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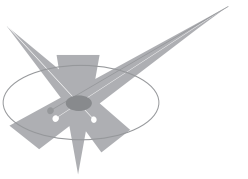

Original Paper

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Dosimetric evaluation of Gammamed High Dose Rate intraluminal brachytherapy applicators

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Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

Summary

Background A survey of the literature on intraluminal brachytherapy reveals that even for a given tumour site, the dose prescribed varies considerably from one centre to another for multiple reasons: the treatment intent, the association with external beam therapy or not, the dose rate, the technique used and the point of dose specification. There is no common language in the literature as to how doses should be recorded and reported.

Aim The purpose of this study was to dosimetrically evaluate various intraluminal brachytherapy applicators for the Gammamed high dose rate afterloading system.

Materials/Methods Dosimetric evaluation was carried out for 8mm, 10mm, 12mm and 14mm diameter intraluminal applicators available with the Gammamed high dose rate afterloading system. Treatment planning for these applicators was carried out with the Abacus treatment planning system for active source length and 8cm, 10cm and 12cm. All evaluations were carried out for a prescription dose of 5Gy at the reference point of 1cm from the source axis. Reference volume length (RVL), treated volume (TV) and hyperdose sleeve radius (HSR) were noted down from the isodose plans. Iterative, geometric and equal times optimization routines were carried out for all evaluations with step size of 0.5cm.

Results The isodose curves showed tapering pattern towards the distal and proximal regions. The reference volume lengths were larger than active source lengths for 8mm and 10mm diameter applicators. Reference volume lengths were smaller than active source lengths for 12mm and 14mm diameter applicators hyperdose sleeve radius decreases with increase in diameter of the applicator. For 14mm diameter applicators, the hyperdose sleeve radius was smaller than the radius of the reference isodose. Iterative optimization routine gave a better average in terms of reference volume length for all four diameter applicators.

Conclusions We evaluated the dosimetric parameters for various intraluminal applicators available with the Gammamed high dose rate remote afterloading system. The values of RVL and HSR were within acceptable limits for the four applicators considered in this study.

Key words HDR brachytherapy • dosimetry

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Background

There has been rapid growth in the use of intraluminal brachytherapy in recent years [1–4]. This technique is utilized in the treatment of tumours of the oesophagus, lungs, trachea and the biliary tract. It is sometimes given with curative intent, but generally the vast majority of patients are not curable. Therefore the results are assessed within the context of palliative therapy, used alone or in association with other modalities such as laser treatment, surgery, external beam irradiation and chemotherapy. It can provide effective palliation quickly with minimal morbidity at low cost.

A survey of the literature on intraluminal brachytherapy reveals that even for a given tumour site, the dose prescribed varies considerably from one centre to another for multiple reasons: the treatment intent, the association with external beam therapy or not, the dose rate, the technique used and the point of dose specification. For instance the diameter of different applicators used to treat carcinoma of the oesophagus can vary from 0.5 to 2.0cm and thus the dose delivered can vary by a factor of 4 according to the point of dose specification. These important disparities result from the rapid dose fall off around a single source.

There is no common language in the literature as to how doses should be recorded and reported. Most often when small diameter applicators are used, doses are prescribed and reported at a reference point 10mm from the source axis. Another practice of dose prescription and reporting which reflects more the individual situation in a patient is related to the applicator or to the oesophageal lumen. Usually a reference point at 5mm from the applicator surface or at 5mm tissue depth is chosen. Taking these different reference points, the reported reference doses and the dose gradients including the applicator and lumen surface doses vary significantly in particular when taking into account the different diameters of the applicators used.

According to the recommendations of ICRU 58 [2], the reference depth for reporting is specified in the central plane at 10mm from the source axis for small applicators. However, this recommendation is only related to the source and not to the individual application and the individual anatomy in the patient. The normal tissue of most concern with oesophageal brachytherapy, both in terms of acute and chronic side effects, is the normal oesophageal mucosa and underlying fibromuscular wall. The recommended active length documented by oesophagoscopy at the time of the planned brachytherapy is the visible mucosal tumour with 1–2cm proximal and distal margin. The American Brachytherapy Society (ABS) guidelines [1] recommend prescribing the dose always at 10 mm from the mid-source or mid-dwell position without optimization. There is concern regarding the high dose to the normal oesophageal mucosa at the proximal and distal region of the active length if optimization programs are used. Furthermore there is great variation in the type of optimization used at different institutions.

Aim

The purpose of this study was to dosimetrically evaluate various intraluminal brachytherapy applicators for the Gammamed high dose rate afterloading system.

Materials and methods

Dosimetric evaluation was carried out for 8mm, 10mm, 12mm and 14mm diameter intraluminal applicators available with the Gammamed high dose rate afterloading system. Treatment planning for these applicators was carried out with the Abacus treatment planning system for active source length and 8cm, 10cm and 12cm. All evaluations were carried out for a prescription dose of 5Gy at the reference point of 1cm from the source axis.

The following dosimetric entities were noted down as defined.

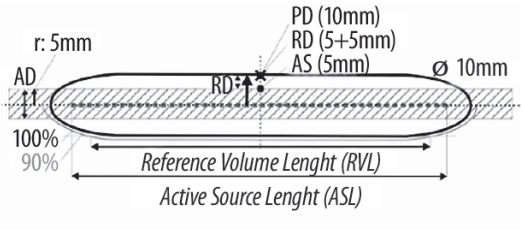

Figure 1. Definitions of dosimetric parameters.

