Novel Radiation Protection System: Significant Radiation Reduction to Typically Under-protected Body Parts Over Traditional Lead in a Mannequin Model

35th Annual Scientific Sessions, May 1st 2022

Florida Vascular Society

Presented by: Angelyn Thayer, MD

Christina Tran, MD, Michael Markovitz, MD, Omeed Jazayeri-Moghaddas, MD, Murray Shames, MD, Bruce Zwiebel, MD

USF Health
UNIVERSITY of SOUTH FLORIDA

Radiation Exposure

Radiation exposure is a daily consideration for vascular surgeons

Effects are both *stochastic* and *deterministic*

Stochastic effects:
-Malignancy
-Neuro-vascular sequala
-Neuro-degenerative sequala

Deterministic effects:
- Cataract formation
- Hair follicle damage
- Skin damage
- Subcutaneous tissue damage

Current Radiation Protection

- Current equipment is cumbersome and associated with long-term orthopedic morbidity[1-4]
- Current eyewear ranges from 10-80% protection, depending on fit and model[5-7]
- Up to 80% of interventionalist have radiation induced lens changes on exam[8]
- Growing question of increased brain malignancy risk in interventionalists, with current skull protection providing, at best 3.3% dose reduction[6]

Objective

This study sought to compare the ability of a novel, weightless, radiation protection system with that of a conventional lead apron to reduce radiation dose to radiosensitive regions on anthropomorphic mannequin models

Bilayer Bismuth antimony apron
(Kemmetech, Kent, UK, 0.5mm side/front lead equivalent [1.0mm front overlap])

Proprietary weightless Exoskeleton

Lead-acrylic face shield
(Kurary Co. Ltd., Nigata Japan, 0.34mm lead equivalent)

Thyroid shield (Kemmetech, Kent, UK, 0.5mm lead equivalent)

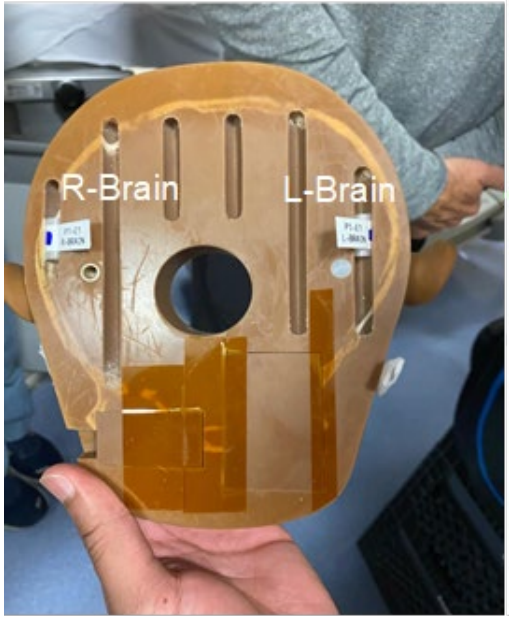
Methods

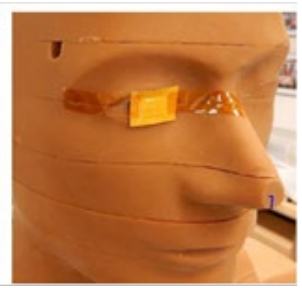
Two Anthropomorphic Matroshka phantoms *(German Aerospace Center [DLR], Cologne, [Koln], Germany)*
1 representing interventionalist, 1 representing patient (not shown)

Interventionalist Mannequin 1a) wearing novel radiation protection exoskeleton with **tall** visor setup
(***short*** *visor setup not pictured)*

Interventionalist Mannequin 1b) wearing traditional lead apron and thyroid shield

