New Radiation Protocols to Reduce Radiation for Complex PCI

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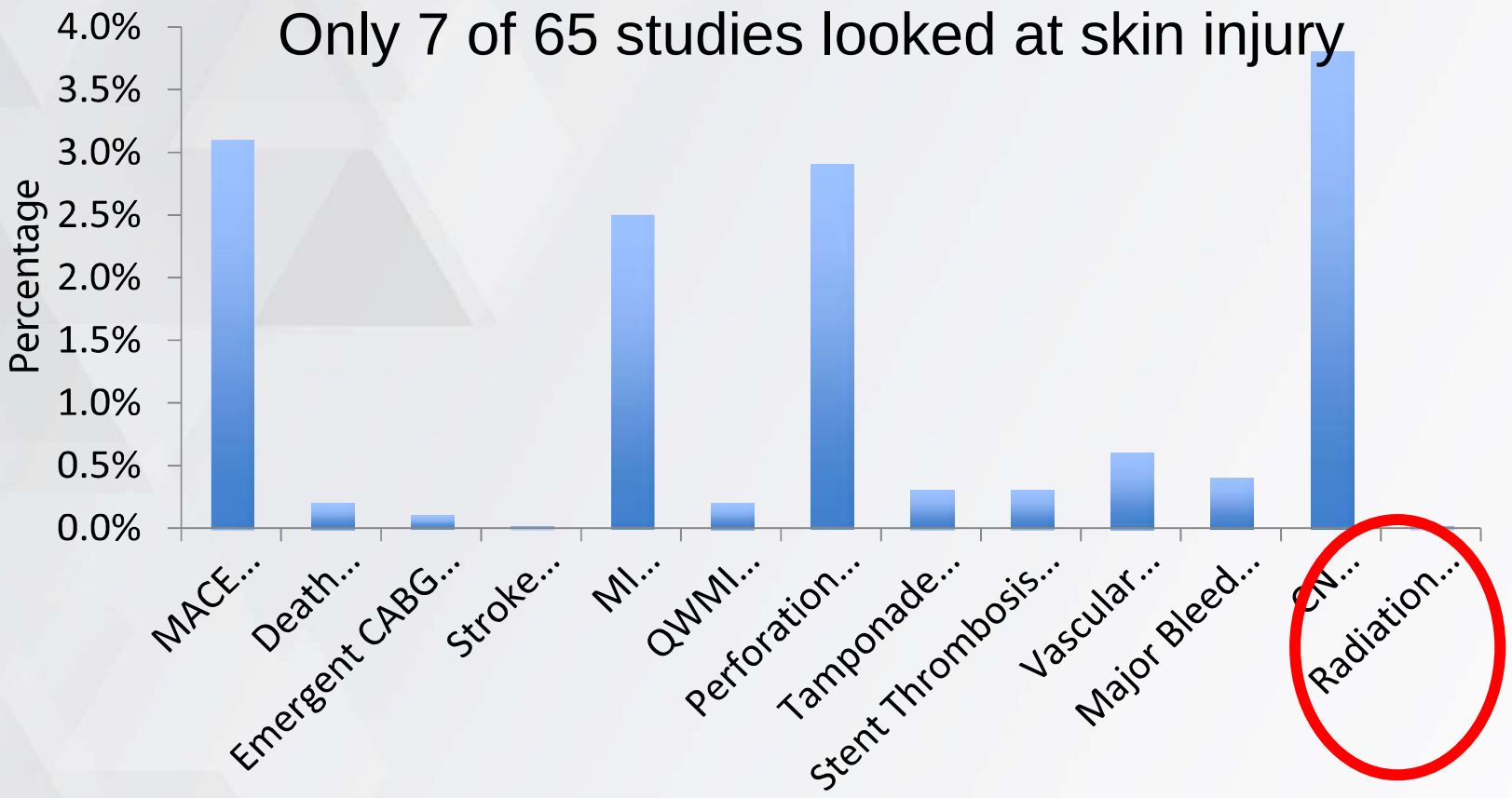
Disclosure

- Disclose potential conflicts of interest
- The modified protocols for radiation exposure were implemented in cooperation with Siemens Healthineers, Forchheim, Germany
- No financial disclosures exist with respect to this presentation

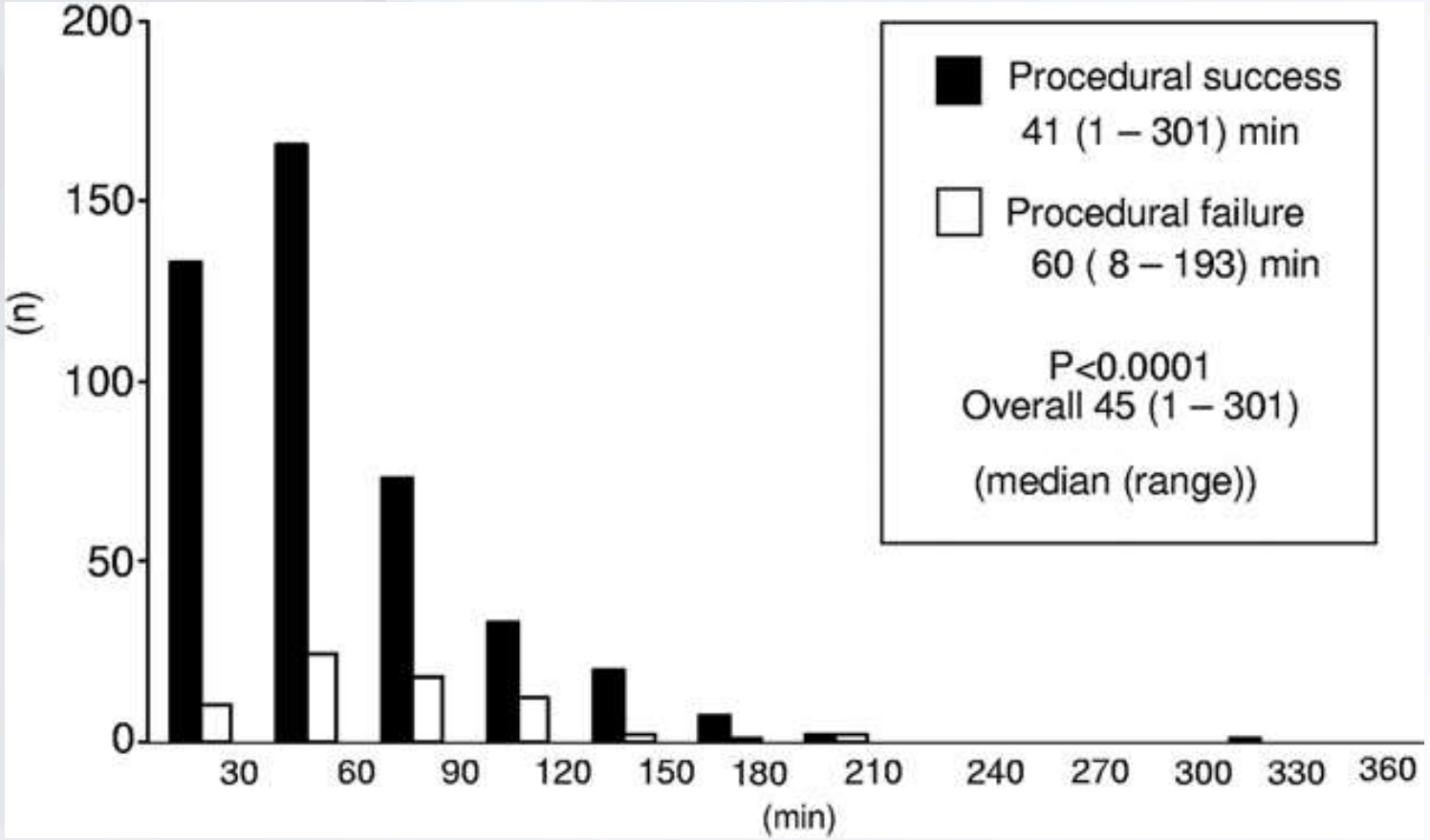
Radiation skin injury rarely reported in studies



Outcome	Pooled Estimate Rate, %	95% CI	Reported Rate, Min–Max %	Cumulative Rate, n/N
Contrast nephropathy	3.8	2.4–5.3	2.4–18.1	165/4,796
Radiation skin injury	<0.01	0–0.1	0–11.1	3/2,857

Patel et al JACC 2013; 71: 160 – 164

Just one of the many registries



No report of any skin injury

Morino et al JACC Interv 2010; 3: 143 – 51

Potential effects on skin from interventional procedures
Watch the Dose Rate !!!

