributions is also better with LS along with the same homogeneity of dose distributions. Probably the more flexible loading pattern for LS technique results in the more favourable dose distributions.

PO-0968

Available guidance, current UK practice, and future directions for HDR brachytherapy quality control

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Purpose/Objective: A survey of high dose rate (HDR) brachytherapy quality control (QC) procedures undertaken at radiotherapy centres in the United Kingdom (UK) is reported [1]. Published recommendations and guidance for HDR QC are also reviewed and compared to current UK practice. Recent changes in clinical brachytherapy techniques and the impact on required QC is discussed. Modern methods to determine optimum quality checking processes are indicated. This work is conducted in the context of the recent 'point/counterpoint' debate in *Medical Physics* that 'QA procedures in radiation therapy are outdated and negatively impact the reduction of errors' [2] and a review of the dosimetric accuracy in HDR [3].
[1] AL Palmer, M Bidmead, A Nisbet. *J Contemp Brachy* 2013 (in press)
[2] HI Amols, EE Klein. *Med Phys* 2011; 38: 5835-5837
[3] A Palmer, D Bradley, A Nisbet. *J Contemp Brachy* 2012; 4: 81-91
Materials and Methods: All UK radiotherapy centres were asked to participate in a survey of their approach and practice for HDR brachytherapy QC. This included guidance used, frequencies and tolerance values for individual QC tests. A comprehensive evaluation of responses was conducted detailing popularity of tests, and the average and range values of testing and tolerance. A literature search was conducted on general guidance, specific QC techniques in both brachytherapy and teletherapy, and on risk-based systems for quality assurance.
Results: Survey data was acquired from 31 UK radiotherapy centres and statistical analysis of responses performed. 45 possible individual QC tests were identified. There was general agreement on measurement frequency and tolerance for key QC tests, e.g. measurement of source position in a straight catheter, checked daily and with a 1.0mm tolerance in most centres. There was disagreement on a number of tests, e.g. the need for regular x-ray imaging of applicators. There was absence of tests that may be deemed necessary for modern brachytherapy practice, e.g. confirmation of planned and delivered dose distributions. There is likely a need to move from a device-centred to a system-centred approach, using risk-based assessment methods to determine required QC testing, with emphasis on clinical processes rather than simple device operation. Table 1 provides sample key results from the work.

Perception of need, within UK, for routine QC	QC test	% occurrence in routine QC schedules	Measurement frequency: Mean value (and range in brackets)	Tolerance value: Mean value (and range in brackets)
Agreed essential	Initial and independent measurements of source strength	100%	At source change (all)	3% (2% to 5%)
	Source dwell timer accuracy	100%	Daily (daily to annually)	1s (0.1s to 2s)
	Source dwell positions in straight catheter	100%	Daily (daily to at source change)	1 mm (1 mm to 2 mm)
No agreement	Repeated source strength through life of source	75%	Monthly (daily to monthly)	3% (0.5% of initial to 5% of cert)
	Source dwell positions in clinical applicators	55%	At commissioning (2-weekly to 12-monthly)	1 mm (1 mm to 2 mm)
	Source transit time	47%	3-monthly (weekly to at commissioning)	Large variations in definition
Low use or absence	X-ray imaging of applicators	32%	At commissioning (3-montly to 12-monthly)	1 mm (all)
	In-vivo dosimetry	Available at 19% of centres	Monthly (monthly to 'as required')	5% (all)
	Dose distribution measurement around applicators	0%	Not performed	Not performed

Conclusions: The only contemporary benchmark survey of HDR QC practice has been undertaken. The outcome of this work is a review of current practice against available recommendations, relevant recent changes in clinical brachytherapy techniques, and the use of modern quality process assessments. Recommendations for appropriate, optimised QC for HDR brachytherapy are made.

PO-0969

Air kerma rate measurements for Ir-192 and Co-60 HDR sources using three different international protocols.

