Is Cesium–l3l, I-125 or Pd-103 the Ideal Isotope for Prostate Boost Brachytherapy

A Dosimetric Viewpoint

Purpose/Objective

Our study aimed to perform a dosimetric comparison of Prostate boost brachytherapy treatment plans generated utilizing Cesium-131, Iodine-125 and Palladium-103 seeds.

Introduction

Trans-rectal Ultrasound (TRUS) guided permanent seed implants for prostate cancer is a constantly growing and technically challenging procedure with a considerable learning curve. Depending on disease stage, brachytherapy is administered solo or in combination with External Beam Radiation Therapy / Hormonal Therapy. Permanent prostate brachytherapy can be performed using different isotopes. Currently three isotopes, namely Cesium-131 (Cs-131), Iodine-125 (I-125) and Palladium-103 (Pd-103), are commercially available for Prostate seed implantation. All three isotopes offer the advantages of low energy with rapid dose fall-ff to minimize doses to normal structures, but differ in half-lives and initial dose rates (Table 1). Cs-131 offers initial dose rate of ~32 cGy/h at prostate periphery which is approximately 1.5× and 4× higher than Pd-103 and I-125 initial dose rates. Some radiobiological advantages for each isotope over other have been claimed in literature. Irrespective of the isotope chosen for implantation clinically, a careful examination and a good handle on the resulting dose distributions within the prostate and to the surrounding bladder and rectum are necessary for establishing appropriate standards of care.

Table 1: Isotope Characteristics

Isotope	Half-Life (Days)	Average Energy (keV)	90% Dose Delivered (Days)
Cesium-l3l	9.7	30.4	33
Iodine-125	59.4	28.5	204
Palladium-103	17.0	20.8	58

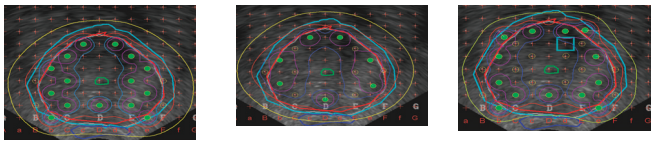
Methods

TRUS Prostate volume studies of 15 patients previously treated in our institution with seed implantation and representing a wide range of prostate sizes were utilized for this study. The TRUS images were obtained intra-operatively using B&K Ultrasound unit in 5 mm steps. The median prostate volume was 27.2 cc (range 16.0 to 39.2 cc). The Clinical Target Volume (CTV) and Planning Target Volume (PTV) were defined according to RTOG 0232 guidelines. For each prostate size, three optimized treatment plans were generated - by changing the isotope to Cs-131, I-125 and Pd-103 respectively. The boost brachytherapy prescription doses were: 85 Gy for Cs-131, 110 Gy for I-125 and 100 Gy for Pd-103. The seed strengths employed were: 1.6 and 1.8 U (for plans utilizing Cs-131 and Pd-103 seeds respectively) and 0.54 U (I-125). Planning goals attempted were: V100 (prostate volume receiving 100% of the prescribed dose) ~ 95%, D90 (dose received by 90% of the Prostate volume) ≥100%, and Prostatic urethra D10≤ 150%. To eliminate bias, auto seed loading and optimization tools of the planning system were utilized. All plans were evaluated for coverage (V100, V90, V80 and D90) and uniformity (V200, V150) using ABS recommended guidelines. Dose calculations were performed using Variseed (Varian Oncology) treatment Planning system using AAPM TG-43 formalism.

Results

A total of 45 treatments plans were analyzed. The results of the comparison study are summarized in Table 2. For similar dose coverage (V100 and D90), the percentage volume of the prostate receiving 200% and 150% of the prescription doses (V200 and V150) which is a measure of dose homogeneity in the prostate was highest for Pd-103 plans followed by I-125 plans and lowest for plans utilizing Cs-131seeds (see Figure 1 and box plots). Urethral doses (UD10) were not significantly different between the three sets of plans. For comparable seed strengths and prostate sizes, the numbers of seed requirements were identical for Cs-131/I-125 seed plans but required ~30% higher number of seeds for Pd-103 implants.