Effect	Threshold dose (Gy)	Minutes fluoro at 0.02 Gy/min	Minutes fluoro at 0.2 Gy/min
Transient erythema	2	100	10
Permanent epilation	7	350	35
Dry desquamation	14	700	70
Dermal necrosis	18	900	90
Telangiectasia	10	500	50
Cataract	> 5	> 250 to eye	> 25 to eye
Skin cancer	Not known	Not known	Not known

J. Cardella, K. Faulkner, J. Hopewell, H. Nakamura, M. Rehani, M. Rosenstein, C. Sharp, T. Shope, E. Vano, B. Worgul, M. Wucherer: “Avoidance of Radiation Injuries from Medical Interventional Procedures”, ICRP publication 85

You should watch your radiation speed continuously

Radiation exposure in published studies

Years Number of patients	Rathore [31] 2002-08 1385	Michael [32] 2006-11 1363	Christakopoulos [36] 2012-2015 748	Maccia [33] 2013-14 710	Maeremans [35] 2014-15 1253	Werner [16] 2014-15 476	Ge [28] 2015-17 192
Body mass index [kg/m^2]	NA	NA	31	28	NA	29	26
Weight [kg]	64	NA	NA	80	NA	88	NA
Fluoroscopy time [min]	86	42	52	36*	35*	46	50
Air Kerma [Gy]	10.4	4.7	4.0	2.7*	1.6*	2.7	2.6
Dose rate index [mGy/min]	121	112	77	75	46	59	52
Efficiency Index [min/Gy]	8.3	8.9	13.0	13.3	21.9	17.0	19.2