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Purpose/Objective: Since several years, Co-60 HDR afterloading sources are commercially available. The long half-life of Co-60 together with its comparable dose distributions to Ir-192 makes this type of sources economically attractive, especially in developing countries. However up to date protocols for brachytherapy dosimetry provide no explicit guidelines for verification of Co-60 source calibration by the clinical physicist. The purpose of this work was twofold: first, the verification procedures recommended for Ir-192 in three existing dosimetry protocols were applied to both Co-60 and Ir-192 sources in order to test their applicability with Co-60 sources. Second, the evaluation of the experiments was performed together with medical physicists trained in a joint education program between Universities in Germany and Bangladesh. Purpose of this step was to add practical experience in Brachytherapy physics, a subject for which the Bangladesh University so far has only very little access to treatment facilities.
Materials and Methods: Three existing dosimetry protocols (IAEA-TECDOC-1274, DIN 6809-2, AAPM Report 41) were applied to Co-60 and Ir-192 sources to measure reference air kerma rate with ionization chambers using the procedures recommended for Ir-192. Wherever the protocols give no correction factors for the chamber readings from Co-60 sources, equivalent factors from literature were used. Verification measurements were performed with three different experimental methods (with a cylindrical ionization chamber both in a solid phantom and free in air, and with a well chamber) and evaluated with all three protocols. The measurements were performed at two hospitals in Germany, and evaluated in parallel in by the groups in Germany and Bangladesh. The results are compared to the reference air kerma rates given in the source certificates.
Results: The measurements with all protocols and methods are in good agreement both for Ir-192 and Co-60. The measured air kerma rates show deviations from the certificate values smaller than 1.2% for Ir-192 and 2.5% for Co-60-Sources. The measurements with the well chamber show the lowest deviations from the certificate value. The results of the experiments were published both in a German and in an Indian medical physics journal.
Conclusions: Air kerma rate measurements for Co-60 HDR sources using the existing protocols are possible with accuracy sufficient to verify source calibration even though the protocols are not specifically designed for Co-60 measurements. The existing protocols for brachytherapy dosimetry are outdated. New protocols are desirable, based on measurements with ionization chambers calibrated in absorbed dose to water and providing the complete measurement procedure and correction formalism also for Co-60 sources. Joint evaluation of experiments by physicist at a teaching institution and physicists in training at a second institution can provide a valuable means to disseminate experience to institutions with missing experimental resources.

PO-0970
Tissue segmentation significance for individualized 192Ir brachytherapy dosimetry
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Purpose/Objective: A water equivalence study of different human tissue compositions is interesting to validate the segmentation schemes employed in contemporary treatment planning systems with advanced dose calculation algorithms, and assist their benchmarking against TG43 based calculations in water.
Materials and Methods: Monte Carlo simulations were performed for a point ^{192}Ir source centered in homogeneous 50cm radius spheres of different tissue compositions taken from Schneider et al (2000) and the AAPM TG186 report. Tissue density was set to 1 in all simulations. Dose was approximated by collision kerma and both water and tissue kerma in tissue (i.e. Kw,t and Kt,t) were scored using the *F2 surface flux tally. Results are expressed as % differences of Kw,t with homogeneous water (Kw,w) to quantify differences in attenuation and scatter, as well as % differences between Kt,t and Kw,w to quantify the combined effect of the attenuation and differences in mass energy absorption.
Results:

		% elemental composition												$K_{t,t}$ % diffs from $K_{w,w}$		$K_{w,t}$ % diffs from $K_{w,w}$	
	HU	H	C	N	O	Na	Mg	P	S	Cl	Ar	K	Ca	1cm	10cm	1cm	10cm
Air[3]	-1000 -950	-	-	75.5	23.2	-	-	-	-	-	1.3	-	-	-10.06	-8.14	-0.13	1.17
Lung[1]	-950 -120	10.3	10.5	3.1	74.9	0.2	-	0.2	0.3	0.3	-	0.2	-	0.07	0.65	-0.02	-0.30
Soft tissues[3]	-120, -83	11.6	68.1	0.2	19.8	0.1	-	-	0.1	0.1	-	-	-	0.11	-0.94	0.09	4.46
	-82,-53	11.3	56.7	0.9	30.8	0.1	-	-	0.1	0.1	-	-	-	0.45	0.10	0.07	3.88
	-52,-23	11.0	45.8	1.5	41.1	0.1	-	0.1	0.2	0.2	-	-	-	-0.01	-0.43	0.04	2.16
	-22,-7	10.8	35.6	2.2	50.9	-	-	0.1	0.2	0.2	-	-	-	-0.34	-0.55	0.03	1.53
	8,18	10.6	28.4	2.6	57.8	-	-	0.1	0.2	0.2	-	0.1	-	-0.45	-0.59	0.01	0.95
Prostate[2]	-	10.5	8.9	2.5	77.4	0.2	-	0.1	0.2			0.2	-	0.02	0.37	-0.01	-0.01
Lung[2]	-	10.3	10.5	3.1	74.9	0.2	-	0.2	0.3	0.3	-	0.2	-	0.07	0.65	-0.02	-0.3
Liver[2]	-	10.2	13.9	3.0	71.6	0.2	-	0.3	0.3	0.2	-	0.3	-	0.21	0.98	-0.02	-0.25
Heart[2]	-	10.4	13.9	2.9	71.8	0.1	-	0.2	0.2	0.2	-	0.3	-	-0.06	0.50	-0.01	-0.13
Mean soft tissue[1]	19,80	10.3	13.4	3.0	72.3	0.2	-	0.2	0.2	0.2	-	0.2	-	0.04	0.558	-0.01	-0.02
Connective tissue[1]	80,120	9.4	20.7	6.2	62.2	0.6	-	-	0.6	0.3	-	-	-	-0.39	0.84	-0.02	0.88
Mean soft tissue (m)[3]	-	10.5	25.6	2.7	60.2	0.1	-	0.2	0.3	0.2	-	0.2	-	-0.05	0.22	0	0.49
Mean soft tissue (f)[3]	-	10.6	31.5	2.4	54.7	0.1	-	0.2	0.2	0.1	-	0.2	-	0.00	0.11	0.01	0.98
Mean skin[3]	-	10.0	20.4	4.2	64.5	0.2	-	0.1	0.2	0.3	-	0.1	-	-0.51	-0.07	-0.01	0.47
Mean adipose[2]	-	11.4	59.8	0.7	27.8	0.1	-		0.1	0.1	-	-	-	0.02	-0.80	0.08	3.65
Mean gland[2]	-	10.6	33.2	3.0	52.7	0.1	-	0.1	0.2	0.1	-	-	-	-0.28	-0.37	0.02	1.51
Skeletal tissues[1]	120,200	9.5	45.5	2.5	35.5	0.1	-	2.1	0.1	0.1	-	0.1	4.5	4.27	7.25	-0.13	-4.29
	200,300	8.9	42.3	2.7	36.3	0.1	-	3.0	0.1	0.1	-	0.1	6.4	4.20	4394	-0.18	-5.61
	300,400	8.2	39.1	2.9	37.2	0.1	-	3.9	0.1	0.1	-	0.1	8.3	8.10	12.71	-0.23	-6.61
	400,500	7.8	36.1	3.0	38.0	0.1	0.1	4.7	0.2	0.1	-	-	10.1	10.00	15.20	-0.27	-7.36
	500,600	7.1	33.5	3.2	38.7	0.1	0.1	5.4	0.2	-	-	-	11.7	11.46	17.01	-0.30	-7.91
	600,700	6.6	31.0	3.3	39.4	0.1	0.1	6.1	0.2	-	-	-	13.2	12.92	18.75	-0.33	-8.38
	700,800	6.1	28.7	3.5	40.0	0.1	0.1	6.7	0.2	-	-	-	14.6	14.10	20.26	-0.36	-8.75
	800,900	5.6	26.5	3.6	40.5	0.1	0.2	7.3	0.3	-	-	-	15.9	15.49	22.00	-0.39	-9.08
	900,1000	5.2	24.6	3.7	41.1	0.1	0.2	7.8	0.3	-	-	-	17.0	16.45	23.13	-0.41	-9.32
	1000,20	4.9	22.7	3.8	41.6	0.1	0.2	8.3	0.3	-	-	-	18.1	17.56	24.44	-0.42	-9.55
	20,1200	4.5	21.0	3.9	42.0	0.1	0.2	8.8	0.3	-	-	-	19.2	18.51	25.43	-0.44	-9.76
	1200,1300	4.2	19.4	4.0	42.5	0.1	0.2	9.2	0.3	-	-	-	20.1	19.29	26.44	-0.45	-9.92
	1300,1400	3.9	17.9	4.1	42.9	0.1	0.2	9.6	0.3	-	-	-	21.0	20.12	27.15	-0.47	-10.08
	1400,1500	3.6	16.5	4.2	43.2	0.1	0.2	10.0	0.3	-	-	-	21.9	20.92	28.15	-0.48	-10.23
Cortical bone[3]	-	3.4	15.5	4.2	43.5	0.1	0.2	10.3	0.3		-	-	22.5	21.57	28.72	-0.49	-10.32

