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Comparison of Dose Distribution around Central Vaginal Applicator Brachytherapy Treatment Calculated with Water Based TG43 & Model Based TG186

Research Article
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Abstract

Aim: The focus of this research was to look at the dosimetric effect and evaluate the dose difference between TG-186 and TG-43 plans for cervical carcinoma using central vaginal applicators, in order to help clinicians to choose right algorithm.

Introduction: TG-43 protocol is for calculation of dose-rate distributions around photon-emitting brachytherapy sources. The radiation is assumed to be carried out through an infinite homogeneous water phantom in the TG-43 dose calculation approach. Thus any heterogeneities within or outside the patient are not taken into account. As a result the accuracy of dose calculations in places near to air or bone may be impacted. The recently published AAPM Radiation Therapy Committee Task Group 186 (TG-186) report has provided new guidelines for dose calculation and reporting in brachytherapy to address the shortcomings of the current TG-43U1 dose calculation methodology. Heterogeneity correction algorithms have only recently been made available to the BT community in contrary to external beam radiotherapy.

Materials and Methods: A retrospective study including 15 patients with cervical cancer who had undergone postoperative brachytherapy was performed. External Beam Radiotherapy (EBRT) was performed with a total dose of 50 Gy in 25 fractions as 2 Gy/per fraction using conventional fractionation schedule.Based on TG-43 and TG-186 algorithms plans were done for 15 cervical patients on the Nucletron- oncentra planning system and treated with Ir-192 brachytherapy source. The plans were not re optimized and therefore the dwell positions and dwell times were identical between the two plans. Retrospectively the plans were recalculated using the TG-186 algorithms. For each patient DVH is used to calculate dose in 0.1cc CGy, 1cc CGy, 2cc CGy and 5cc CGy of OAR doses as well as prescription point doses.

Results: D w,m, found small changes in Prescription doses and in D0.1 cc, D1 cc, D2 cc, D5 cc for rectum and bladder with all dose parameters for individual patients differing from TG-43 values by < 1%.

Conclusion: The dose difference between TG43 and TG186 algorithms is for most clinical cases not significant for target volumes and OARs. Cylinder applicators although TG43 algorithm overestimated the tissue dose the difference of dose distribution caused by the two algorithms was almost negligible because the difference of dose distribution was not much (less than 1%) and both were located around the applicator.

Keywords: Applicators; Brachytherapy; CVS; HDR; TG-43; TG-186

Introduction

Intracavitary Brachytherapy (BT) is a significant part of the treatment of cervical carcinoma and has been demonstrated to improve radiotherapeutic outcomes such as enhancing target dose distribution and lowering rectal and bladder toxicities. The American Association of Physicists in Medicine Task Group 43 (TG-43) protocol is currently being used in worldwide for accurately determining the dose delivered in brachytherapy treatments. TG-43 protocol is for calculation of dose-rate distributions around photon-emitting brachytherapy sources. The radiation is assumed to be carried out through an infinite homogeneous water phantom in the TG-43 dose calculation approach. Thus any heterogeneities within or outside the patient are not taken into account. As a result the accuracy of dose calculations in places near to air or bone may be impacted [1].

The recently published AAPM Radiation Therapy Committee Task Group 186 (TG-186) report has provided new guidelines for dose calculation and reporting in brachytherapy to address the shortcomings of the current TG-43U1 dose calculation methodology. TG-186 recommends using Model-Based Dose Calculation Algorithms (MBDCA) along with current TG-43U1 methods for dosimetry as contrast-

ed to the TG-43U1 methodology which treats the patient with 15 cm radius sphere in water with uniform unity density for dose calculation purposes [2].

The aim of Task Group 186 (TG-186) is to provide guidance for early adopters of Model-Based Dose Calculation Algorithms (MBDCAs) for Brachytherapy (BT) dose calculations to ensure practice uniformity. Heterogeneity correction algorithms have only recently been made available to the BT community, in contrary to external beam radiotherapy. However, the accuracy of BT dose calculations is highly influenced by scatter circumstances and photoelectric effect cross-sections in relation to water.

Differences in calculated doses between the current water-based BT dose calculation formalism (TG-43) and MBDCAs can exceed a factor of 10 in specific situations.

The focus of this research was to look at the dosimetric effect and evaluate the dose difference between TG-186 and TG-43 plans for cervical carcinoma using central vaginal applicators in order to help clinicians to choose right algorithm [3].