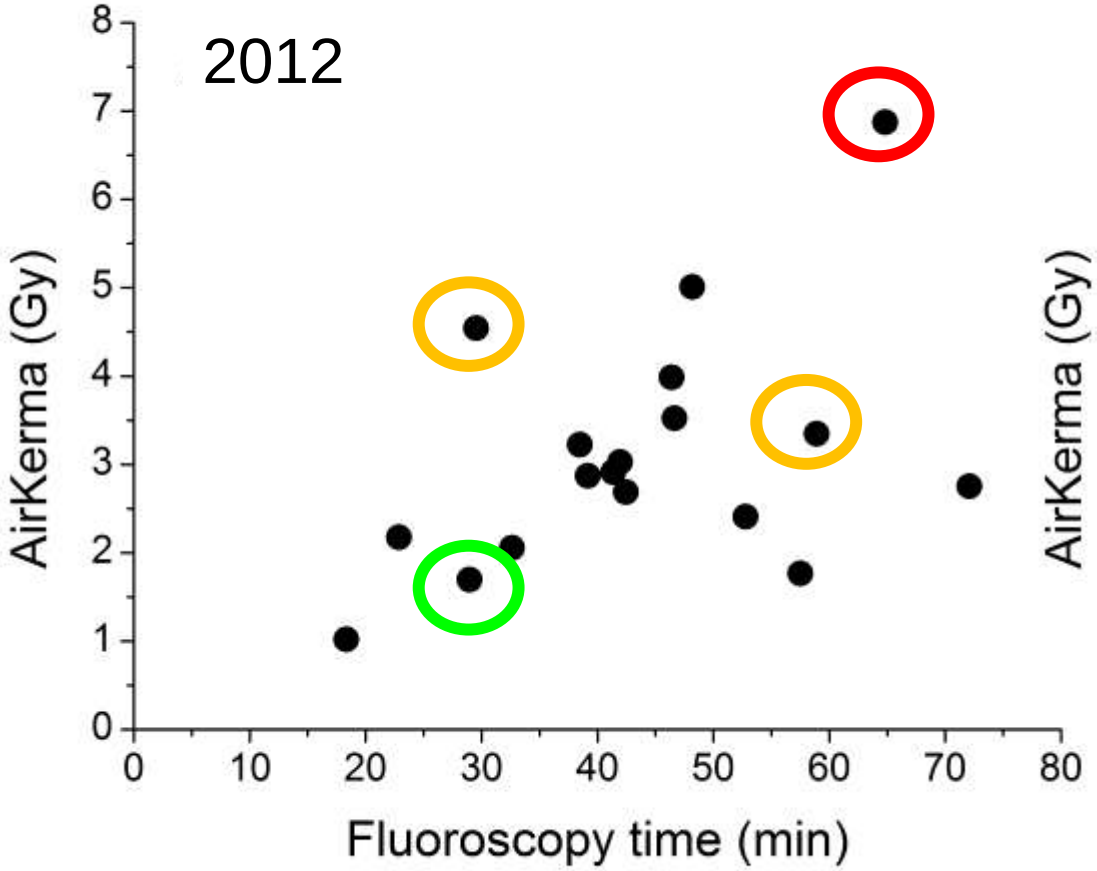
Werner et al CCI 2020

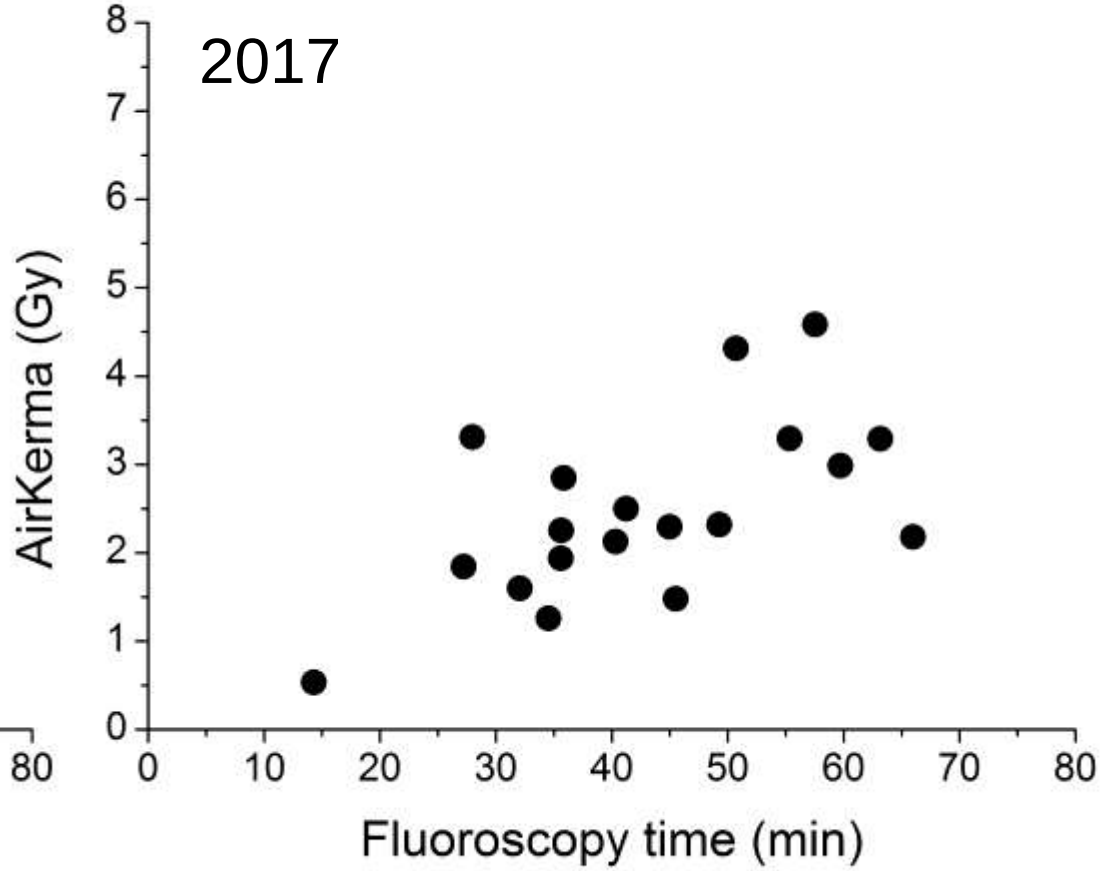
J-CTO Score and radiation exposure

Lesion complexity	Easy	Moderate	Complex	p
J-CTO Score	0-1	2-3	4-5	
	134	240	102	
Retrograde approach [%]	20.1 *)	51.5 *)	88.2	<0.001
Procedural success [%]	99.3	97.5	90.2 *)	<0.001
Duration of procedure [min]	97 ± 44 *)	133 ± 58 *)	183 ± 65	<0.001
Total fluoroscopic time [min]	26.8 ± 17.9 *)	44.9 ± 26.1 *)	71.7 ± 33.6	<0.001
Contrast volume [ml]	203 ± 99 *)	228 ± 98 *)	257 ± 96	<0.001
Air Kerma [mGy]	2108 ± 1356 *)	2713 ± 1675 *)	3478 ± 1867	<0.001

