Evaluation of ZeroGravity Radiation Protection System vs. Standard Lead Apron in Clinical Interventional Procedures

Introduction
As fluoroscopic equipment features and image technology continue to advance, radiation protection technology afforded the operator has remained relatively stagnant. Even those interventionalists who utilize protective equipment including leaded aprons and glasses, protective drapes, and accessory shields, are exposed to cumulative radiation doses that may be career ending. We previously described a suspended radiation protection system: ZeroGravity Radiation Protection System, CR Medical Solutions, Pensacola, FL that provides near comprehensive radiation protection while maintaining critical components of operator mobility and sterile exit and entry; features that have eluded previous stand-alone radiation protection devices.

Our prior reports compared the ZeroGravity (Zgrav) Radiation Protection System with that of conventional lead protection and accessory shielding using phantoms, demonstrating dramatically decreased radiation exposures using the Zgrav system to the entire body, including the eyes and face. Recognizing the limitations of phantom studies, we focused the next phases of our Zgrav investigation on observing radiation protection in clinical practice.

Methods
In a 3 phase study including 118 procedures – two phases involving use of Zgrav and one phase involving standard lead apron and all ancillary shields used in all cases (Figure 5). Since the hanging and Zgrav face shield both use similar Pb (0.5 mm Pb), the use of Zgrav system was expected to provide some increase in hand or eye protection when using Zgrav. In contrast to the Zgrav group, the LA data showed extreme variability in head and eye exposures despite adequate use of the hanging lead shield in all cases (55). Since the hanging and Zgrav face shield both use similar Pb (0.5 mm Pb), the use of Zgrav system was expected to provide some increase in hand or eye protection when using Zgrav. In contrast to the Zgrav group, the LA data showed extreme variability in head and eye exposures despite adequate use of the hanging lead shield in all cases (55).

“LA” Group
Fig. 2. Badge positions for both groups: Phases I and II (Mid forehead badge in Phase I only).

“ZGRAV” Group
The ZeroGravity (Zgrav) device was early model commercial stock approved device (CR Medical Solutions, Pensacola, FL). This fully mobile, overhead-supported system with a suspended lead acrylic head shield (0.5 mm Pb equivalent), lead apron extending to the distal calves (1 mm Pb centrally [63.5 cm X 69.3 cm], 0.5 mm peripherally) with 0.5 mm Pb flaps hanging over the arms to the elbows. A sterile plastic drape permits quick entry, exit, and reentry while maintaining sterility. The manufacturer offers floor or ceiling supported systems, but only the floor supported system was studied here. No weight is supported by the operator.

Results
Fig. 3b. Zgrav provides shielding in LAO-AP tube angle without obtrusive hanging shield.

Fig. 3c. Small operator is able to lean over patient during real time clinical interventional cases using either the Zgrav system or conventional lead shielding.

Table 1

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<tr>
<th>Phase</th>
<th>Eye TLDs</th>
<th>Head TLDs</th>
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<tbody>
<tr>
<td>II</td>
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<td>15%</td>
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<td>I</td>
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Fig. 3d. Operator may come and go from patient while wearing the Zgrav face shields.

Fig. 4. Operator head exposures per total patient dose area-product

Comparison to standard lead aprons with multiple ancillary shields, the ZeroGravity Radiation Protection System provided substantial reductions in operator exposures (78-100%) during clinical interventional fluoroscopy, while permitting non-use of potentially obstructive ancillary shields. Phase III demonstrated reductions in head and eye exposures of 99% compared to Lead Apron + all shields, regardless of use or non-use of mobile shield. ZGRAV Wrist exposures were unaffected by ZGRAV or the mobile shield.

Discussion
Our current three phase clinical study compared radiation protection using leaded apron and supplemental shielding to that of Zgrav with or without supplemental shields. Despite increased use of ancillary shielding in Phase I relative to Phase I, results showed similar patterns of reduction, with ZGRAV providing an average 92% decrease in wrist dose reduction, respectively. Wrist data were compared to both phases I and II to relate LA (lead apron) to ZGRAV (ZeroGravity). The comparisons showed a dramatic reduction in exposures with ZGRAV.

Fig. 5. Reductions in mean Eye & Head Exposure in Phase II were 89% (P=0.003) as shown in bar graph.

Fig. 6. Scatter plot shows higher doses for all LA procedures (squares) compared to ZGRAV (diamonds). Exposures were consistently lower for ZGRAV.

Table 2

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Conclusions
The ZeroGravity device was early model commercial stock approved device (CR Medical Solutions, Pensacola, FL). This fully mobile, overhead-supported system with a suspended lead acrylic head shield (0.5 mm Pb equivalent), lead apron extending to the distal calves (1 mm Pb centrally [63.5 cm X 69.3 cm], 0.5 mm peripherally) with 0.5 mm Pb flaps hanging over the arms to the elbows. A sterile plastic drape permits quick entry, exit, and reentry while maintaining sterility. The manufacturer offers floor or ceiling supported systems, but only the floor supported system was studied here. No weight is supported by the operator.

References
1. Fenton, MD, T. Seale IV MD, C Shaw MD, C Savage MD, A Bruner PhD, CR Rees, MD

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