Eye lens dosimetry: results from the ELDO project

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STUDIECENTRUM VOOR KERNENERGIE
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Introduction

- European **ELDO** Project

"European epidemiological study of radiation-induced cataracts for interventional cardiologists - Methodology implementation"

- Several European countries create a national cohort
- Joined analysis of the pooled European cohort

⇒ To elucidate further the reduction of the threshold for cataract (ICRP-118)

⇒ To confirm if there is a threshold

NEED FOR GOOD DOSIMETRY

USING THE SAME PROTOCOL

- Epidemiology part
- Dosimetry part

Acknowledgement: Funded by the DoReMi Network of Excellence

Eye lens dosimetry – 2 approaches

Approach #1: Correlation to Hp(10)

Estimating eye lens dose from whole body dose from routine monitoring
→ only dosimetric data available for past practices

Need for Hp(10) values above the lead apron

Approach #2: Recent data to past practices

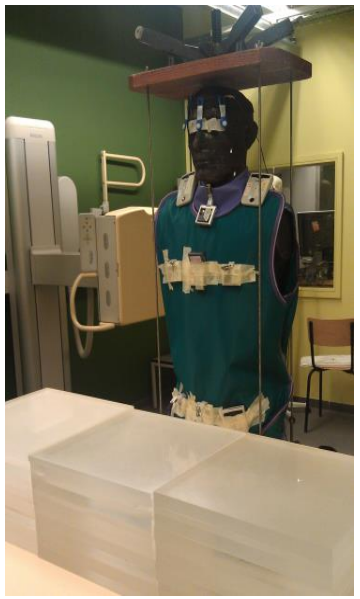
Accounting for the evolution of X-ray systems

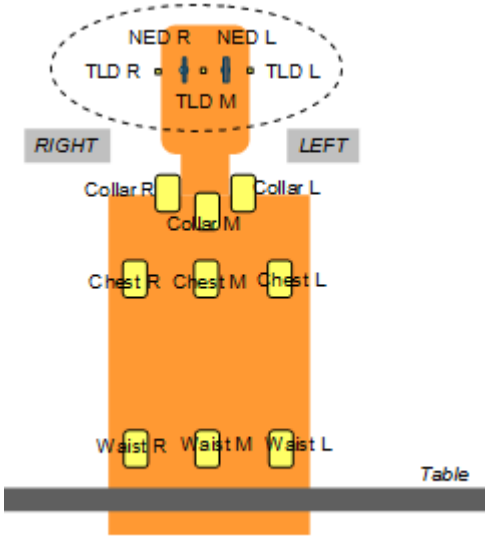
Need for precise information on workload, procedures, used equipment, etc.

Approach #1: Correlation to Hp(10)

Eye lens dosimetry – APPROACH 1

- Measurement of eye lens doses and whole body doses in clinical conditions
  - Operator: Rando-Alderson phantom
  - Patient: PMMA plates
  - Passive and active dosemeters
  - Measurements above the lead apron
    - Eye level
    - Collar level
    - Chest level
    - Waist level
    - Left – middle – right side
  - ~ 50 experiments/set ups