Werner et al; CCI 2017

Improvement in management is possible but still too much individual variability

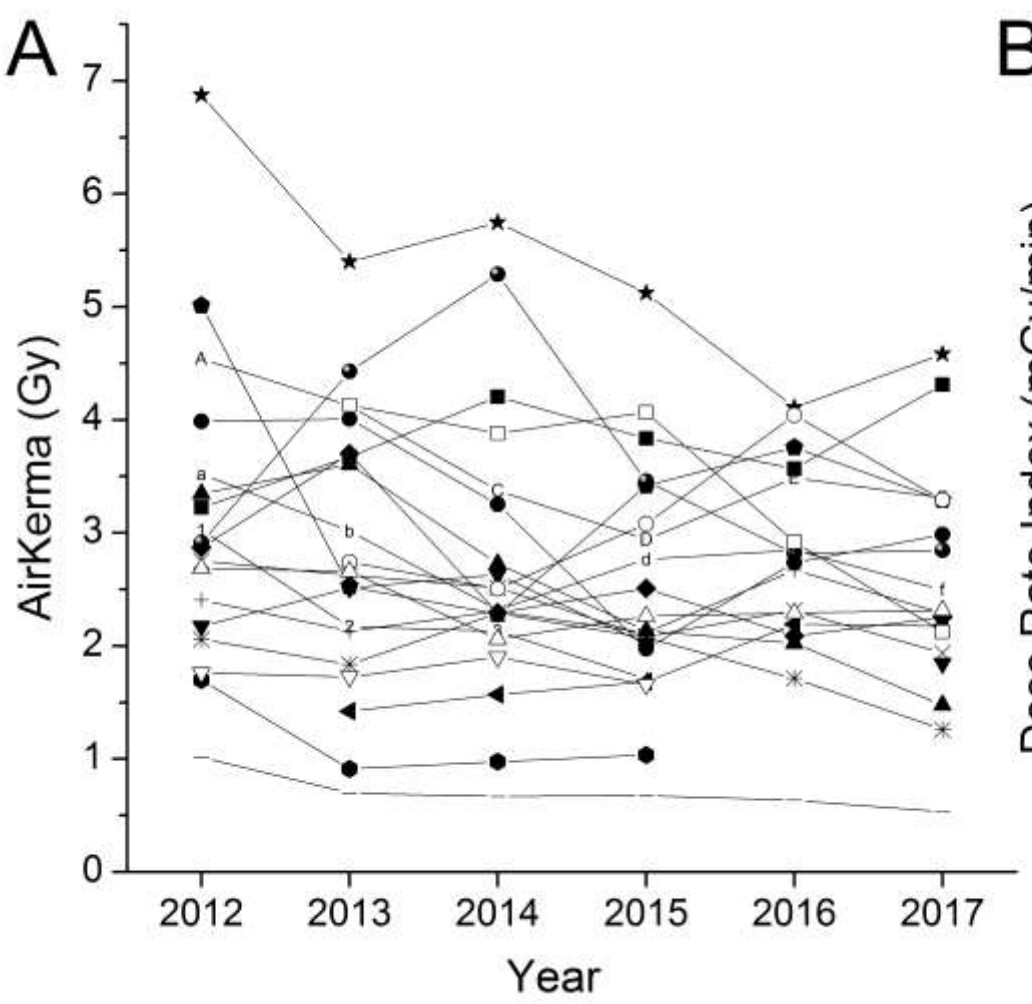


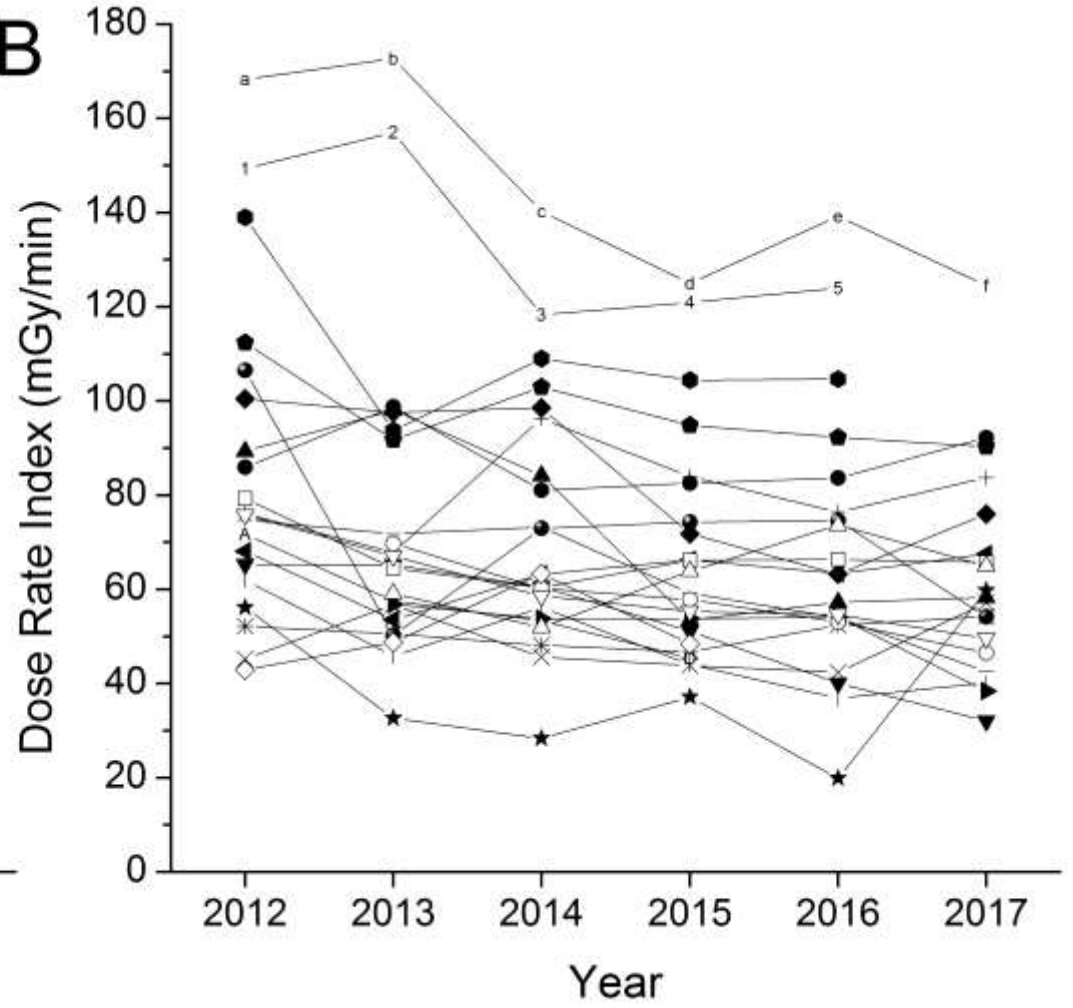


ERCTO Registry

Werner et al J Inv. Cardiol 2021

Changes of AirKerma over time per operator





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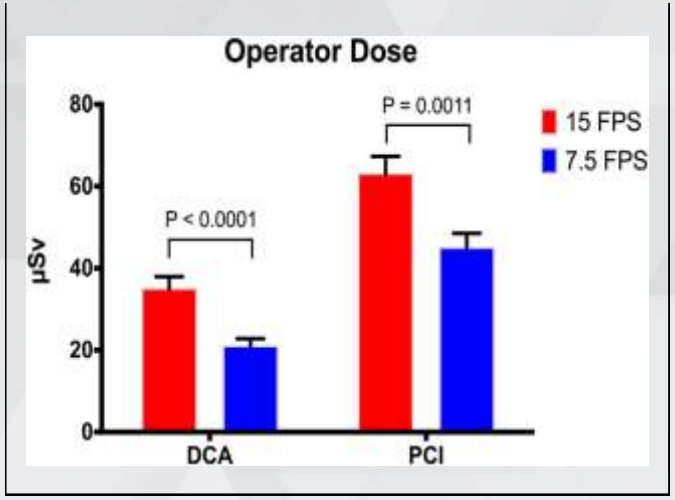
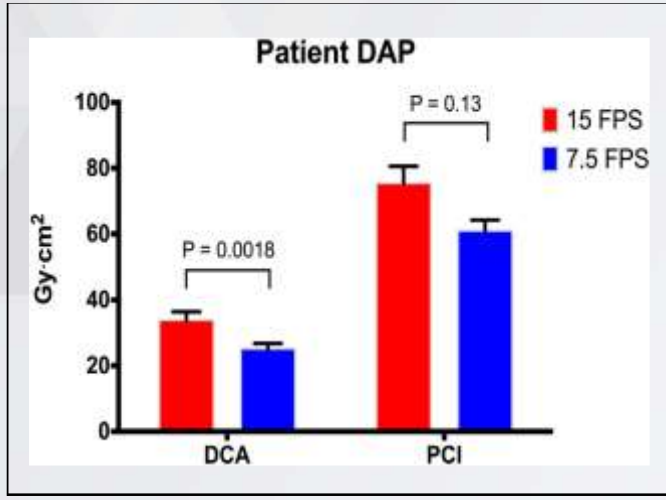
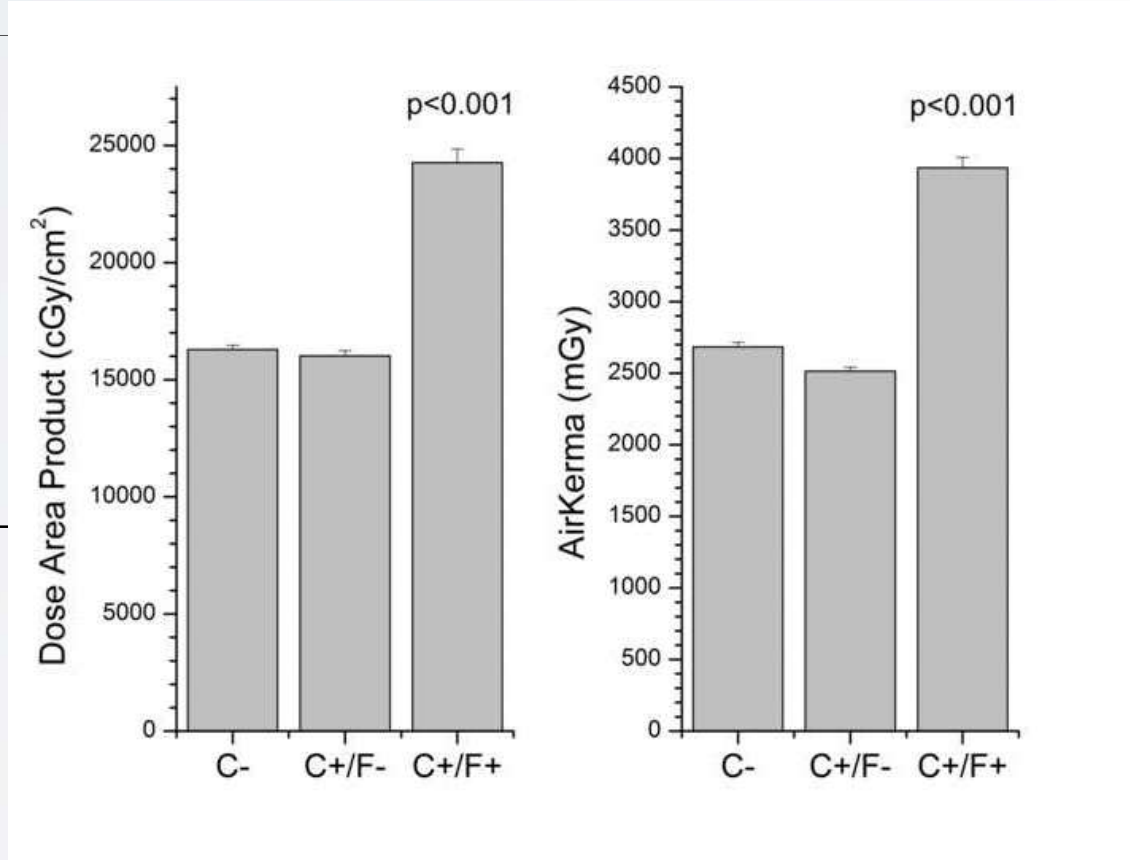
Lower fluoro frame rate 7.5 vs 15, but…







