

MEDIRAD

Evaluation of the performance of shielding protective equipment in interventional procedures: results from the MEDIRAD project

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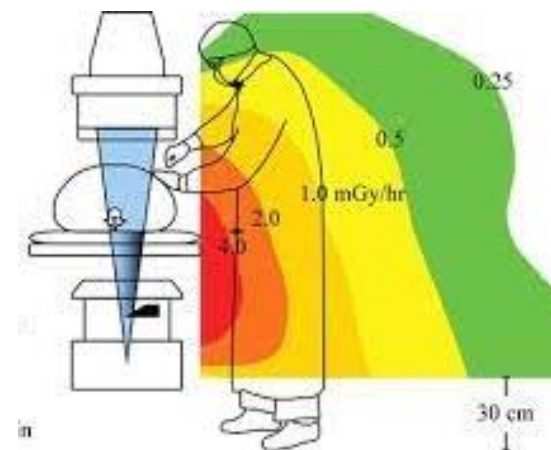


This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 755523.

EAN 20th workshop
ALARA for interventional radiology & nuclear medicine
Vienna, Austria, 2-4 October 2023

Physician exposure during interventional procedures

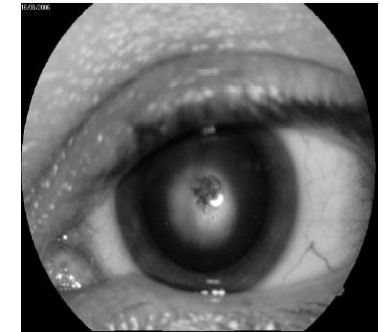
- Patient = source of scattered X-rays
- Daily exposures
- Potentially thousands of procedures



Potential for high cumulative doses over a complete career

→ risk for unprotected organs

- Eye lens
- Extremities
- Cardiovascular system (?)
- Brain (?)
- ...



Loganovsky et al 2020

Ref: Andreassi et al 2015, 2016; Ciraj-Bjelac et al 2016; Roguin et al 2012, 2013; Vaño et al 2010,...

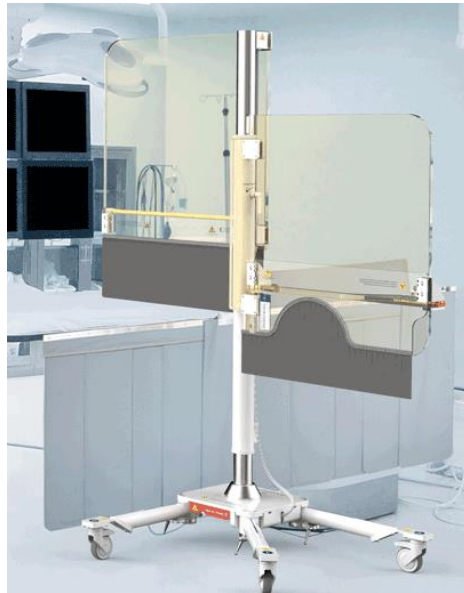
Many radiation protection devices available to the staff



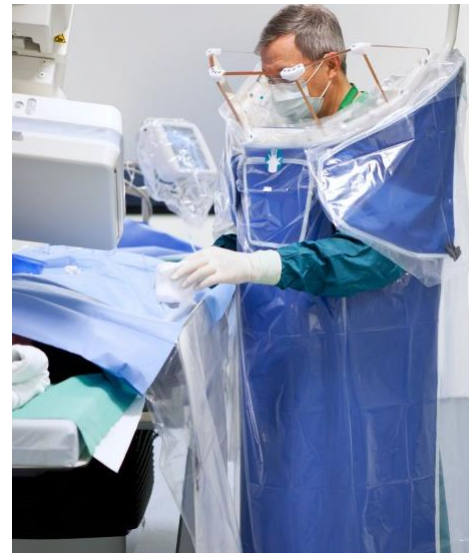
McCutcheon et al 2021,
Circ Cardiovasc Interv 2020