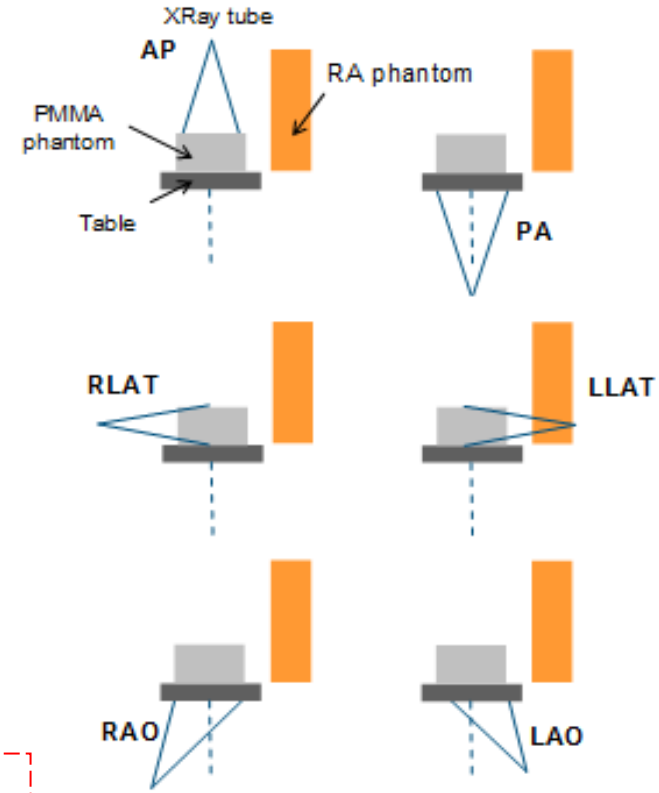




Ref: J Farah, L Struelens, J Dabin, et al. *A correlation study of eye lens dose and personal dose equivalent for interventional cardiologists.* Rad. Prot. Dos., 2013; 1-9

Eye lens dosimetry – APPROACH 1

- Clinical conditions
  - Different x-ray beam projections
  - Different operator positions with respect to the x-ray field
  - Different x-ray beam energies
  - Mono-plane and bi-plane x-ray systems
  - Without protective equipment (lead glasses and ceiling-mounted screen)



Result = ratio [eye lens dose/whole body dose] and associated uncertainty

Based on spread between ratio's for different clinical configurations

Ref: J Farah, L Struelens, J Dabin, et al. *A correlation study of eye lens dose and personal dose equivalent for interventional cardiologists.* Rad. Prot. Dos., 2013; 1-9

Eye lens dosimetry – APPROACH 1

Ratio of average **left eye** lens dose and whole body dose measured at different locations, considering **all projections and operator positions**.

	Collar L	Collar M	Collar R	Chest L	Chest M	Chest R	Waist L	Waist M	Waist R
Ratio	3.3	2.1	11.5	0.8	1.2	2.5	1.5	1.8	8.0
Standard deviation	**42%**	48%	81%	90%	73%	100%	159%	143%	147%

Best correlation

Ratio of average **left eye** lens dose and whole body dose measured at different locations, considering projections and operator positions for **CA&PTCA** and **RF ablations**.

	Collar L	Collar M	Collar R	Chest L	Chest M	Chest R	Waist L	Waist M	Waist R
Ratio	4.0	2.6	12.8	0.7	1.0	1.9	0.5	0.7	3.7
Standard deviation	**41%**	40%	56%	52%	56%	50%	46%	64%	101%

Reduced uncertainties

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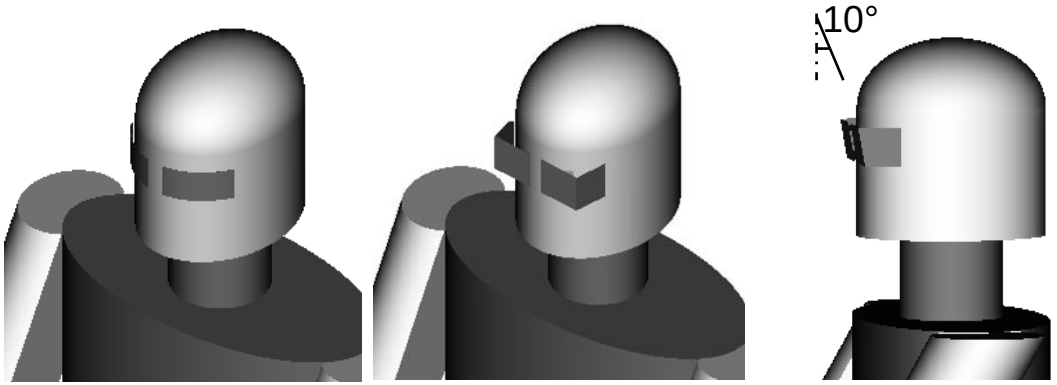
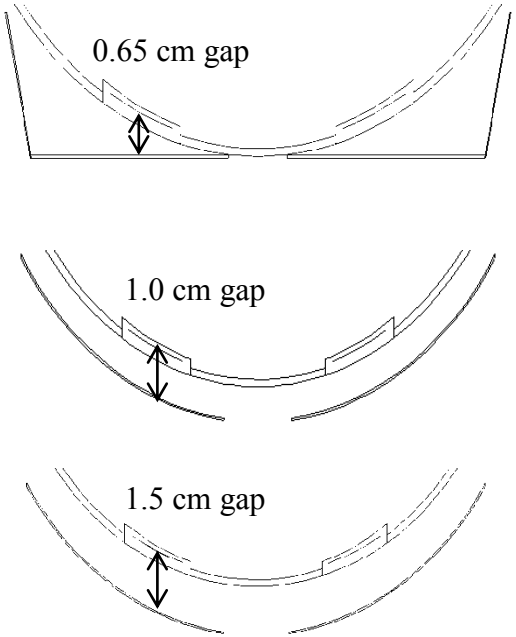
Eye lens dosimetry – APPROACH 1