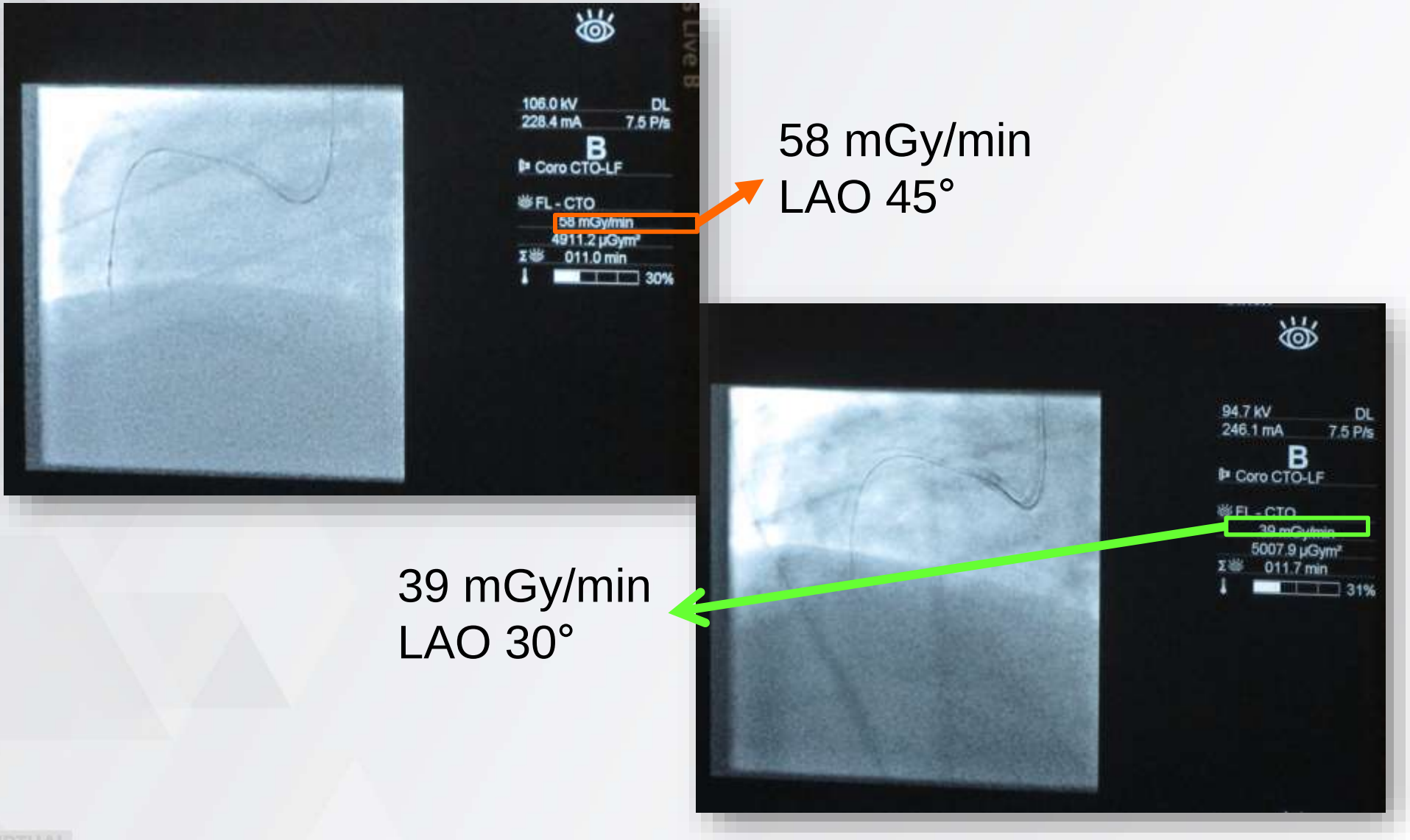
Why is there not more of a difference ?

- **Used 15 f/s for cine**
- The contribution of cine runs to the total dose should not be underestimated
- Avoid cine runs when ever possible, use fluoro storage
- Cine at 7.5 f/s