Cs-131 I-125 Pd-103



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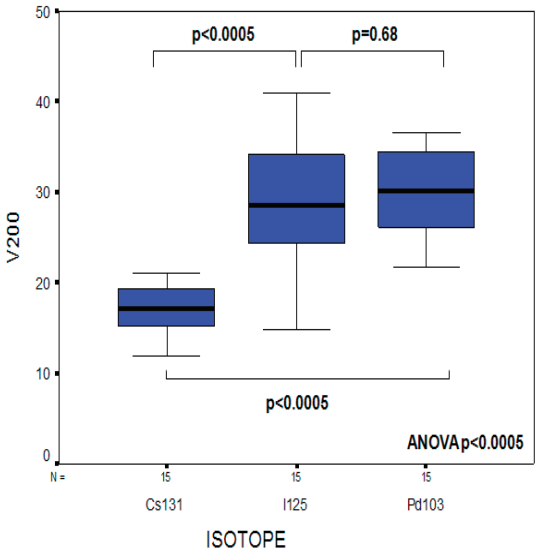
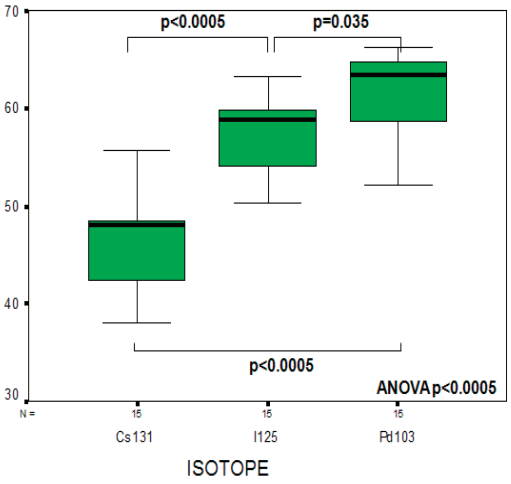
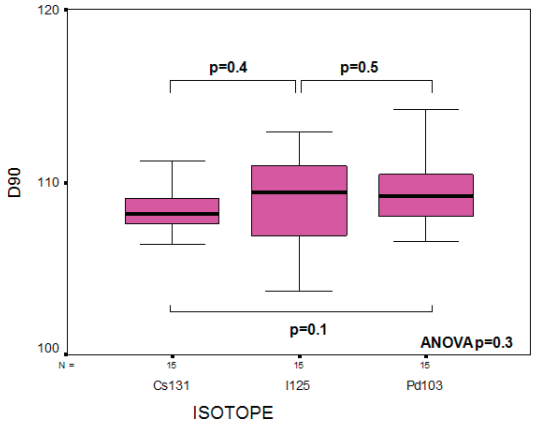
Box Plot and p(means): V_{200}



Box Plot and p(means): V_{150}



Box Plot and p(means): D_{90}



		Isotope	N	Mean	Standard Deviation	Standard Error Mean	p Value
Uniformity	V_{200}	Cs-131 I-125 Pd-103	15 15 15	18.2 28.7 29.7	4.7 7.8 5.0	1.2 2.0 1.3	p<0.0005
	V_{150}	Cs-131 I-125 Pd-103	15 15 15	46.9 57.0 61.2	5.5 5.0 5.3	1.4 1.3 1.4	p<0.0005
Dose Coverage	V_{100}	Cs-131 I-125 Pd-103	15 15 15	94.3 94.3 94.3	0.7 1.1 0.8	0.2 0.3 0.2	P=0.3
	V_{90}	Cs-131 I-125 Pd-103	15 15 15	97.8 97.6 96.9	0.7 0.9 0.7	0.2 0.2 0.2	
	D_{90}	Cs-131 I-125 Pd-103	15 15 15	108.4 109.2 109.7	1.7 2.7 2.5	0.4 0.7 0.6	
Normal Tissue Doses	Urethra UD_{10}	Cs-131 I-125 Pd-103	15 15 15	125.6 132.0 126.2	8.7 8.5 12.6	2.3 2.2 3.2	
	Rectum RD_{10}	Cs-131 I-125 Pd-103	15 15 15	68.0 69.1 51.6	6.3 9.5 6.1	1.6 2.4 1.6	
Seeds/cc		Cs-131 I-125 Pd-103	15 15 15	2.0 2.0 2.6	0.3 0.3 0.4	0.08 0.07 0.09	

Conclusions

From a dosimetric view point, boost brachytherapy treatment plans utilizing Cs-131 seeds yielded “homogeneous” dose distributions within the prostate while providing desired dose coverage and acceptable normal tissue doses compared to I-125 or Pd-103 seed implants. However, clinical history with Cs-131 seed implants is limited compared to I-125 or Pd-103 seed implants and therefore, longer-term follow-up and toxicity studies are warranted.

Pertinent Literature

1. Nag S, Beyer D, Friedland J, et al. American Brachytherapy Society (ABS) recommendations for transperineal permanent brachytherapy of prostate cancer. Int. J. Radiat. Oncol. Biol. Phys.44:789-799, 1999.
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