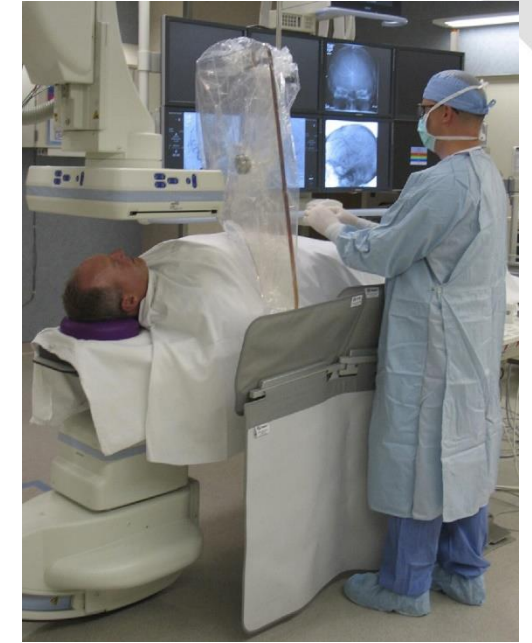
lermerpax.com, Cathpax air



rampartic.com, M1128



biotronik.com; Zero-Gravity



Schueler B, 2010, Tech Vasc Interv Radiol

Many radiation protection devices available to the staff ... some more controversial ones...



Autminnie.com; BloXR



protechmed.com; Proguard Protex



www.protecx.co.uk; Envirolite Lead Free Cap

Science-based evidence

Efficiency investigations of 5 devices using 3 complementary approaches:

Monte Carlo simulation



- 5 projections
 - 2 physician positions
 - 2 head rotations
 - Dosimeters + organ dose
- **>200 configurations simulated**

Staff monitoring



- Real cardiac procedures
 - At least 2 hospitals
 - Dosimeters – no organ doses!
- **11 hospitals, >1200 procedures**
& **>1300 person.months**

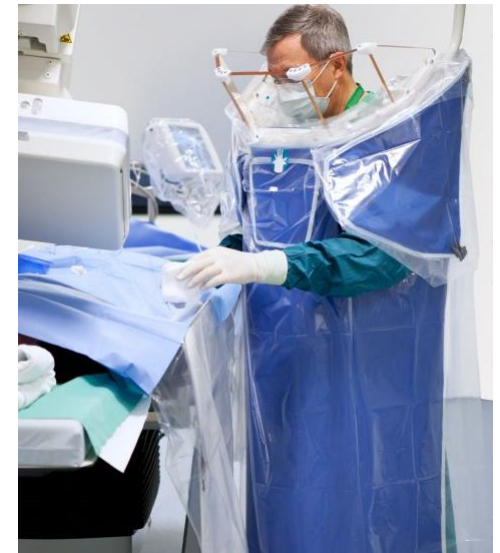
Phantom measurements



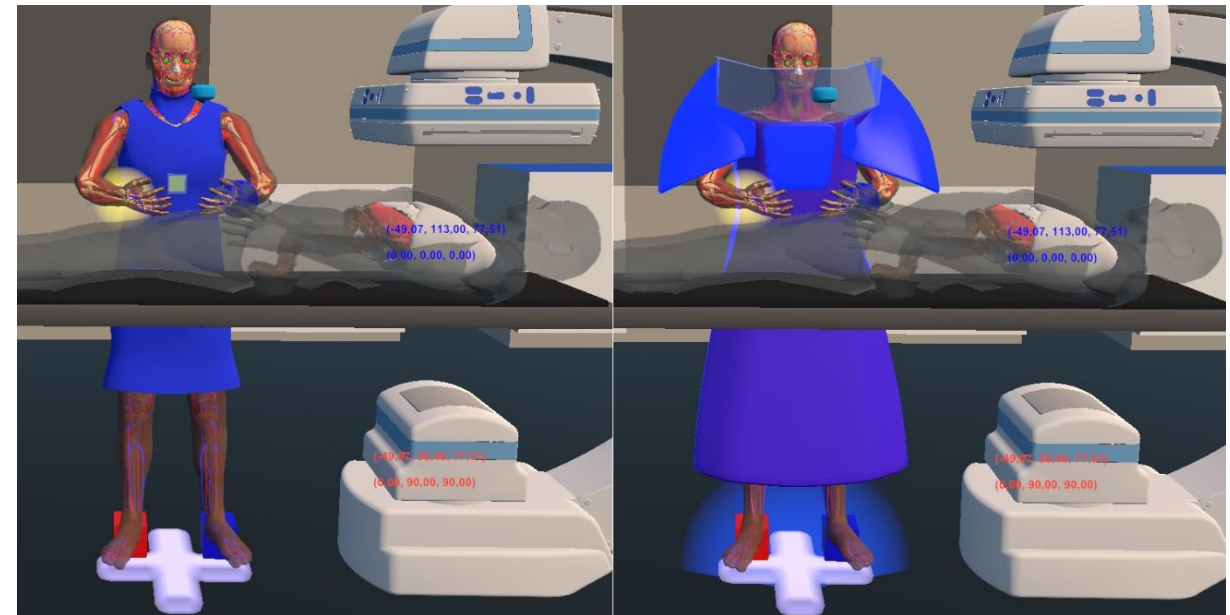
- At least 3 projections
 - Dosimeters + detector in organs
- **>20 configurations**