Methods



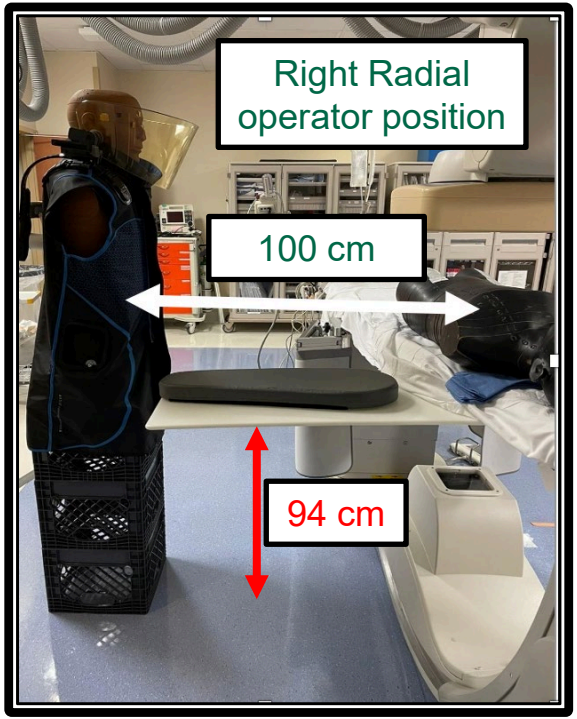


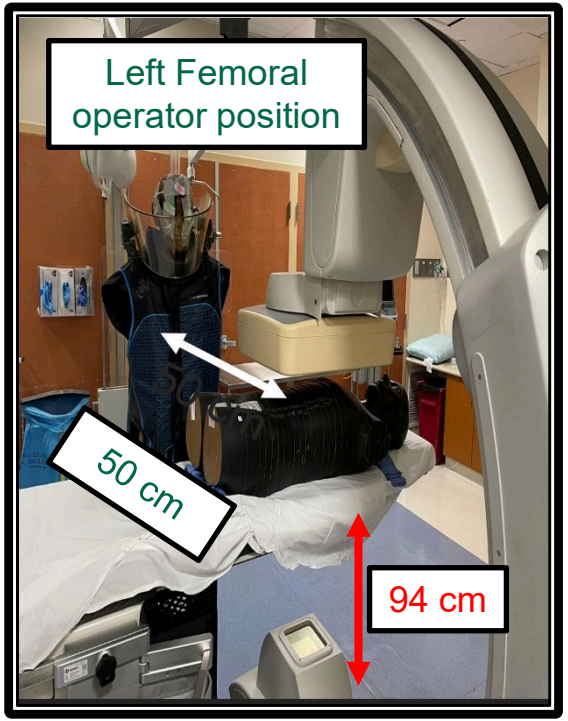
Thermoluminescent detectors (TLD) placed in radiosensitive regions of 3 Anthropomorphic phantoms

Detector locations:
(8 TLD patches, 2 TLD tubes)

- Scalp
- Left and right eye lenses
- Left and right head inside visor
- Left and right brain
- Torso and thyroid

Methods





Radiation source: Phillips FD-20 C-arm machine

Average Air-Kerma (Exposure) to mannequin:

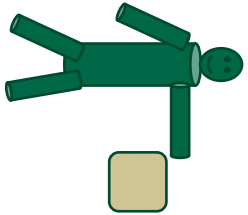
2301± 2 mGy

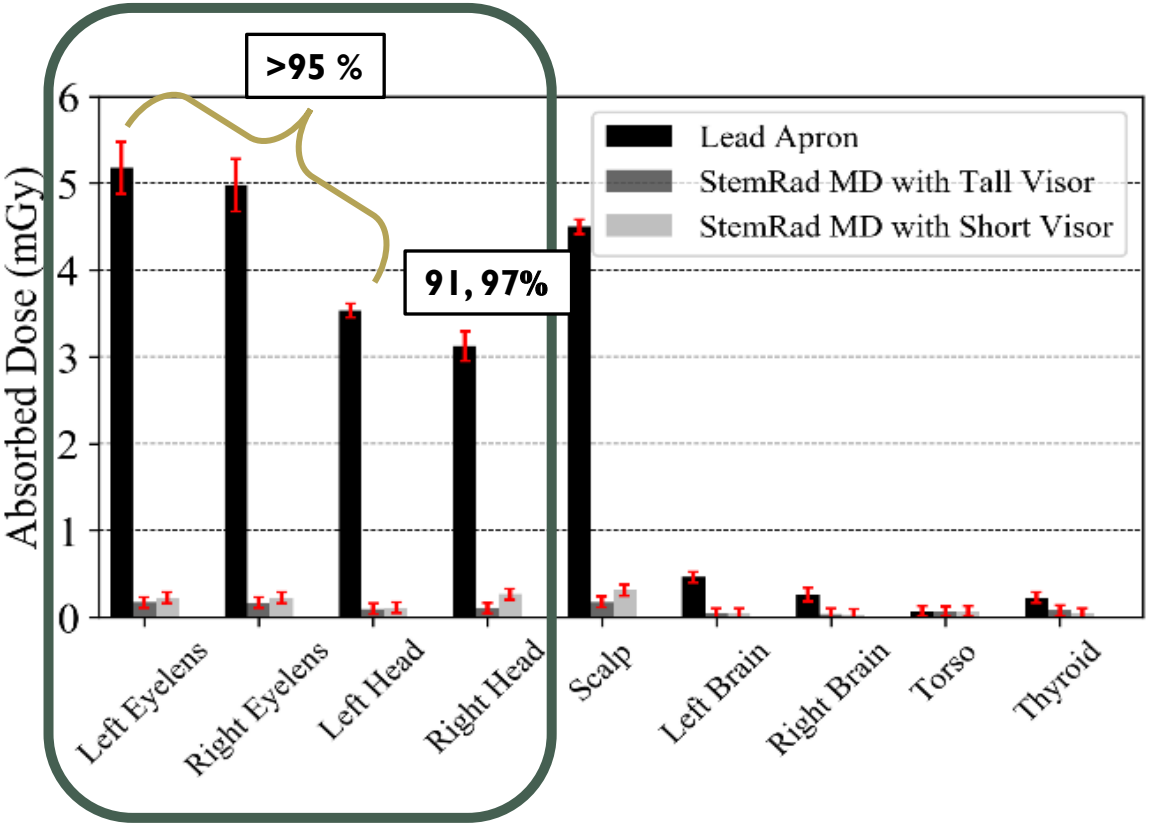
Methods

Calculation of radiation dose reduction with novel exoskeleton system compared to conventional lead apron (LA)

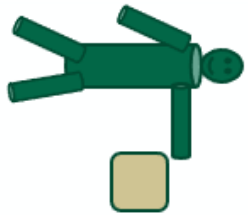
$$Reduction\ (\%) = \frac{(\text{Dose with LA} - \text{Dose with Novel System})}{\text{Dose with LA}} \times 100$$