Abdelaal et al JACC Interv 2014; 7: 567– 74

Werner et al J Inv. Cardiol 2021

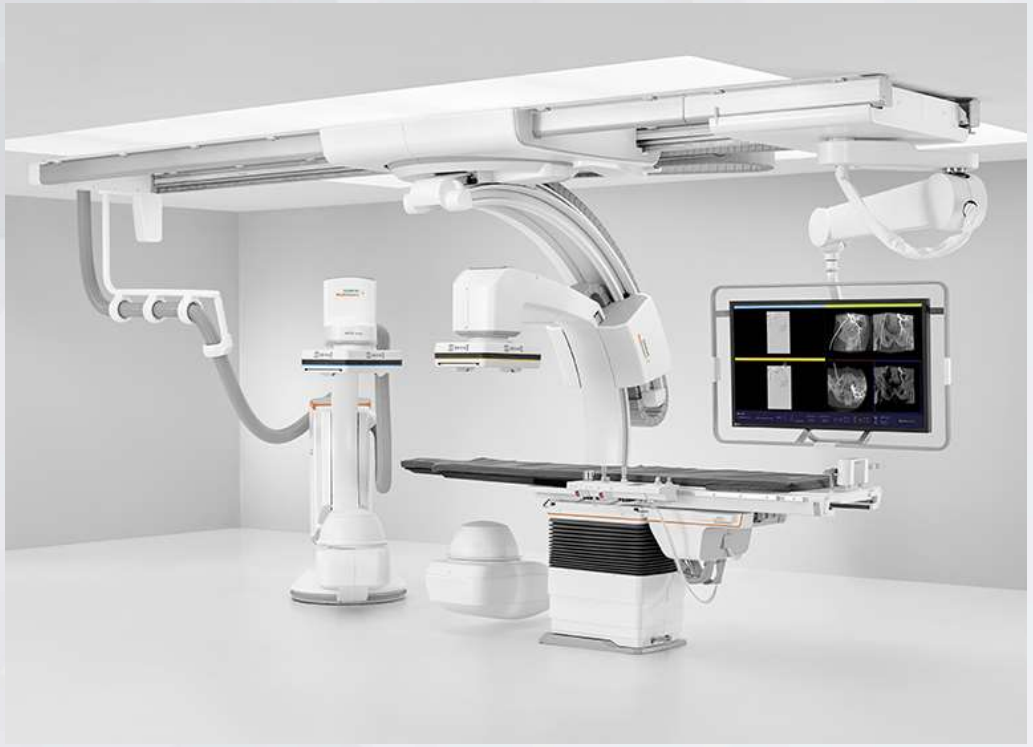
Changing angulation influences dose



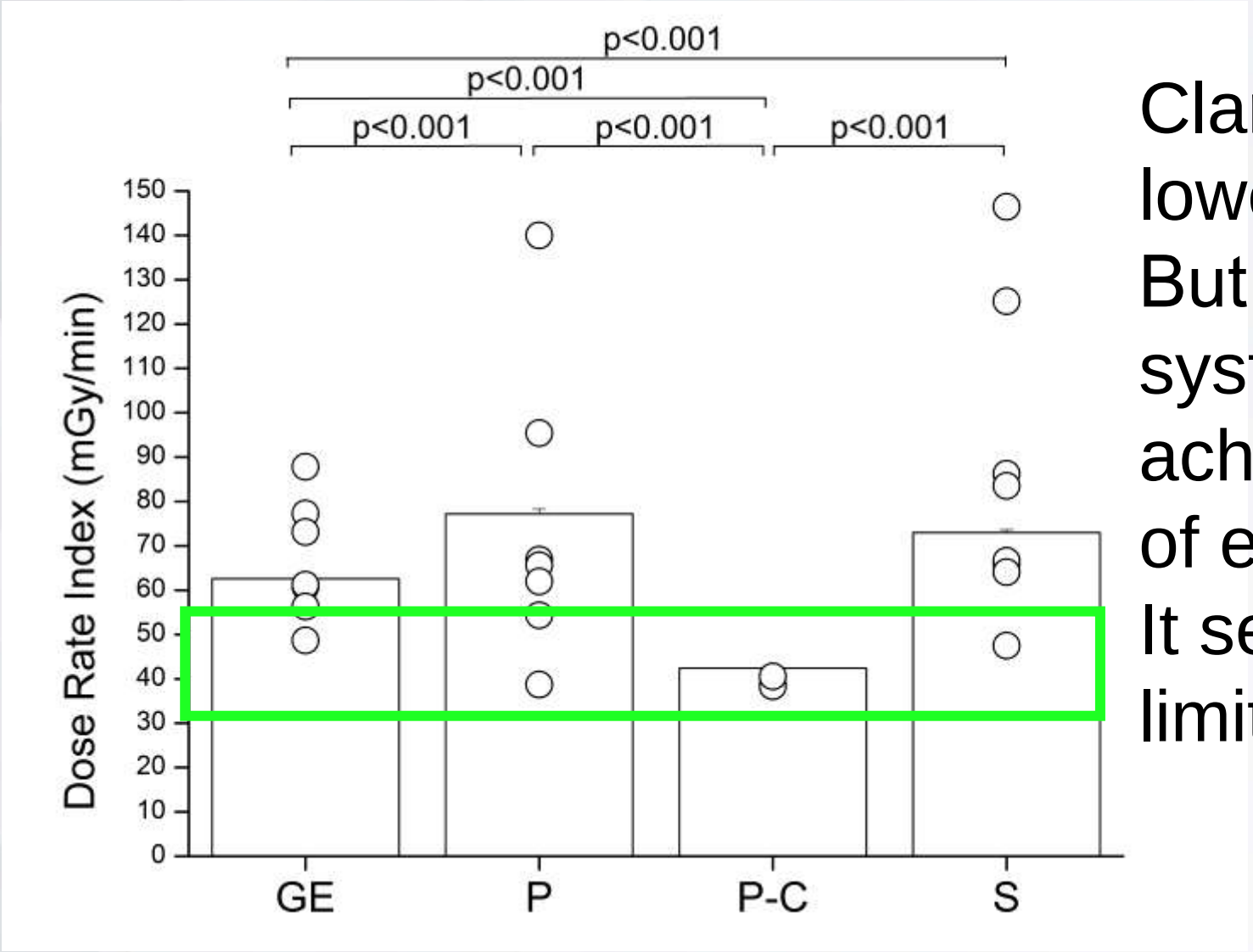
My approach to ALARA

- The initial bilateral imaging to visualize collaterals is done with 15 f/s (only for retrograde options), then filming is reduced to minimum at 7.5 f/s
- Pulse rate for fluouro is sufficient at 6 p/s
- Always work with low dose fluoro protocol
- **But we are not at the end of the story** her than dose
- Never film a balloon or stent, just store the flouro
- Use low radiation angulations for routine steps of balloon advancement etc.

Do we need all new machines ?



Is it down to the equipment ?



Clarity systems had the lowest DRI

But even with an “old” system you could achieve the same range of efficiency

It seemed that Clarity limited the outliers

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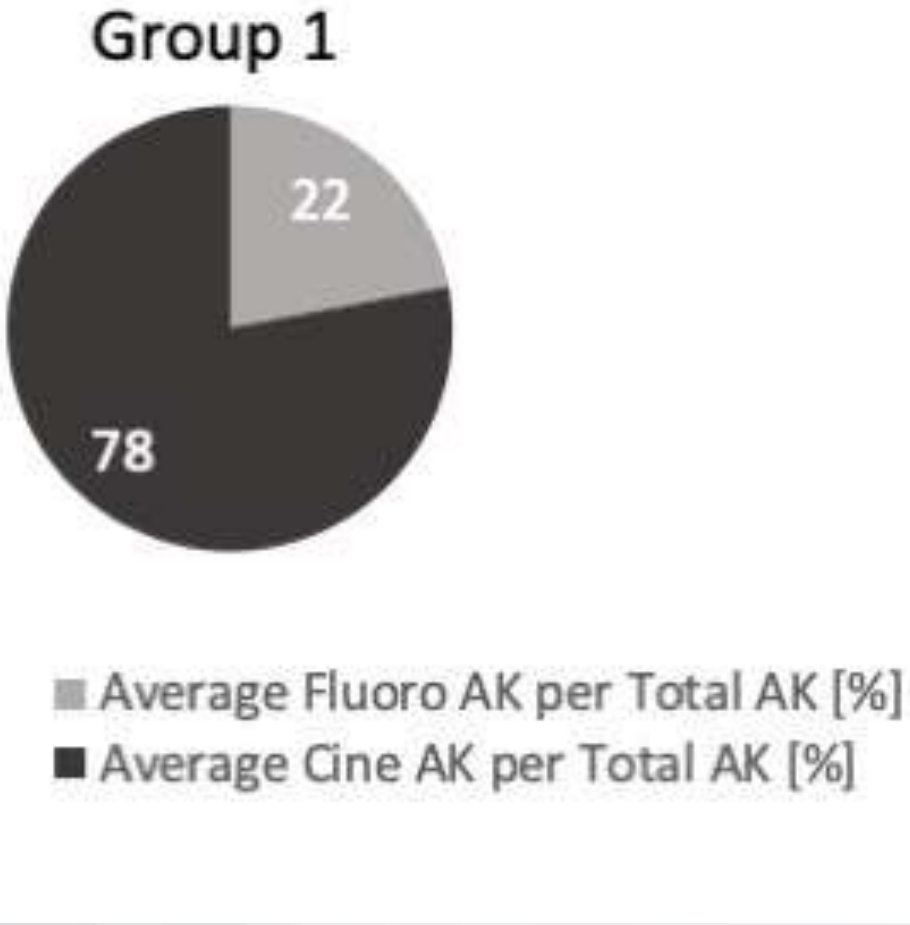
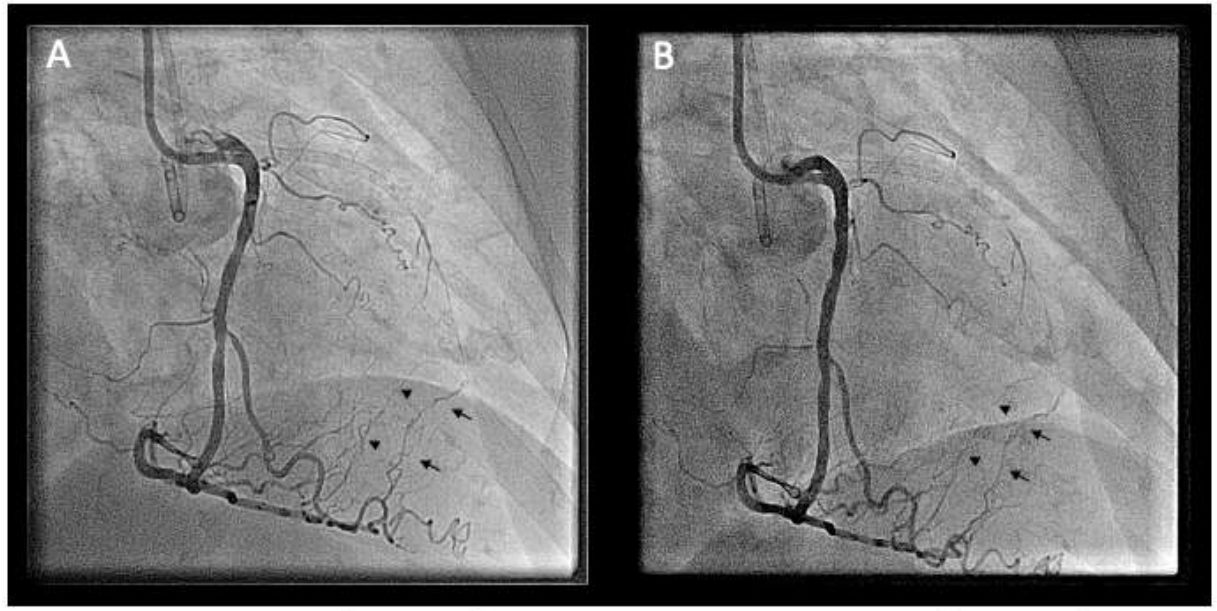
What is radiation usually used for: Cine or Fluoro ?