- Monte Carlo simulations: efficiency of the protective equipment
  - Size, thickness and shape of **lead glasses**





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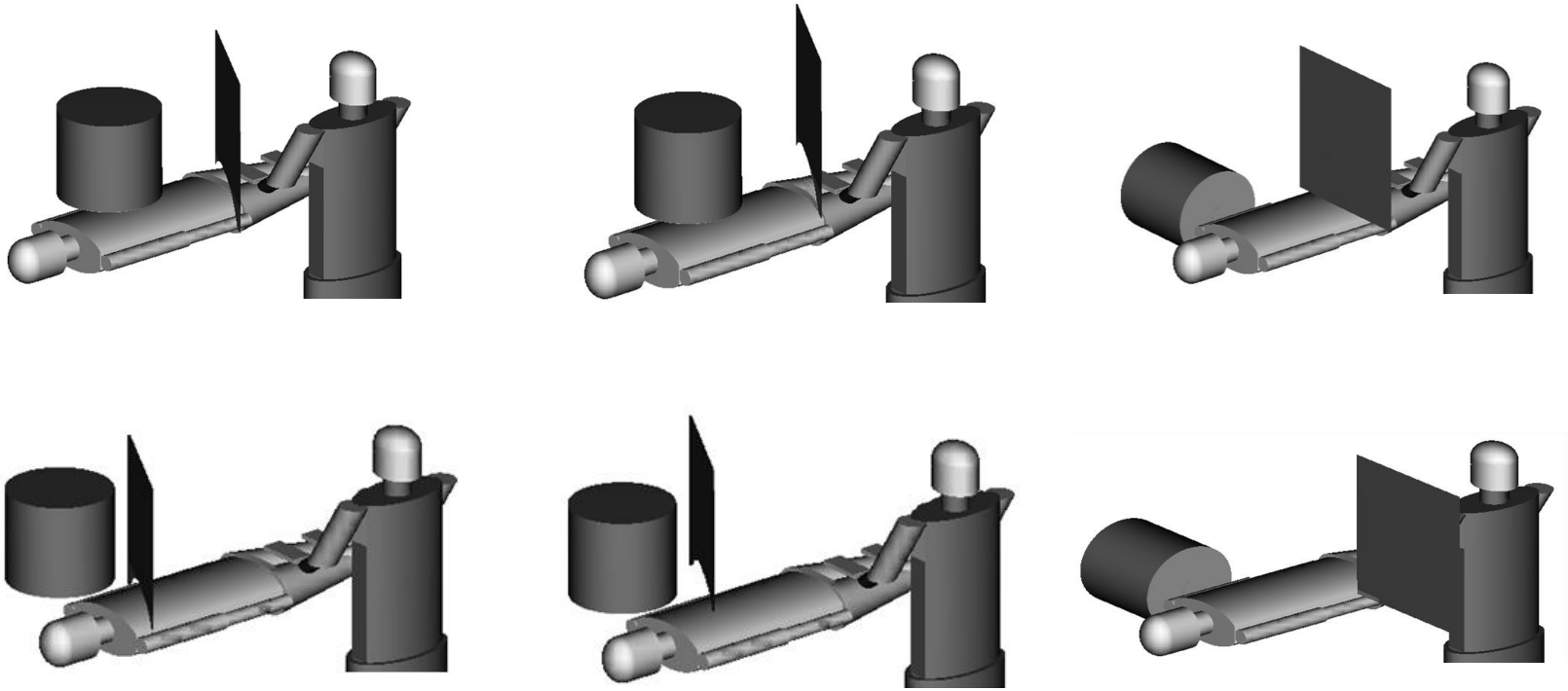
Eye lens dosimetry – APPROACH 1