Materials and Methods

Patient Selection and Contouring

A retrospective study including 15 patients with cervical cancer who had undergone postoperative brachytherapy was performed. External Beam Radiotherapy (EBRT) was performed with a total dose of 50 Gy in 25 fractions as 2 Gy/per fraction using conventional fractionation schedule. All patients were underwent HDR brachytherapy which was performed in three fractions 6 Gy per fraction for 2 weeks usually starting in the last week of EBRT [4]. For these 15 patients two different applicators were used namely tandem and ovoid (T&O) applicator and cylindrical applicator. Depending on the dose distribution requirements two types of applicators used in brachytherapy treatment. The most popular applicators used in intracavitary techniques are the intracavitary applicator and the central vaginal applicator. Both methods of applicator dose prescribing are different from one another. Manchester dose prescription methods are used with the intracavitary applicator. The point of prescription is 2 cm lateral and 2 cm superior from the cervical OS point.

The CVS prescription point was placed 0.5 cm from the applicator's external surface or exactly to the applicator's external surface according to AAPM guidelines. The ICRT applicator thickness does not change from patient to patient, however the CVS thickness is determined on the patient's vaginal measurements. When the plan is calculated using the water-based TG-43 method altering the thickness will increase the error in treatment planning [5-7]. When data is obtained at a greater distance from each manufacturing source the anisotropic function and radial dose function are more similar according to the TG-43 data analysis. When the distance between the source is greater than 6 cm the encapsulation effect has been shown to have a relatively small effect on the dose distribution. In comparison to CVS prescription systems the dose prescription point of ICRT applicators is farther away from the applicator. As a result dosimetry work is typically done with CVS applicators with different patients. On post-implant CT the clinical Prescription point, bladder and rectum were delineated and the vaginal wall was contoured [8].

Methods of Treatment Planning

Based on TG-43 and TG-186 algorithms plans were done for 15 cervical patients on the Nucletron- oncentra planning system and treated with Ir-192 brachytherapy source [9,10]. The plans were not re optimized and therefore the dwell positions and dwell times were identical between the two plans. Retrospectively the plans were recalculated using the TG-186 algorithms. For each patient DVH is used to calculate dose in 0.1cc CGy, 1cc CGy, 2cc CGy, and 5cc CGy of OAR doses as well as prescription point doses (Figure 1).

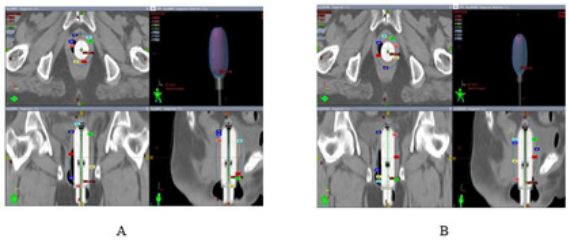

Figure 1: A- Dose distribution around the Cylindrical applicator calculated by TG-43 and B- Dose distribution around the Cylinrical applicator calculated by TG-186.

Results and Discussion

The precision of brachytherapy treatment includes the following aspects: the precision of contouring of target and organs at risk implantation location of the applicators dose calculation and positioning before treatment. Regardless of the precision the goal is to reach an accurate dose distribution (Table 1). The American Association of Physicists in Medicine TG186 report recommended continued use of the TG43 methodology for clinical dose calculations in brachytherapy while performing MBDCA calculations in parallel [11,12]. The dose difference comparison between TG-43 and TG-186 a cylindrical applicator reveals that TG-186 achieves better accuracy than TG-43. The algorithm of TG-43 overestimates the dose of target area and OARs compared with TG-186 algorithm under the condition of the same dwell point and dwell time although the plan of applying the two algorithms can meet the clinical requirements. Doses calculated by TG-43 were up to 5% larger than TG-186 calculated. The TG-186 used for brachytherapy dose calculation could reduce the uncertainty of dose distribution and around 3% of the total error in soft tissue (Figure 2).

Lastly, Hofbauer et al. [13] recalculated HDR 192Ir treatment plans for nine cervix patients delivered with plastic tandem and ring applicators for which applicator models were not available using Acuros BV in Brachy Vision v.10.0 [13]. Five of the nine patients were treated with a combined intracavitary/ interstitial technique. Based on reporting D w,m the authors observed only a very small dosimetric impact with D90 and V100 for high-risk CTV reduced by < 0.5% and D2 cc and D0.1 cc for organs at risk reduced by < 2%. Mikell et al. [14] also studied conventional CT-based tandem and ovoids HDR 192Ir treatment plans that incorporated stainless steel shielding in the ovoids using Brachy Vision v.10.0.26 in a retrospective study involving 24 patients [14]. Using the same dose parameters and heterogeneity factors employed in their earlier study and again reporting D w,m the authors found reductions relative to TG-43 of up to 3.8%, 11.9%, 7.2% and 9.3% for Point A dose D2 cc rectum, D2 cc bladder and D2 cc sigmoid respectively.