ZG suspended system: dose reduction in all simulated configurations

- High protection to brain and eye lens (~-95%)
- Equivalent or better than lead apron for organs normally covered (but low doses anyway)
- Can be used in combination with other equipment
- Similar trends for MC simulations and measurements on staff and phantoms
- Ergonomics: no weight on shoulders but bulky and feet not visible



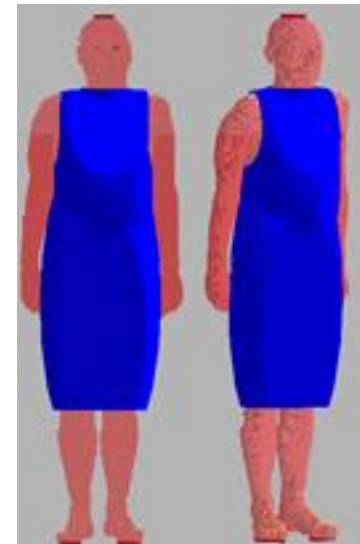
biotronik.com; Zero-Gravity



Huet et al 2023

Lead-free aprons : equivalent to lead apron in all simulated configurations

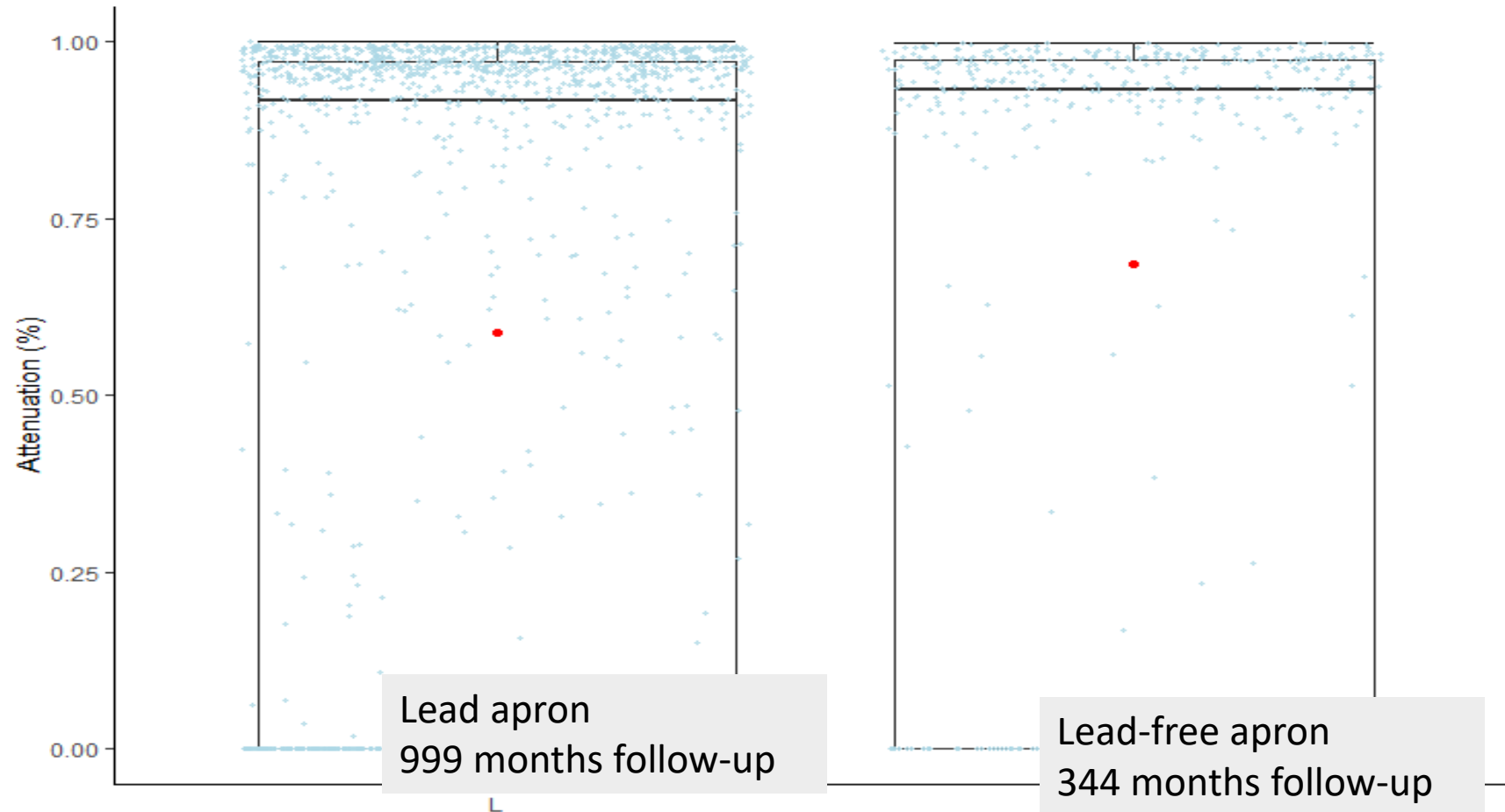
- No significant difference in effectiveness for organs in the chest region (effective dose):
 - Far from field: ~-80%
 - Close to field: ~-90%
- Ergonomics: effect of arm holes?
- Be aware of the real apron properties!
 - Not characterized by a single attenuation value!
 - Knowing the composition would be ideal!



