Brachytherapy LDR Prostate Plans Robustness Test Based on Random Sampling

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INTRODUCTION

- Brachytherapy LDR radioactive seed plans for prostate implants are generated based on the dosimetry alerts set on the targets (e.g PTV V100%) and the organs at risk (e.g Urethra V125%). Those dosimetry alerts would be met only if the seeds are placed in the intended position.
- However, dosimetry has uncertainties associated to seed position variabilities [1]. Seed displacement has been reportedly associated to needle placement errors, patient position reproducibility in the OR, prostate volume changes, and potential prostate movement during implantation[2].

AIM

- The main objective of this investigation is to create a systematic procedure that provides improved quantifiable evaluation of the variation in the dose distribution of brachytherapy LDR prostate radioactive seed implant as a function of the seed position uncertainty.

METHOD

- An in-house window-based software (BrachyVIC) has been coded with Python to calculate the 3D dose distribution of brachytherapy LDR radioactive seeds arrangements, using the AAPM TG43 formalism[3].
- Plans generated in the treatment planning system are exported to BrachyVIC which randomly shift the seeds up to 2mm in any direction and recalculate the dose distribution. The process of seed shifting and dose calculation is done 100 times (see algorithm in Fig 1). Total time is approximately 25 seconds.

…METHOD

- It further calculates the mean dose and the standard deviation (STD) of each ROI dosimetry alert (i.e PTV V100, PTV V150, Pros V100, Pros V150, Urethra V125 and Rectum D1cc). See Fig 1.
- The probability to meet each dosimetry alert is then calculated using the probability density function of the normal distribution (Fig 2).

Fig 1. *Algorithm to calculate the probability to meet ROI dosimetry alerts.*

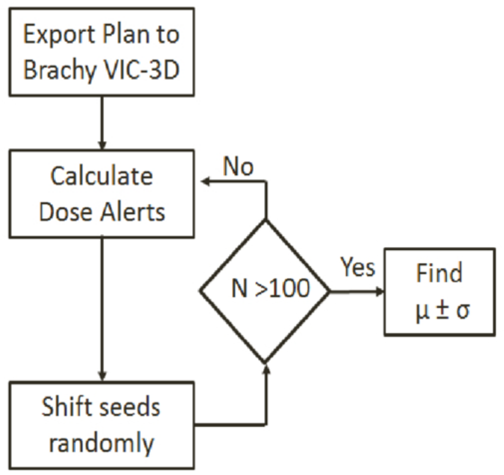
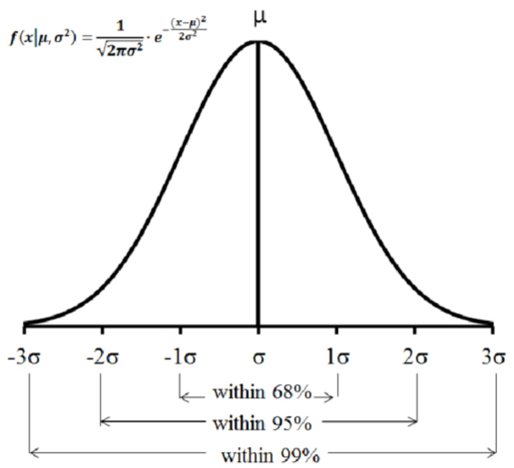


Fig 2. *Probability density function of the normal distribution.*



RESULTS

- In average, the standard deviation of PTV100 and PTV150 dosimetry alerts are 0.3% and 1.6%, respectively. Compatible quantities are observed for prostate volumes and rectum but urethra goes to 18% (see Table 1).

Table 1. *Standard deviation (STD) of ROI dosimetry alerts after calculating planned dose distributions with different seed displacements.*

PTV			Pros		Urethra	Rectum
V100%	**V150%**	**V200%**	**V100%**	**V150%**	**V125%**	**D1cc**
0.3%	1.6%	1.0%	0.3%	2.2%	18.0%	1.0%

- Different sources/needle displacements mainly affect the standard deviation of PTV V150, Pros V150, and Urethra V125 but PTV V100 and Pros V100 have a consistent and stable metric regardless of the source/seed distribution.
- Plan robustness is more correlated to the standard deviation in the dose metric but the probability to meet the objectives is a function of both the original planned dosimetry alerts and the standard deviation due to seed displacement.

CONCLUSIONS

- Giving the dose uncertainty as a function of position uncertainty provides a more accurate and precise overview of the dosimetry objectives.
- Probability to meet objectives is a comprehensive metric to dosimetrically evaluate/compare LDR plans and provides an improved prediction of dosimetry outcome after seeds implant.

REFERENCES

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