- Monte Carlo simulations: efficiency of the protective equipment
  - Shape and position of **ceiling suspended screens**



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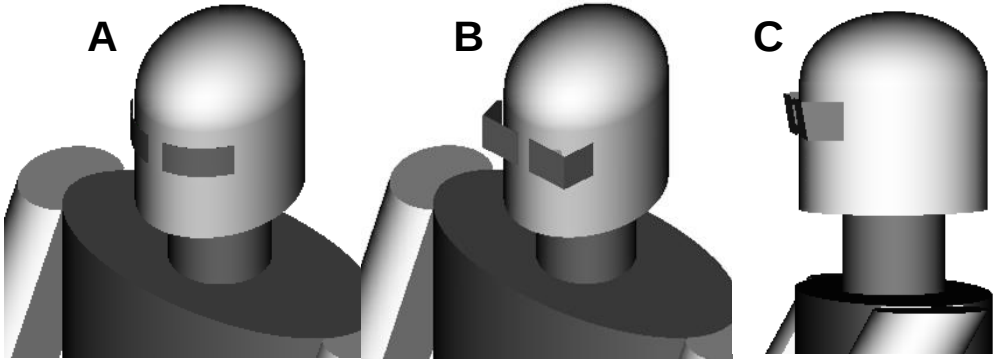
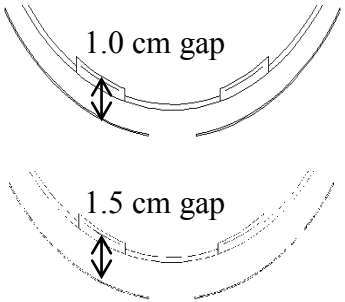
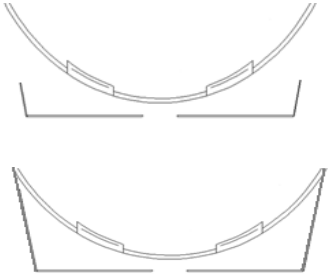
Eye lens dosimetry – APPROACH 1

- Monte Carlo simulations: efficiency of the protective equipment
  - For all possible x-ray projections, operator positions and tube configurations
  - > 100 calculations





	with / without glasses		
	A	**B**	**C**
Left eye	0,18	0,57	0,44
Right eye	0,85	0,68	0,54



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Eye lens dosimetry – APPROACH 1

- Monte Carlo simulations: efficiency of the protective equipment
  - For all possible x-ray projections, operator positions and tube configurations
  - > 100 calculations

Result = correction coefficients considering effect of protection and associated uncertainty

↓

Based on spread between coefficients for the variation in protection efficiency

With / without	Left eye	Right eye	Collar	Chest	Waist
Lead glasses	0,37	0,75	/		
	67%	*34%*			
Ceiling shields	0,45	0,42	0,53	0,63	0,80
	86%	*85%*	*71%*	52%	*24%*

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Eye lens dosimetry – APPROACH 1

Summary

- The correlation between eye lens and whole body dose depends on
  - Type of procedure
  - The position of the whole body dosemeter (always ABOVE lead apron)
  - The working practice
    - position of operator
    - The use of protective equipment
- Assessing eye lens dose from whole body dose can introduce large uncertainties
  - 40% to 160% without protection
  - Additional 35% to 85% for variation in protection efficiency
- Of interest for future retrospective epidemiological studies
- Not advisable for routine monitoring