Reductions in doses to organs at risk were predominately associated with the applicator. Some inconsistencies in applicator properties modelled in the Brachy Vision applicator library and obtained from radiographic measurements were noted although these were deemed not to be of clinical concern. Cervix the earliest work with MBDCAs focused on cervix treatments delivered using unshielded tandem and ovoids applicators. Mikell et al. [14] conducted a retrospective assessment of the impact of heterogeneities on CT-based conventional Manchester system HDR 192Ir treatment plans for 26 patients using Acuros BV in Brachy Vision v.8.8 software. Reporting D w,m they found minor changes in Point A and B doses and in D2cc for rectum, bladder and sigmoid with all dose parameters for individual patients differing from TG-43 values by < 5%. Larger differences of up to ~10% observed at locations within the imaging volume were shown to be attributable

to three factors: radiation source modelling and patient boundary applicator modelling, and tissue heterogeneity. Our study concluded that D w,m found small changes in Prescription doses and in D0.1 cc, D1 cc, D2 cc, D5 cc for rectum and bladder with all dose parameters for individual patients differing from TG-43 values by < 1%.

Table 1: Comparison of dose difference of bladder and rectum calculated with two algorithms.

No. of Patients	Protocols	Bladder				Rectum			
		D0.1cc (CGy)	D1 cc (CGy)	D2 cc (CGy)	D5 cc (CGy)	D0.1 cc (CGy)	D1 cc (CGy)	D2 cc (CGy)	D5 cc (CGy)
1	TG- 43	477.1	408.2	375	316.9	812.3	679.3	616	513.8
	TG - 186	474.8	406.4	373.4	315.7	807.4	675.4	612.8	511.3
2	TG- 43	523.3	441.3	403.2	341.5	813	650.4	566.7	431.4
	TG - 186	520.8	439.4	401.5	340.3	807.8	646.7	563.6	429.5
3	TG- 43	883	628.9	526.5	403.8	888	752.2	678.5	553.1
	TG - 186	877.2	625.5	523.9	402.1	882.3	747.6	674.5	550.2
4	TG- 43	701.8	547.6	486.6	408.3	819.3	634.8	571.1	474.7
	TG - 186	697.1	544.4	484	406.3	814.1	631.3	568.2	472.5
5	TG- 43	594.5	465.3	424.5	359.2	640.2	529.3	480	402.5
	TG - 186	590.7	462.9	421.8	356.3	637.6	525.8	476.8	399.5
6	TG- 43	791.8	665.9	599.4	482.4	718.3	598.1	551.2	469.1
	TG - 186	786.9	661.9	595.9	480	713.9	594.7	548.1	466.8
7	TG- 43	893.4	693.3	595.1	478.7	884.6	764.9	693.9	569.6
	TG - 186	887.6	689.2	591.9	476.4	878.9	760.3	689.8	566.6
8	TG- 43	448.1	388.6	356.3	302.1	745.2	641.5	583.9	484.6
	TG - 186	445.8	386.8	354.7	301	740.6	637.9	580.8	482.4
9	TG- 43	474.7	383	344.9	288.1	871.1	700.9	623.6	510.1
	TG - 186	471.9	381	343.1	287	865.2	696.7	619.9	507.5
10	TG- 43	414.2	332.1	293.8	238	812.8	629	553.3	431.6
	TG - 186	412	330.6	292.5	237.1	807.4	625.3	550	429.3
11	TG- 43	633.1	510.6	463.9	391.9	814.7	717	663.4	560.6
	TG - 186	629.4	507.9	461.6	390.2	809.7	712.7	659.6	557.8
12	TG- 43	464.9	404.2	375.2	322.6	836.1	696.9	616.2	478.7
	TG - 186	462.4	402.2	373.4	321.2	830.2	692.5	612.4	476
13	TG- 43	327.7	268.1	2241	198.9	706.6	502.2	422.9	312.9
	TG - 186	325.8	266.7	239.8	198.1	701.9	499.4	420.7	311.5
14	TG- 43	588.6	513.6	481.2	415.3	818.4	640.9	557.5	422
	TG - 186	585.4	511	478.9	413.4	813.3	637.3	554.6	420.2
15	TG- 43	588.9	513.9	481.5	415.5	818.7	641.1	557.7	422.3
	TG - 186	585.4	511	478.9	413.4	813.3	637.3	554.6	420.2

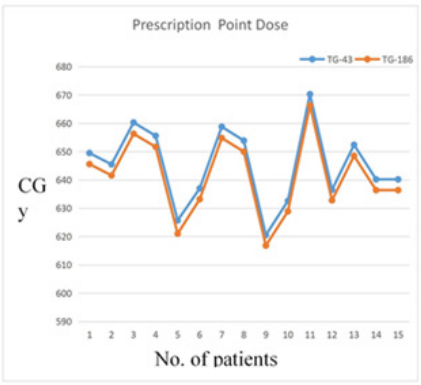

Figure 2: Comparison of Prescription point dose difference of all patients calculated with TG-43 and TG-186.