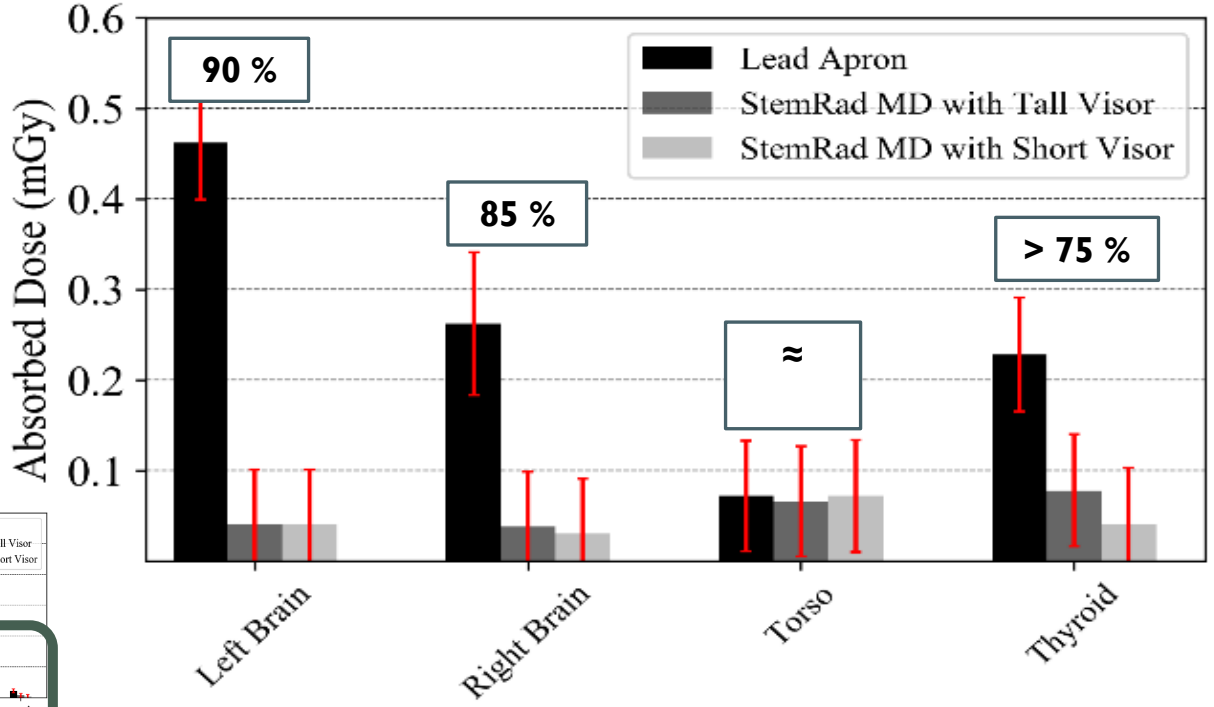
Results: Left Radial Position

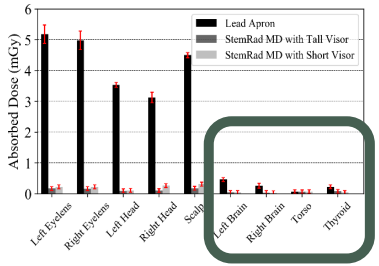




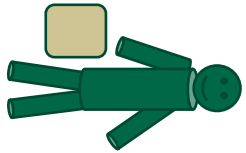
Results: Left Radial Position

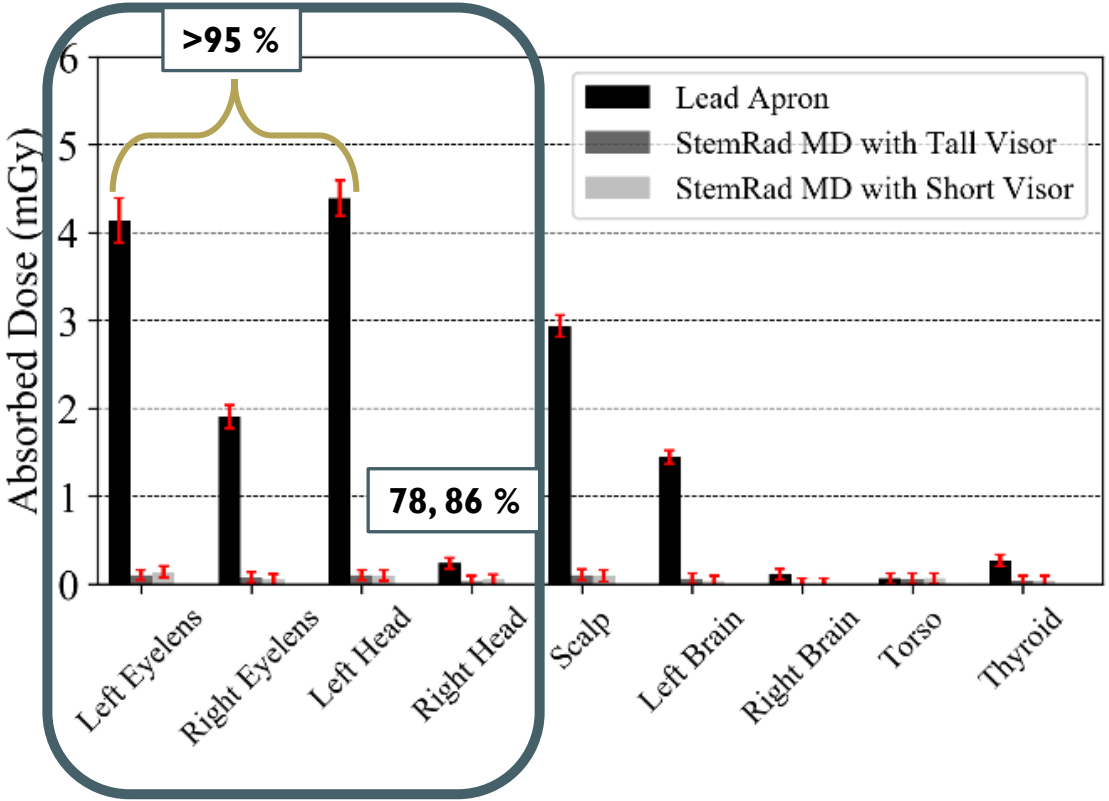




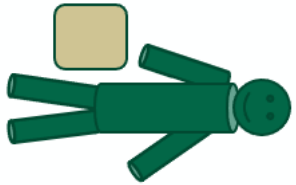


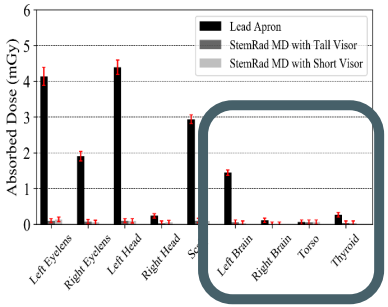
Results: Right Femoral Position

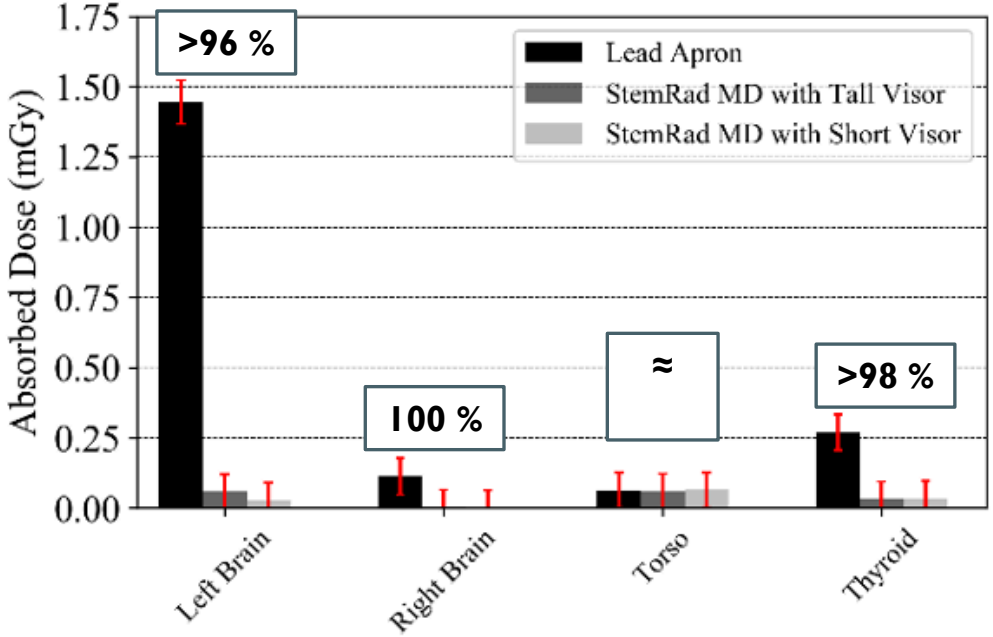




Results: Right Femoral Position







Discussion: Torso and Thyroid

Radiation dose was essentially negligible for both the torso and the thyroid during all runs and in both operator positions

The torso (containing nearly all major organs) contributes approximately 88% of whole-body effective dose

The novel exoskeleton system provides equivalent or better protection for the **torso & thyroid** than traditional lead apron with the added benefit of a weightless, mobile suspension system

Discussion: Eyes

International Committee on Radiologic protection dose limits:

- 20 mSv over 5 yrs, no greater than 50 mSv in a single yr
  - pre 2011 recommendations were 150 mSv per yr
- Multiple studies have shown interventionalists potential to reach over 20-50 mSv absorbed dose per year

Over 95% dose reduction to the lens in both the tall and short visor configurations and, in both positions

The novel visor system provides the same or better eye protection as currently available eyewear

Discussion: Brain

The use of anthropomorphic phantoms mimics the skull's protective effect from radiation allowing for a more accurate determination of absorbed dose (mSv) to either side of the brain

Dose reduction to the head just inside the visor is significantly different depending on operator position which is likely due to most of the radiation source being lower-energy scatter radiation