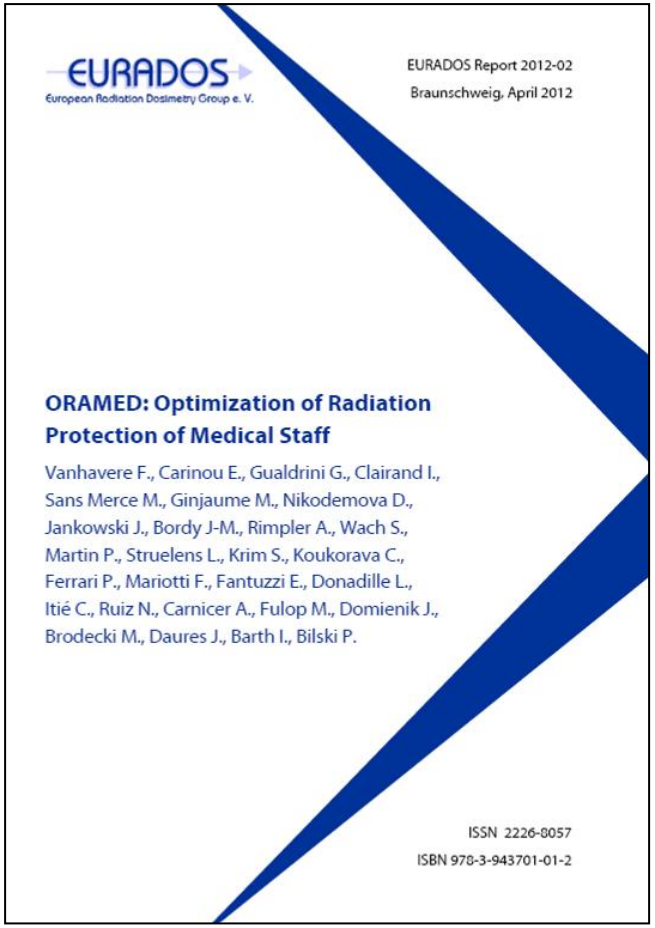
Approach #2: Recent data to past practices

Eye lens dosimetry – APPROACH 2

- ORAMED database of eye lens dose measurements
  - 1329 eye lens dose measurements
  - 6 European countries ; > 40 hospitals
  - Common dosimetry protocol
  - Several interventional procedures

  ⇒ **Representative for current practices**

- Adjusting recent data to past practices
  - Evolution of x-ray systems and interventional procedures
  - Interviews with manufacturers and interventional radiologists/cardiologists



Eye lens dosimetry – APPROACH 2

- Evolution of x-ray systems before year 2000:
  - Beam filtration → no significant effect on dose (less than 10%)
    - Aluminium filtration from [3,0 – 7,0] mm Al
    - Copper filtration from [0 – 0,9] mm Cu
  - Dose at the detector → a factor ~2 on dose
    - Beginning of 2000
      - More and more interest in radiation protection of the patient: doses at the detector reduced with around 60% compared to the first systems
      - Improvements of the detectors itself: evolution from image intensifiers to flat panel detectors
  - Change in frame rate for image acquisition → a factor ~2 on dose
    - 1980-1990: 50 F/S
    - 1990-2000: 30 F/s
    - > 2000: 15 F/s

Eye lens dosimetry – APPROACH 2

- Evolution of x-ray systems before year 2000:
  - Beam filtration → no significant effect on dose (less than 10%)
  - Dose at the detector → a factor ~2 on dose
  - Change in frame rate for image acquisition → a factor ~2 on dose
- For procedures performed before 2000:
  a correction factor of 2 to 4 identified, depending on type of procedure
- Information on working practice and type of procedures is needed
  - Protective equipment, type of x-ray system, work load, …

Conclusion

- The ELDO project developed a dosimetry protocol for retrospective assessment of eye lens doses for interventional cardiologists
  - 2 approaches, depending on available information

- Approach 1: based on whole body doses above lead apron
  - Ratio [eye lens/whole body] dose determined
  - Correction factors for the use of protective equipment

- Approach 2: based on recent eye lens dose measurements
  - Detailed information needed on working practices (also for the past)
  - Corrections identified for procedures performed before the year 2000

- Both approaches of major interest for future epidemiological studies
  - Further validation of both approaches needed

Acknowledgement: Funded by the DoReMi Network of Excellence

Questions?

Thank you for your attention !!!

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