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Dosimetric Characterization of Bonvoisin-Gerard Esophageal Applicators with High Contrast Agent

Keying Xu[1], Bryan Traughber[1,2], Eleanor Harris[1,2], Tarun Podder[1,2],
1 University Hospitals Cleveland Medical Center, Cleveland, OH; 2 Case Western Reserve University, Cleveland, OH

University Hospitals Seidman Cancer Center
Cleveland | Ohio

INTRODUCTION/IMPACT

The Bonvoisin-Gerard esophageal applicators (Elekta Inc.) are manufactured with materials of high x-ray contrast so they can be easily visualized and reconstructed for image-based brachytherapy treatment planning. The Hounsfield Unit of these applicators can be over 3000 (**Figure 1**). While the high attenuation of imaging radiation (<140kVp) is advantageous, little to no study can be found in literature regarding their attenuation to treatment radiation (E_{mean} = 380 KeV for ^{192}Ir). If an appreciable portion of the treatment radiation beam is attenuated by these applicators, the currently widely used water equivalent dose calculation scheme would be erroneous.

AIM

This study investigated the dosimetric characteristics of the Bonvoisin-Gerard esophageal applicators, thereby, verify the validity of the water equivalent dose calculation scheme used in current treatment planning systems. To the best of our knowledge, this is the first study to investigate such property of these applicators.

METHOD

The Bonvoisin-Gerard applicators (6, 8, 10, 12mm diameter) were wrapped in air bubble sheets to maintain a straight and central configuration before been fully inserted into an IVB1000 well chamber. Air kerma rate and accumulated radiation dose of 30s exposure were measured for each applicator, with ^{192}Ir source (Flexitron afterloader) dwelling at the same position relative to the well chamber. Same measurement was performed with a LumenCare Azure applicator (5F thin-walled blue plastic catheter for endobronchial use).

For each Bonvoisin-Gerard applicator, a treatment plan delivering 5Gy to the applicator surface was generated. Dose distributions were measured with EBT3 gafchromic films. Identical plans were also delivered by the LumenCare applicator with 3, 4, 5, and 6mm boluses, approximating the buildup thickness of the esophageal applicators. The experiment setup is shown in **Figure 2**.

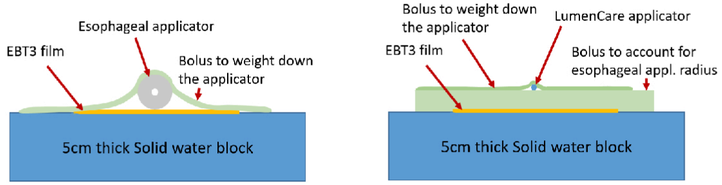

Figure 2. Schematics of the film measurement set up for the esophageal applicator (left) and the LumanCare applicator + bolus (right) configuration.

RESULTS

Figure 1. Images of the Bonvoisin-Gerard esophageal applicators. (top) the 6, 8, 10, 12mm diameter applicators. (bottom left) the X-ray image of the 10 mm applicator with metal markers inside the catheter. A metal x-ray marker is place at the tip end of the applicator; a BB marker is also shown at the upper left side of the applicator. (bottom right) CT image of the 10mm applicator displayed in MIM with the bone window.

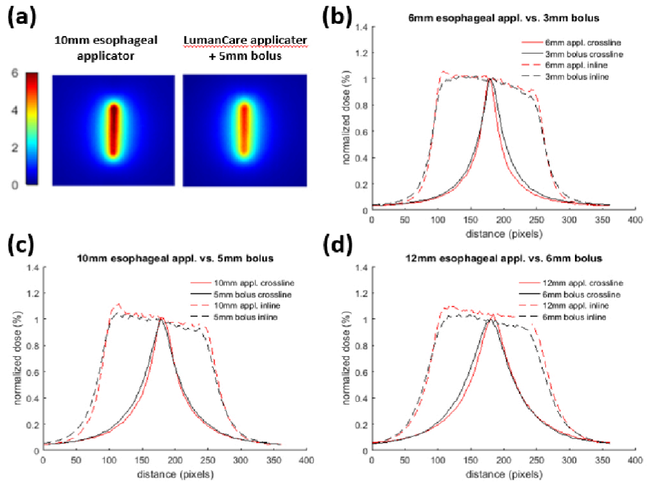

Figure 3. Dose distribution of the surface plan via the esophageal applicator vs. LumanCare applicator+bolus. (a) Planer dose distribution; (b, c, d) crossline and inline profiles of the 6, 10, 12mm esophageal applicators overlaid with correspondent LumanCare applicator + bolus configuration.

	LumenCare Azure catheter	Esophageal applicator			
Diameter	~1mm	6mm	8mm	10mm	12mm
Source position (mm)	1320	1375	1375	1400	1400
Measured current (nA)	58.192	58.511	57.58	57.338	56.425
Normalized current	1.000	1.006	0.989	0.985	0.970
Collected charge (nC)	1785.3	1793.9	1765.5	1758.7	1730.1
Normalized charge	1.000	1.005	0.989	0.985	0.969

Table 1. Well chamber measurements. The length of the esophageal applicators vary with diameters. Consequently, the source positions were offset so that the source dwell at the same position in respect to the well chamber geometry. Due to its small dimension and thickness, the endobronchial catheter was considered to have negligible attenuation to the treatment radiation, and its measurements were used as normalization bases for the esophageal applicator measurements. Although esophageal applicators displayed increased attenuation with increasing diameters, no more than 3% radiation was 'exceedingly' attenuated by those applicators.

All results were normalized to correspondent measurements with the LumanCare Azure applicator (5F thin-walled blue plastic catheter).

Well chamber measurement (**Table 1**):

1. Air kerma rate through the 6, 8, 10, and 12mm diameter esophageal applicators were 100.6, 98.9, 98.5 and 97.0% of the LumenCare applicator measurement.
2. The 30s accumulated dose were 100.5, 98.9, 98.5, and 96.9% of the LumenCare applicator measurement.

Film measurement (5Gy surface plan):

The surface plan measurements originally reported higher dose doses in the esophageal applicator comparing to the LumenCare catheter: 121.7, 115.9, 116.4, and 118.9% for the 6, 8, 10, 12mm diameter applicator, respectively. This can be attributed to the additional radial distance added by the LumanCare applicator, i.e. LumanCare + 5mm bolus yielded a source-film-distance of about 5.5mm while the 10mm diameter esophageal applicator has a true source-film-distance of 5mm.

After been corrected for the radial differences, the measurements from the esophageal applicator and the LumenCare catheter displayed improved agreement, the mid-point dose agree with each other by 100.3, 95.6, 101.5 and 104.1%. The inline and crossline profiles of are shown in **Figure 3**.

CONCLUSIONS

Although the Bonvoisin-Gerard esophageal applicators present high contrast in x-ray and CT images, their dosimetric characteristics follow water equivalent behavior with <5% difference.

The water equivalent dose calculation method is acceptable for these applicators for ^{192}Ir source.

CONTACT INFORMATION

Keying.Xu926@gmail.com
Tarun.Podder@UHhospitals.org