This same low-energy scatter is more effectively shielded by the human skull which accounts for the lack of marked dose difference absorbed internally by either side of the brain, regardless of visor height

The smaller dose reduction to the right brain in the left radial position (85% vs 90-100% reduction), is presumably due to further distance from the image intensifier tube which results in lower overall dose

Conclusions

This novel, weightless, radiation protection system offers equivalent or better radiation protection for the wearers torso and thyroid while providing substantially improved radiation protection to the eyes and brain over currently available equipment.

References

- 1. Dehmer, G. J. *Cath and Cardiovasc Int* 68, 974–976 (2006).
- 2. Goldstein, J. A., et al. *Cath and Cardiovasc Int* 63, 407–411 (2004).
- 3. Ross, A. M., et al. *American Journal of Cardio* 79, 68–70 (1997).
- 4. Orme, N. M., et al. *Journal Am College of Cardio* 65, 820–826 (2015).
- 5. Haga, Y., et al. *Sci Rep 7 (1), 569* (2017).
- 6. Fetterly, K., et al. *JACC Cardiovsasc Interv 10(5), 520-528* (2017).
- 7. Carinou, E., *J Radiol Prot., 35(3), 17-34* (2015)
- 8. Ko, S., *J Vasc Interv Radiol 29(3), 353-366* (2018).
- 9. O'Connor U. *Br J Radiol*. *88(1049):20140627* (2015).

Questions?

Discussion

Region	Recommended limit by ICRP	Conventional protection	StemRadMD Anthropomorphic phantom study	StemRadMD real-time clinical protection
Eyes	20 mSv/yr over 5 years, max 50 mSv any single year	10-80% reduction *dependent on style and fit[5-7]	>95% reduction *for tall & short visors	~ 100% reduction *for tall & short visors
Head/Face		3.3% reduction with skull cap[6]	91-97% reduction *dependent on position and visor height	88% +/- 4 reduction
Brian		3.3% reduction with skull cap[6]	85-100% reduction *dependent on position and visor height	