Lead-free aprons :

Challenging to measure on staff

- Attenuation of aprons: $(D_{\text{over}} - D_{\text{under}}) / D_{\text{over}}$



- Average attenuation was 14% higher with lead free apron
- Challenging to compare very low doses! But is it useful? Large number of measurements below LDL...

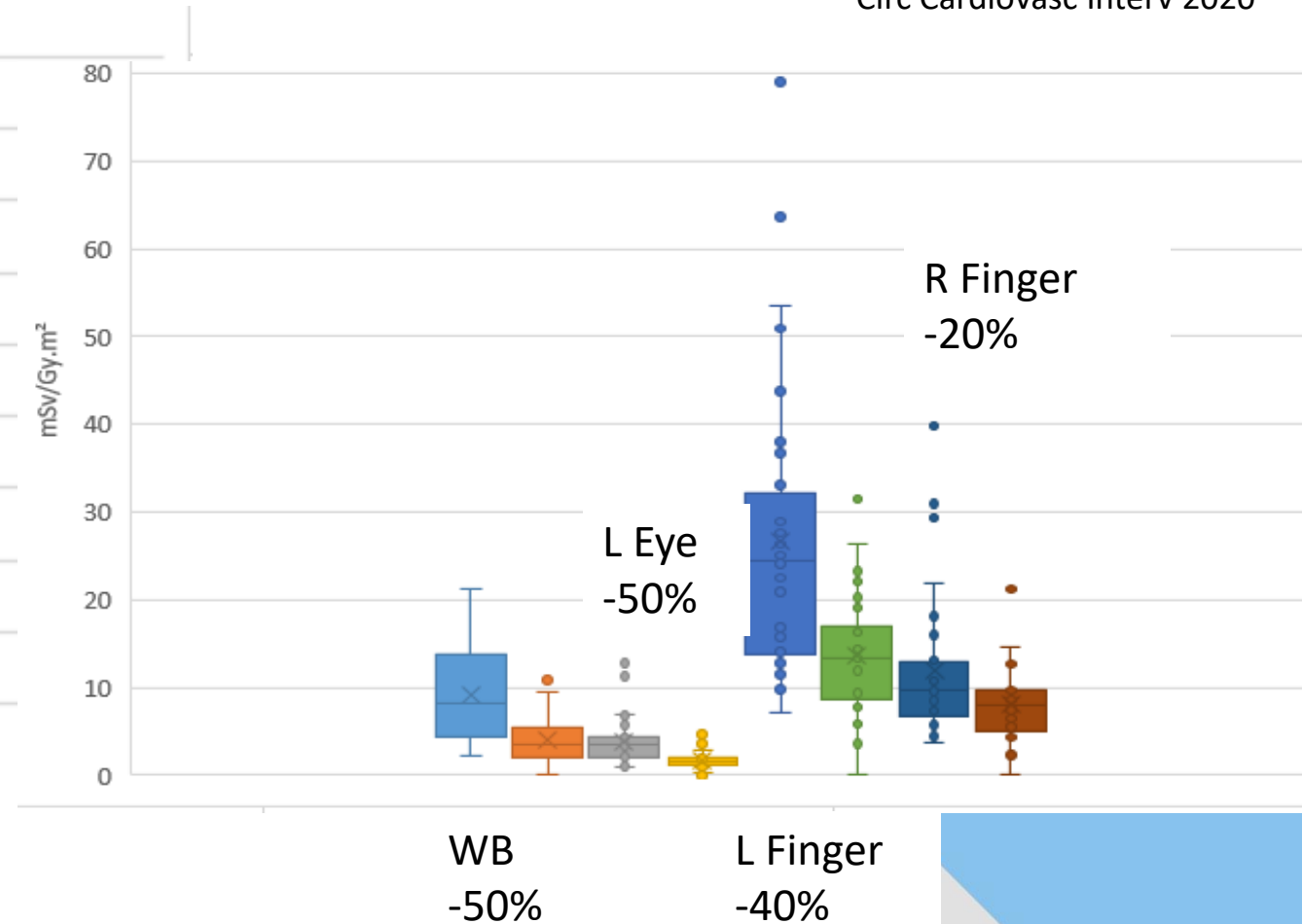
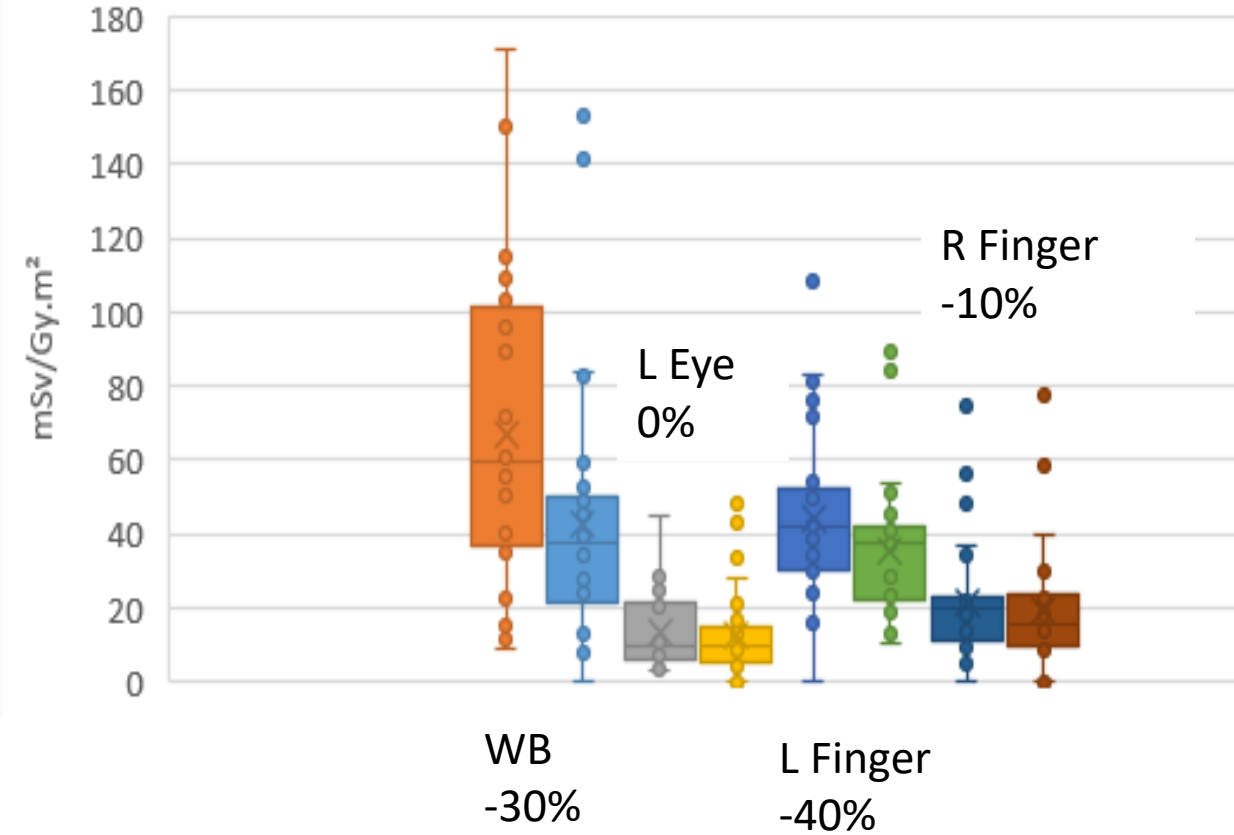
Lead(-free) drapes: Potential for dose reduction at least for the hands

