Radiation Management for Complex PCI

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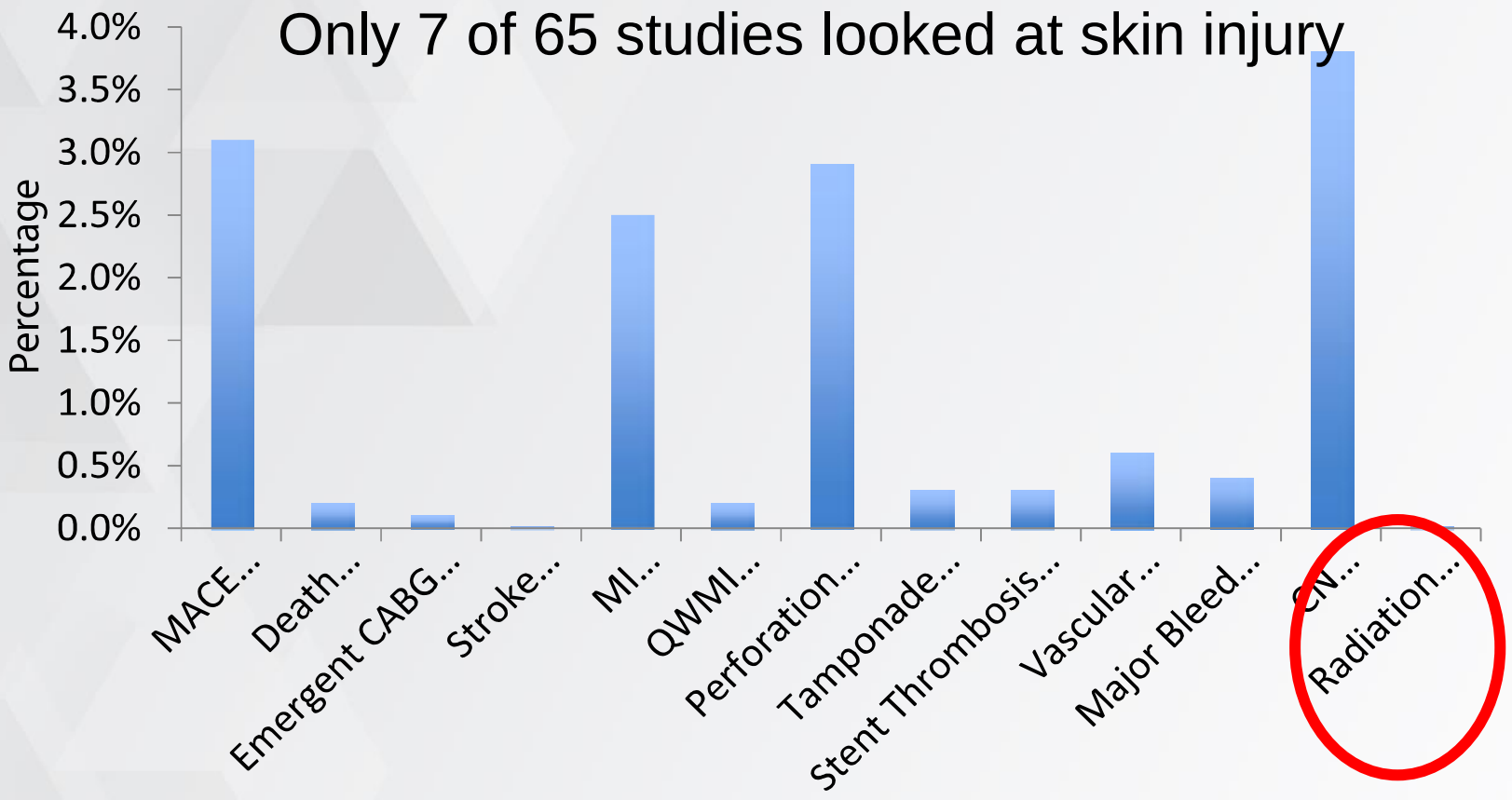
Disclosure

- The modified protocols for radiation exposure were implemented in cooperation with Siemens Healthineers, Forchheim, Germany
- Speaker honoraria from Abbott Vascular, ASAHI Intecc, Orbus-Neich, Philips, Shockwave, Siemens, Terumo