Conclusion

The dose difference between TG43 and TG186 algorithms is for most clinical cases not significant for target volumes and OARs. Cylinder applicators although TG43 algorithm overestimated the tissue dose the difference of dose distribution caused by the two algorithms was almost negligible (less than 1%) and both were calculated around the applicator. Future in this study is extended to more number of patient and Comparison with monte carlo analysis for further analysis.

References

1. Nori D, Dasari N, Allbright RM (2002) Gynecologic brachytherapy I: Proper incorporation of brachytherapy into the current multimodality management of carcinoma of the cervix. Semin Radiat Oncol 12(1): 40-52.

2. Enger SA, Vijande J, Rivard MJ (2020) Model-Based Dose Calculation Algorithms for Brachytherapy Dosimetry. Semin Radiat Oncol 30(1): 77-86.

3. Sinnatamby M, Nagarajan V, Reddy KS, Karunanidhi G, Singhavajala V (2016) Comparison of image-based three dimensional treatment planning using AcurosTM BV and AAPM TG-43 algorithm for intracavitary brachytherapy of carcinoma cervix. J Radiother Pract 15(3): 254-262.

4. Beaulieu L, Tedgren CÅ, Carrier JF, Davis SD, Mourtada F, et al. (2012) Report of the Task Group 186 on model-based dose calculation methods in brachytherapy beyond the TG-43 formalism: Current status and recommendations for clinical implementation. Med Phys 39(10): 6208-6236.

5. Cawston-Grant B, Morrison H, Menon G, Sloboda RS (2017) Experimental verification of Advanced Collapsed-cone Engine for use with a multichannel vaginal cylinder applicator. J Appl Clin Med Phys 18(3): 16-27.

6. Lymperopoulou G, Pantelis E, Papagiannis P, Rozaki-Mavrouli H, Sakelliou L, et al. (2004) A monte carlo dosimetry study of vaginal 192Ir brachytherapy applications with a shielded cylindrical applicator set. Med Phys 31(11): 3080-3086.

7. Papanikolaou N, Battista J, Boyer A, Kappas C, Klein E, Mackie T, et al. (2004) Tissue inhomogeneity corrections for megavoltage photon beams. AAPM Report No. 85, Task Group No 65 of the Radiation Therapy Committee of the American Association of Physicists in Medicine.

8. Zourari K, Major T, Herein A, Peppa V, Polgár C, et al. (2015) A retrospective dosimetric comparison of TG43 and a commercially available MBDCA for an APBI brachytherapy patient cohort. Phys Medica 31(7): 669-676.

9. Abe K, Kadoya N, Sato S, Hashimoto S, Nakajima Y, et al. (2018) Impact of a commercially available model-based dose calculation algorithm on treatment planning of high-dose-rate brachytherapy in patients with cervical cancer. J Radiat Res 59(2): 198-206.

10. Jacob D, Lamberto M, Lawrence L D, Mourtada F (2017) Clinical transition to model-based dose calculation algorithm: A retrospective analysis of high-dose- rate tandem and ring brachytherapy of the cervix. Brachytherapy 16(3): 624-629.

11. Georg P, Pötter R, Georg D, Lang S, Dimopoulos JC, et al. (2012) Dose effect relationship for late side effects of the rectum and urinary bladder in magnetic resonance image-guided adaptive cervix cancer brachytherapy. Int J Radiat Oncol Biol Phys 82(2): 653-657.

12. Rivard MJ, Coursey BM, DeWerd LA, Hanson WF, Saiful Huq M, et al. (2004) Update of AAPM Task Group No. 43 Report: A revised AAPM protocol for brachytherapy dose calculations. Med Phys 31(3): 633-674.

13. Hofbauer J, Kirisits C, Resch A, Xu Y, Sturdza A, et al. (2016) Impact of heterogeneity- corrected dose calculation using a grid-based Boltzmann solver on breast and cervix cancer brachytherapy. J Contemp Brachytherapy 8(2): 143-149.

14. Mikell J, Klopp A, Price M, Mourtada F (2013) Commissioning of a grid-based Boltzmann solver for cervical cancer brachytherapy treatment planning with shielded colpostats. Brachytherapy 12(6): 645-653.