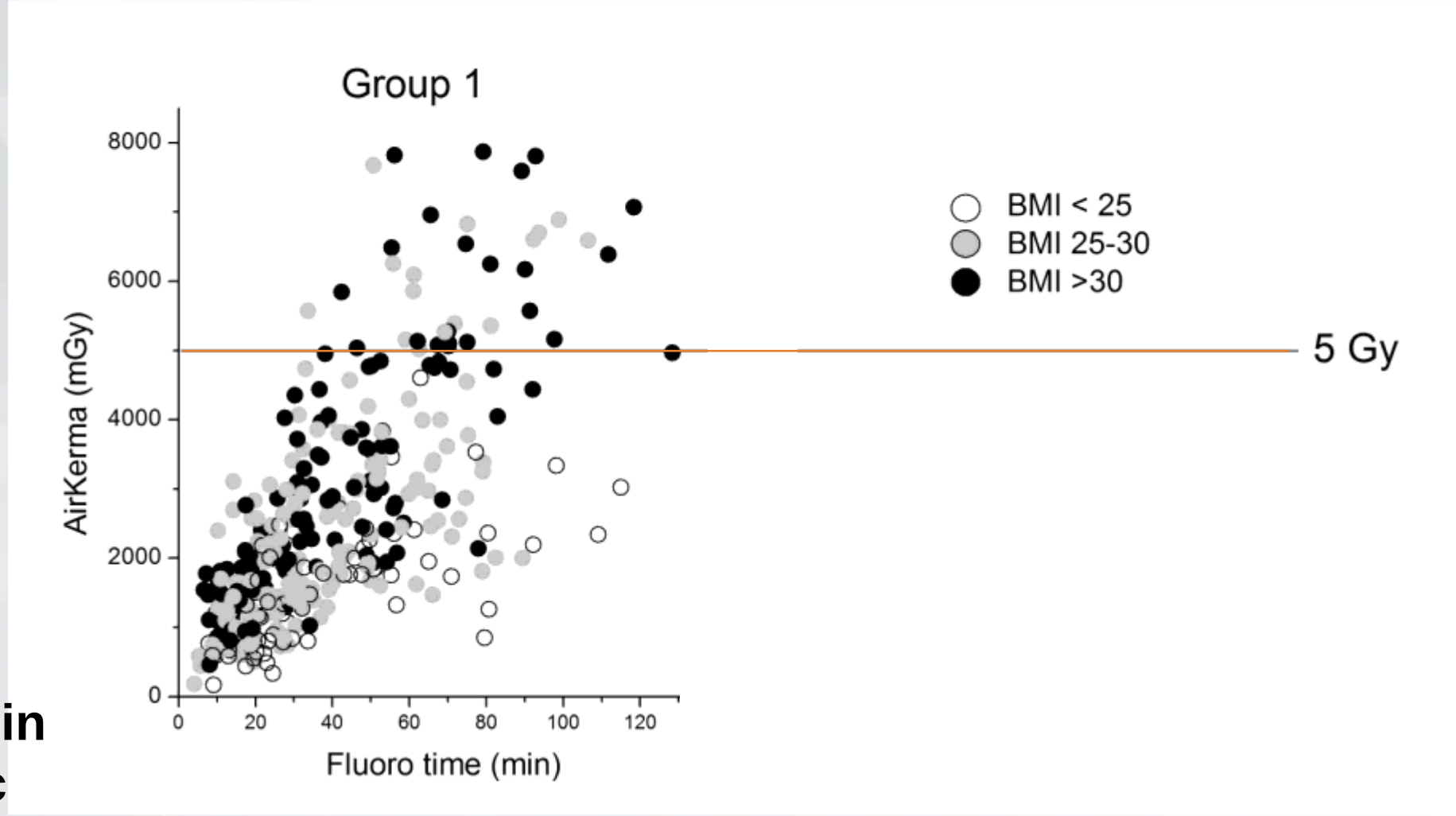




	Standard protocol group 1 (0.0 mm Cu)	Modified protocol group 2 (0.3 mm Cu)
Frame rate	15 /s	15 /s
Number of frames	88	88
Tube voltage	81 kV	78 kV
Tube current	745 mA	326 mA
AirKerma	45.8 mGy	6.2 mGy
Dose Area Product	407.7 cGy*cm²	55.6 cGy*cm²

Werner et al CCI 2020

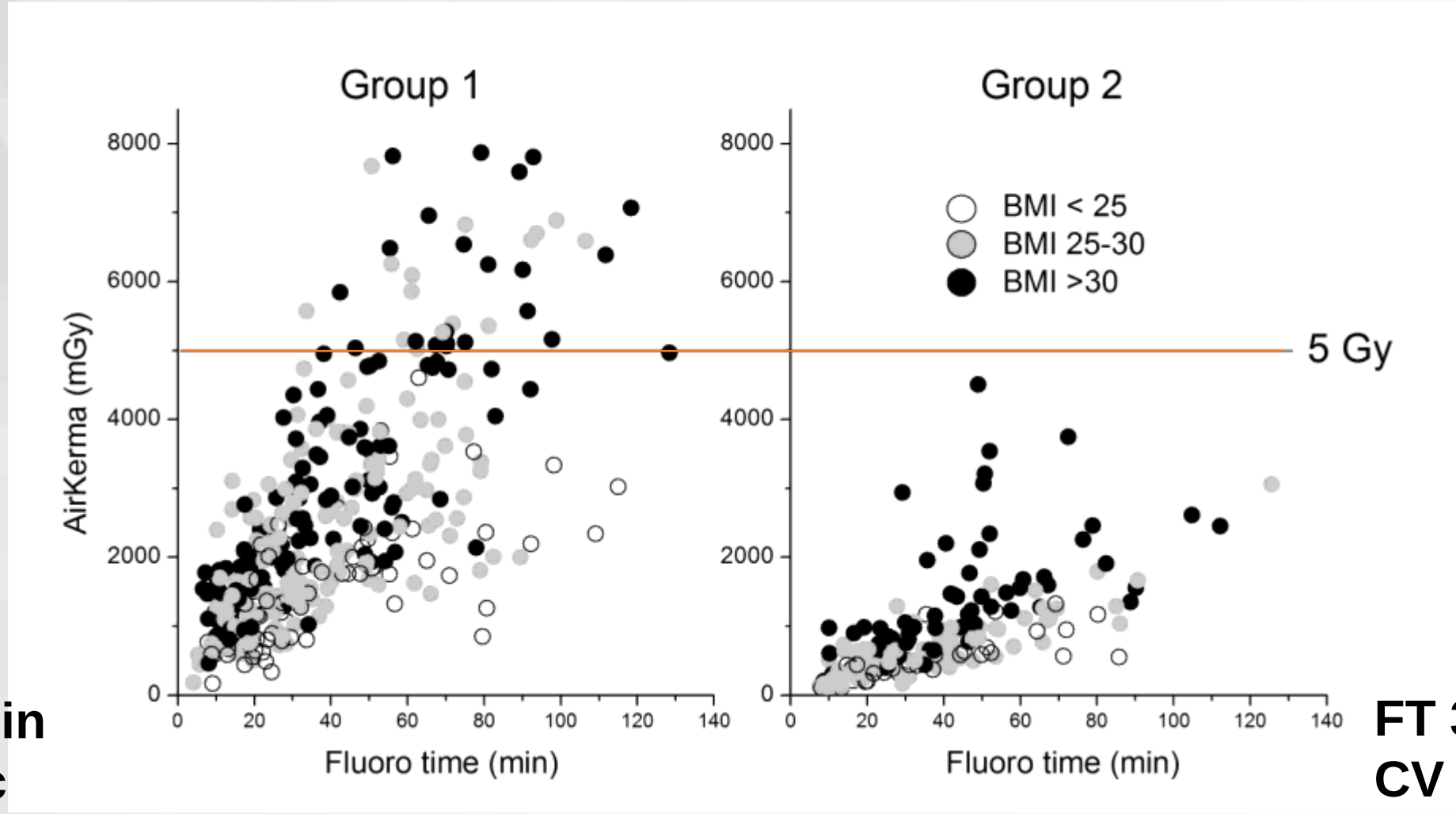
We exceeded the 5 Gy limit in 10.4 % of patents !



FT 32.7 min
CV 204 cc
AK 2040 mGy
DAP 127 Gy*cm²

Werner et al CCI 2020

Never exceed the 5 Gy limit ever again !!!