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

A 52-year-old patient after a (failed) CTO procedure

A LAD CTO was tried mostly in AP cranial with too many cine runs

Effect	Threshold dose (Gy)	Minutes fluoro at 0.02 Gy/min	Minutes fluoro at 0.2 Gy/min
		20 mGy/min	200 mGy/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

Werner GS. EuroInterv 2018; e496-8

Radiation management for complex PCI

- Understand the readings of the X-ray equipment
- What determines high radiation
  - Lesion complexity
  - Body weight
  - X-ray equipment
  - Operator’s interest in optimising the settings

You should watch your radiation speed continuously

Radiation exposure in published studies

	Rathore [31]	Michael [32]	Christakopoulos [36]	Maccia [33]	Maeremans [35]	Werner [16]	Ge [28]
Years	2002-08	2006-11	2012-2015	2013-14	2014-15	2014-15	2015-17
Number of patients	1385	1363	748	710	1253	476	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 [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

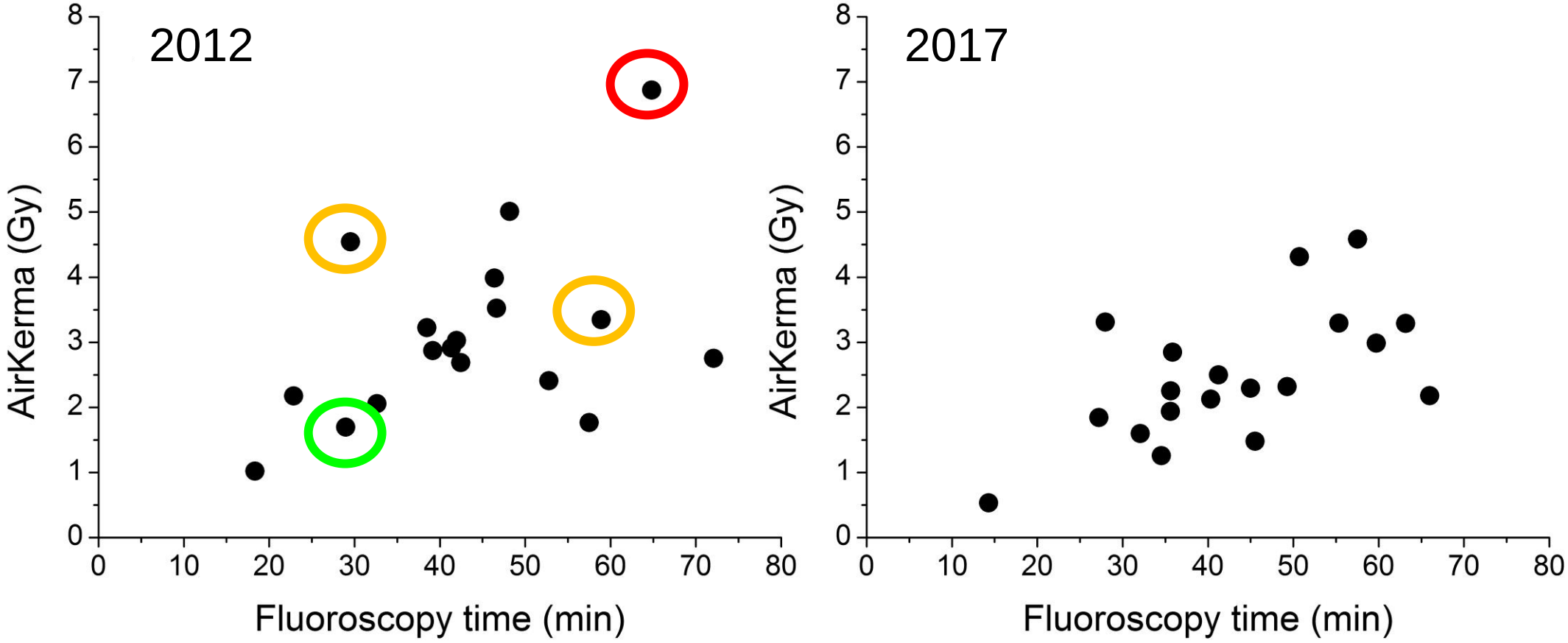
Werner et al Catheter Cardiovasc Interv. 2017;89:1005-12