- 62% and 30% decrease to the left and right hands on average (MC simulations)
- Very limited to no effect for other organs (including organs covered by aprons)
- Effect on chest exposure and eye exposure in some hospitals



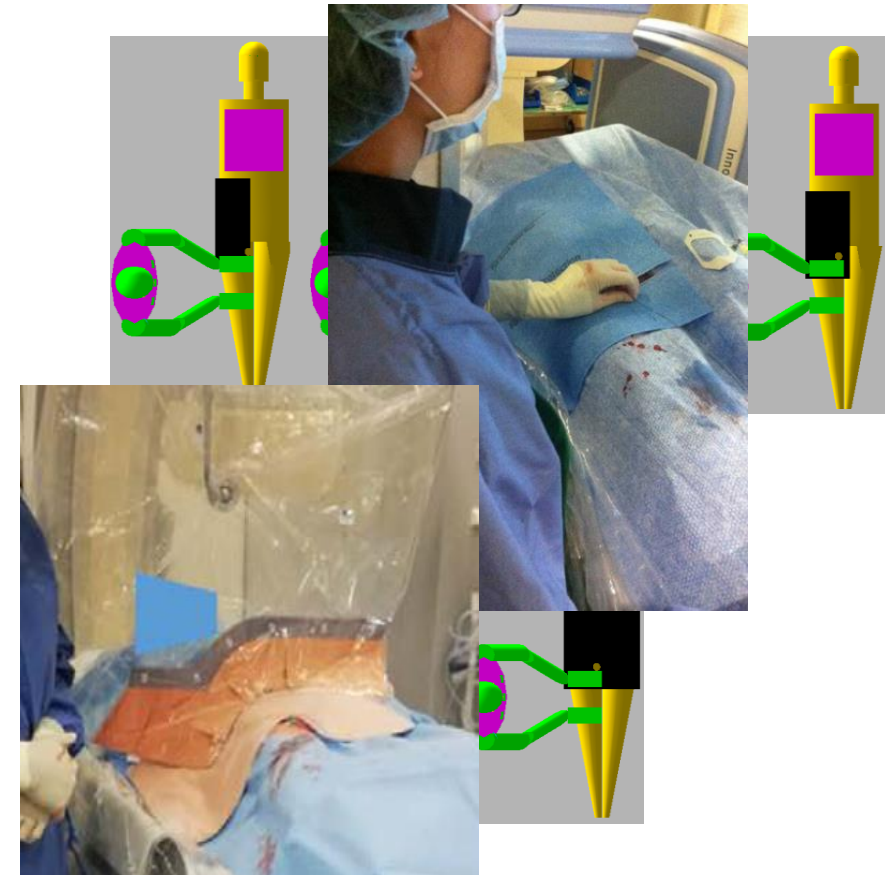
Lead(-free) drapes: Dose reduction potential? Example from measurements in 2 hospitals

McCutcheon et al 2021,
Circ Cardiovasc Interv 2020



Lead(-free) drapes: Sensitive to position and design

- Drape closer to the X-ray field: increase dose reduction
 - Hands above the drape
 - Drape between staff and patient side
- Need to be positioned between staff and X-ray source(s)
≈ Staff in the “shadow” of the drape