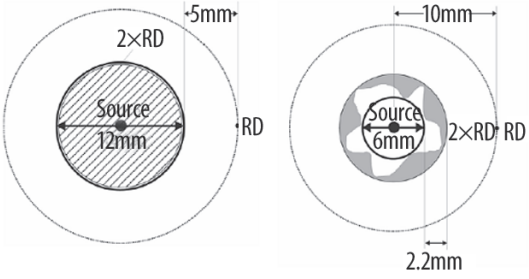

Figure 2. Definition of tissue overdose volume.

Reference volume length (RVL) – length of the 90% isodose (4.5Gy) at the reference depth (Figure 1) [4].

Treated volume (TV) – volume encompassed by the reference isodose (5Gy) [3].

Hyperdose sleeve radius (HSR) – radius of the volume receiving a dose equal to or greater than twice the reference dose (Figure 2) [3,4].

Iterative, geometric and equal times optimization routines were carried out for all evaluations with step size of 0.5 cm.

Results

Figure 3 shows the isodose plot for intraluminal applicators with radius 10mm for active source length and 10 cm with iterative optimization routine. Isodose curves for 5Gy, 4.5Gy and 1Gy are depicted in the figure. The isodose curves showed a tapering pattern towards the distal and proximal regions.

Dosimetric parameters for all four diameters are shown in Table 1. The reference volume lengths were larger than active source lengths for 8mm and 10mm diameter applicators. Reference volume lengths were smaller than active source length for 12mm and 14mm diameter applicators. Hyperdose sleeve radius decreases with increase in diameter of the applicator. For 14mm diameter applicators, the hyperdose sleeve radius was smaller than the radius of the reference isodose. Iterative optimization routine gave a better average in terms of reference volume length for all four diameter applicators.

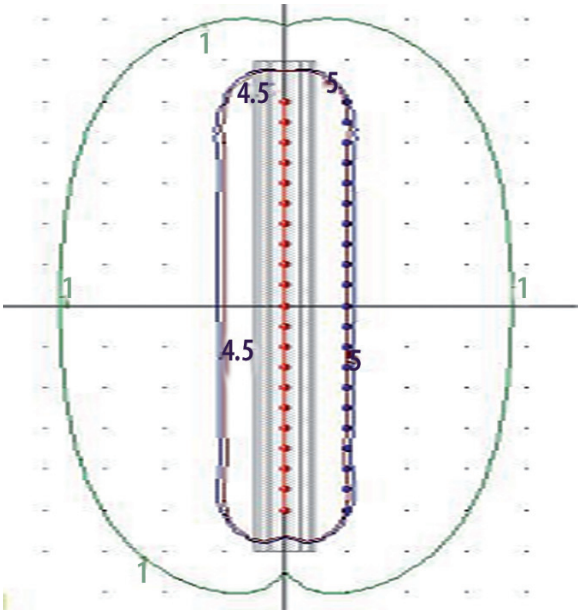

Figure 3. Isodose distribution for 10cm active source length, 0.5cm step size, iterative optimization for 10mm diameter intraluminal applicator.

Discussion

We evaluated the dosimetric parameters for various intraluminal applicators available with the Gammamed high dose rate remote afterloading system. The values of RVL and HSR were within acceptable limits for the four applicators considered in this study. Such an evaluation gives an idea regarding dosimetric coverages for various treatment planning parameters and assists in selection of these for a prospective clinical situation.

Conclusions

The length of the planning volume (PTL) is determined taking into account tumour length, safety margins for subclinical extension and positional uncertainties. The length of the reference volume (RVL) is defined as the length of the 90% isodose at the reference depth. The RVL should enclose the PTL as tightly as possible. The

Table 1. Values of dosimetric parameters for intraluminal applicators.

Diameter (mm)	Optimization routine		ASL (cm)		
			8	10	12
8	Iterative	RVL	8.7	10.82	12.88
		TV	26.8	32.9	38.7
		TSR	0.20	0.23	0.20
	Geometric	RVL	8.12	10.24	12.16
		TV	26.3	32.4	37.9
		TSR	0.20	0.23	0.20
	Equal Times	RVL	8.04	10.04	11.88
		TV	26.2	32.0	37.0
		TSR	0.20	0.23	0.17
10	Iterative	RVL	8.32	10.24	12.42
		TV	26.8	32.9	38.7
		TSR	0.1	0.1	0.1
	Geometric	RVL	7.52	9.44	11.56
		TV	26.3	32.4	37.9
		TSR	0.1	0.1	0.1
	Equal Times	RVL	7.26	9.2	10.7
		TV	26.2	32.0	37.0
		TSR	0.1	0.1	0.1
12	Iterative	RVL	7.46	9.76	11.82
		TV	26.8	32.9	38.7
		TSR	0.0	0.0	0.0
	Geometric	RVL	6.32	8.38	11.02
		TV	26.3	3.24	37.9
		TSR	0.0	0.0	0.0
	Equal Times	RVL	6.0	7.72	10.3
		TV	26.2	32.0	37.0
		TSR	0.0	0.0	0.0
14	Iterative	RVL	7.2	9.04	11.02
		TV	26.8	32.9	38.70
		TSR	In	In	In
	Geometric	RVL	6.6	8.64	10.24
		TV	26.3	32.4	37.9
		TSR	In	In	In
	Equal Times	RVL	6.12	7.84	9.64
		TV	26.2	32.0	37.0
		TSR	In	In	In

hyperdose is important clinically because the tissue volume covered by the hyperdose envelope correlates with treatment complication.

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