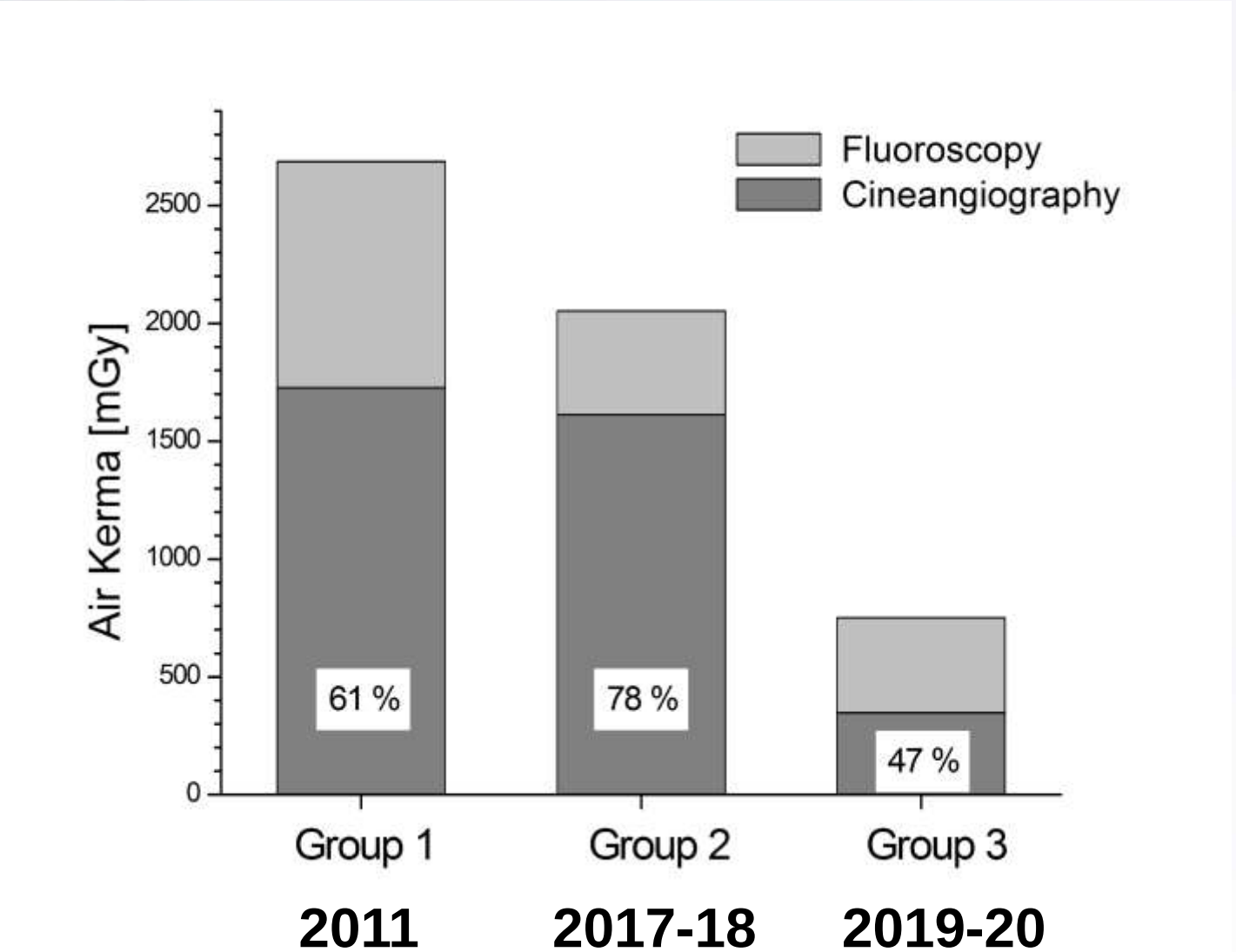


FT 32.7 min
CV 204 cc
AK 2040 mGy
DAP 127 Gy*cm²

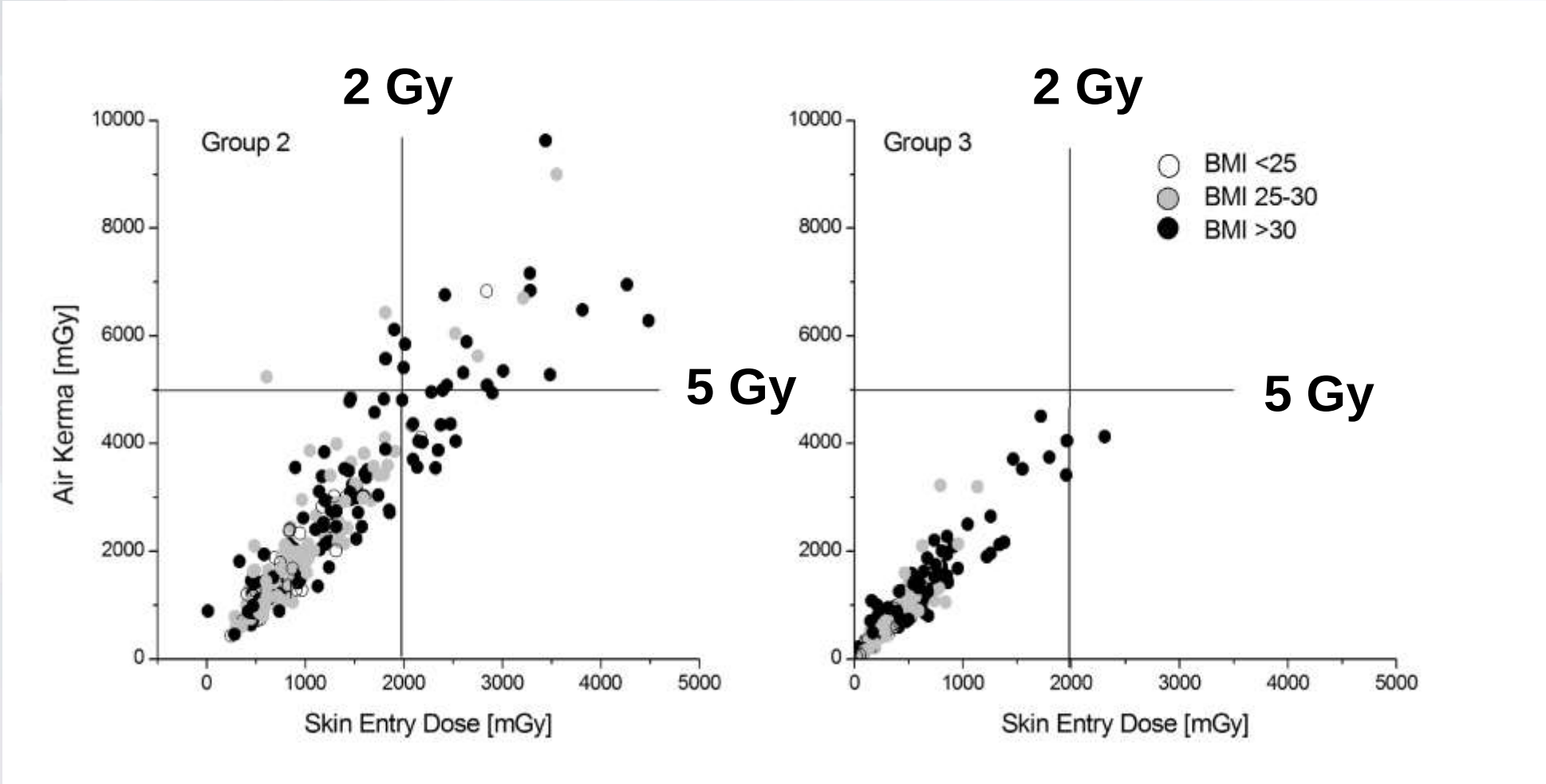
Werner et al CCI 2020

FT 34.7 min
CV 202 cc
AK 655 mGy
DAP 37 Gy*cm²

Dramatic changes over time with the same equipment !!!



The alert thresholds of X-ray exposure: 5 Gy for Air Kerma, 2 Gy for maximum skin entry dose



Conclusion / Take-home Message

- The potential of further reduction of radiation exposure to the patient and the operator is still not optimized
- Operators are still often ignorant of ways to optimize their radiation use

- In my own practice, radiation has no longer been a concern for abandoning a procedure