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2H. Q. Woodard and D. R. White, "The composition of body tissues," Br. J. Radiol. 59, 1209–1218 (1986).
3International Commission on Radiation Units and Measurements, "Photon, electron, proton and neutron interaction data for body tissues," Report No. 46 (ICRU Publications, Bethesda, MD, 1992).

When the effect of density is ruled out, differences in electron density and Z_{eff} between air and water translate to negligible differences in attenuation (Kw,air is within 1% with Kw,w in contrast to Kair,air which is 10% lower due to the lower mass energy absorption of air). Dosimetric differences between lung and water are negligible regardless of kerma reporting in lung or water, albeit positive in the former case and negative in the latter. For soft tissue materials, Kw,t reporting would yield significant differences from water for high adipose content (lower O weight) only at increased distances. Kt,t reporting would yield negligible differences from water for all materials and distances. The connective and mean soft tissues all appear dosimetrically equivalent to water regardless of reporting Kw,t or Kt,t, except for mean adipose. Skeletal tissues present increasing differences from water with increasing proportion of osseous tissue to bone marrow, with negative differences for Kw,bone and positive for Kbone,bone.
Conclusions: Lung and average soft tissue materials set forth by the AAPM TG186 are water equivalent for the ^{192}Ir energies regardless of kerma reporting material. Departure from water equivalence is only observed when Kw,t is reported and only for large tissue thickness. Kerma reporting material also affects the differences relative to water for skeletal materials. Tissue density is the determining parameter for individualized ^{192}Ir patient dosimetry. A method for stoichiometric CT calibration is not required unless reporting water kerma in the inhomogeneous geometry is of the essence.
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POSTER: BRACHYTHERAPY TRACK: PROSTATE CANCER

PO-0971
The impact of TRUS probe type on treatment planning of I-125 permanent prostate brachytherapy.
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Purpose/Objective: In permanent I-125 seed implants of the prostate, the quality of the implant depends, amongst other factors, on the quality of the image modality used during implantation. The image modality most frequently used in the OR is TRUS. Since March 2009 a new type of TRUS probe is introduced in our clinic. This is a dual sagittal crystal probe (DSCP) with a transversal crystal in between, instead of the conventional single sagittal crystal probe (SSCP) with a transversal crystal in front. In a retrospective study it was investigated whether a longer sagittal view using a DSCP allowed for more accurate online-planning in I-125 permanent implant