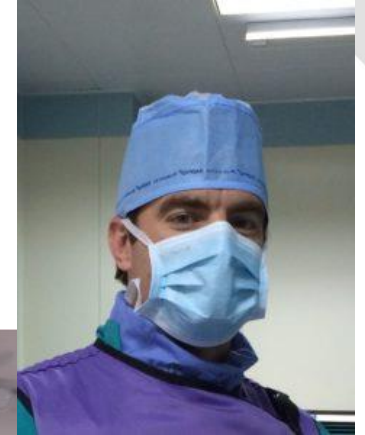


Effectiveness of the caps and masks **strongly depends** on design, exposure conditions and staff position

Lead(-free) cap and mask:

- Cap: - 35% dose to the brain on average
- Mask: - 65% dose to the brain & - 25% to eye on average
- Some sensitive brain regions unprotected!

- >>> Influence of irradiation conditions :
 - less effective when staff closer to X-ray field
 - Projections and head orientation
 - No protection at all in worst case
- >>> influence of design (mask)
 - No protection at all in worst case



Device specific recommendations

- Separately for each tested devices
 - Lead and lead-free cap
 - leaded mask
 - Lead and lead-free drapes
 - light lead and lead-free aprons
 - Zero-gravity suspended system
- Also other common devices:
 - Ceiling-suspended screen
 - Lead glasses
- Pro and cons
- Based on MEDIRAD results
- Completed with literature
- ~½ page per device


Lead cap

- **PRO:** potential for dose decrease to the brain in specific conditions

(MC) Results of MC simulations showed a dose reduction of 35% averaged over several configurations. (PH) Phantom measurements showed a considerably lower average reduction (7%), indicating the great influence of the irradiation conditions.


- **PRO:** protection comparable for lead and lead-free caps

(MC) Results of MC simulations showed comparable reduction of the brain dose, ranging from 10% to 43% depending on the configuration.



Light lead and lead-free aprons


- **PRO:** protection comparable to that of conventional lead aprons for covered organs



Lead glasses

- **PRO:** potential for dose decrease to the eyes

(LI) The lead glasses have a potential for significantly reducing the dose to the eyes, particularly to the eye closer to the X-ray field (often the left eye). For instance, MC simulations of a wrap-around glass model lead to an average dose reduction as high as 74% to the left eye [14]. Phantom measurements showed similar potential with dose reductions up to 88% to the left eye [15].



- **PRO:** potential for dose decrease to the brain

(LI) The lead glasses can also offer limited protection to the brain. Results of MC simulations showed a dose reduction between 10% and 17% to the brain [7]. However, only few configurations were investigated, and the dose decrease is very dependent on the configuration and type of lead glasses.

- **CON:** efficiency strongly affected by design and operator position

(LI) MC simulations showed that glass design, in particular the shape and the air gap (distance between glasses and face), operator position with respect to the X-ray beam and the head orientation have a significant effect on the efficiency. For instance, a factor two was calculated between the efficiency of two models simulated using MC software [14]. Phantom measurements confirmed these effects with the efficiency of five models tested in various conditions varying between 9% and 88% for the left eye and between 0% and 57% for the right eye [15].

- **CON:** dose decrease to eye-lens dosimeter is not representative of eye lens dose decrease

(LI) MC simulation [16] and phantom studies [17] have shown that a dedicated eye-lens dosimeter can severely under- or over-estimate the actual dose to the eye lens when lead glasses are worn.

Lead-free aprons

...smaller the dose ... can reach the ... from the beam, ... position was ... average reduction ... of the table) has

Light lead and lead-free aprons

... can be lighter (up to ...)

Lead-free aprons

... organs (breast for instance) with ... clinical conditions as a possibly

Lead-free aprons

... light not be met ... es being smaller than the values ...

Equipment type	Cost
Cap	€
Face mask	€€
Glasses	€€
Thyroid collar	€
Gloves	€
Lead-free aprons	€€
Lead aprons	€€
Drapes	€ (disposable)/ €€ (reusable)
Table-suspended curtain	€€
Ceiling-suspended screen	€€€
Zero-Gravity suspended system	€€€€
-	
Cabin	

There is more than just radiation protection effectiveness

Cost symbols are: € = €0 to €100, €€ = €100 to €1000, €€€ = €1000 to €10000, €€€€ = €10000 to €100000

Funding

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