Implanted Cardiac Device Management for Total Skin Electron Therapy Patients

Andrew Veres, MS[1], Stephanie Lo, PhD[1], Kathy Kolsky, PhD[1], Madeline Christensen, APRN, CNP, DNP[1], Shelby Kern, PA-C, MS[1], Khaled Aziz, MD, PhD[1], William Breen, MD[1], Scott Lester, MD[1] and J. John Lucido III, PhD[1]

[1]Department of Radiation Oncology; Mayo Clinic, Rochester, MN

ABSTRACT

BACKGROUND

Implanted cardiac device manufacturers provide variable recommendations regarding acceptable radiation dose to maintain device functionality; however, AAPM TG-203 recommends avoiding direct irradiation by the primary beam whenever possible. No published shielding technique exists for TSE patients with implanted cardiac devices.

This work presents a practical and cost-effective method of shielding using a widely available material (Superflab bolus) that offers numerous benefits.

OBJECTIVE

This work aimed to characterize a shielding technique for total skin electron therapy (TSE) patients with implanted cardiac devices. Goals of the work included quantifying shielding effectiveness by quantifying and minimizing the dose delivered to the ICD.

METHODS

Delivery of a standard TSE plan was delivered to an anthropomorphic phantom at treatment position, rotating through each of the six Stanford TSE positions. Radiochromic films were placed on the surface of the bolus-shield and between each layer, with a PDD film placed behind the shield and between layers in the phantom. In vivo films of two TSE patients were acquired on the patient's surface and top of shielding to confirm dosimetry.

RESULTS

The estimated dose to the simulated ICD was 43.1 cGy, ~3.6% of prescription. For two TSE patients, in-vivo measurements demonstrated delivered doses to the ICD below 5% of prescription.

CONCLUSIONS

Approximately 2 cm of bolus substantially reduces surface dose to superficial ICDs during 6 MeV TSE.

METHODS

Superflab bolus was selected as the shielding material due to its low atomic number (minimizing x-ray contamination), biocompatibility, and ease of customization. Multiple 1cm thick pieces of bolus were stacked, so the device (assumed depth of 7mm based on review of diagnostic computed tomography images) was beyond the practical range for 6MeV electrons on the patient's surface (including 0.8 cm acrylic beam spoiler).

Delivery was simulated with an anthropomorphic phantom at treatment position, rotating through the six Stanford positions. Radiochromic films were placed on the surface of the bolus-shield and between each layer, with a PDD film placed behind shield between layers in phantom. Surface film and PDD films were placed on the contralateral chest to represent unshielded delivery. In vivo films were acquired on the patient's surface and top of shielding for 2 patients to confirm dose.

FIGURE 1: (A) Example of shielding; (B) Phantom set up for simulated treatment; (C) PDD film placement behind shield in phantom; (D) Close up of Phantom with shielding placement

DISCUSSION

TSE patients with implanted cardiac devices has grown increasingly common in our clinic. From 2023 – 2025, 5 of 42 total TSE patients had an ICD. With variable recommendations from ICD manufacturers, a solution to adequately shield the ICD to maintain device functionality, while not inadvertently compromising treatment coverage, was required. Through this work, the proposed superflab bolus shielding solution achieved both with an estimated dose delivered ~5% of prescription utilizing common, cost-effective and widely available materials.

RESULTS

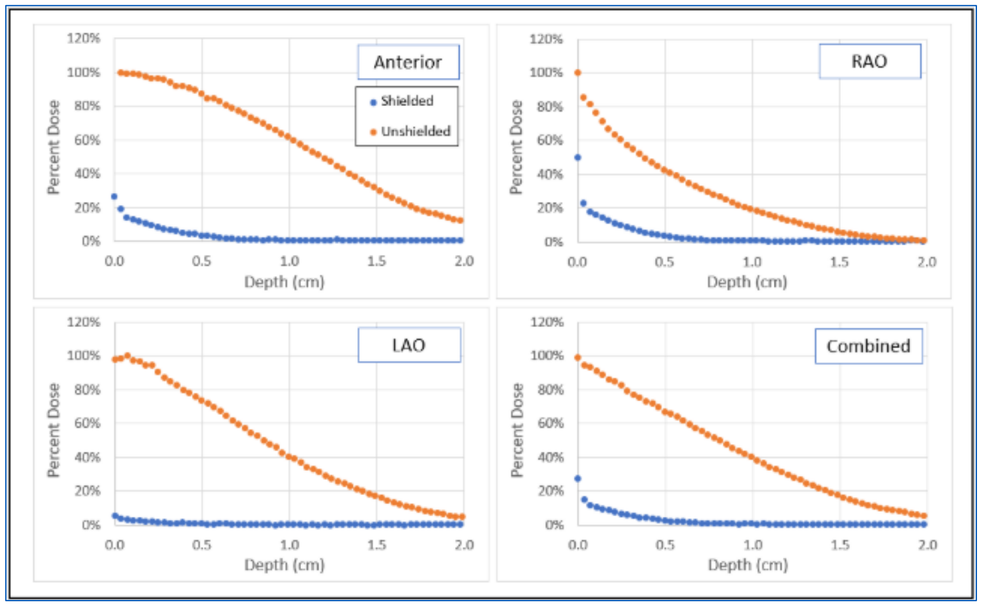

FIGURE 2: Percent depth dose curves for the three simulated treatment positions with greatest dose to the device, and the composite dose for the treatment with and without shielding

Measurement Point	Patient 1	Patient 2
Prescribed Dose	150 cGy/fx	100 cGy/fx
ICD Depth	7 mm	5 mm
Surface of Shield	154 cGy	113 cGy
Patient Skin	50 cGy	5 cGy
ICD	8 cGy	1 cGy

TABLE 1: In-vivo dosimetry results for the first two patients treated with this shield. The dose at the ICD was estimated by measuring the minimum distance from the skin to the device using a diagnostic CT and inferring the dose at this depth from the curve shown in Figure 2.

CONCLUSIONS

For 6 MeV TSE treatment utilizing the Stanford TSE treatment technique, approximately 2 cm of Superflab bolus substantially reduces the dose to superficial ICDs. With a growing TSE patient population with ICDs and limited guidance on this clinical scenario, our approach leverages a common cost-effective Radiation Oncology tool and achieves minimizing dose to the ICD without sacrificing clinical coverage.

REFERENCES

1. Miften, M., Mihailidis et. al, (2019), Management of radiotherapy patients with implanted cardiac pacemakers and defibrillators: A Report of the AAPM TG-203. Med. Phys.