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 Catheter Cardiovasc Interv. 2017;89:1005-12

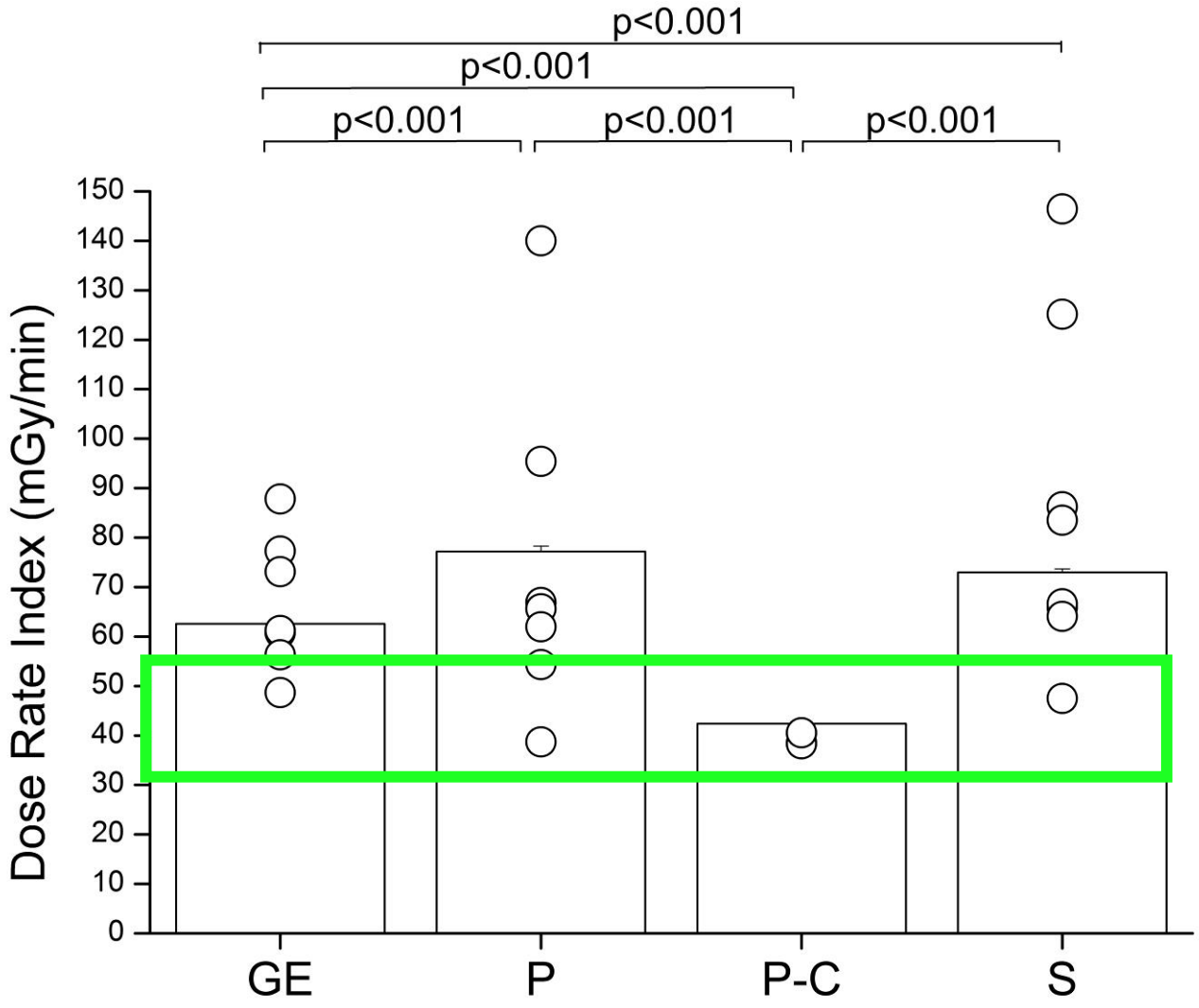
Improvement in management is possible but still too much individual variability



ERCTO Registry

Werner et al J Invasive Cardiol. 2021;33:E146-E54

Is it down to the equipment ?



Clarity systems had the lowest Dose Rate Index
But even with an “old” system you could achieve the same range of efficiency
It seemed that Clarity limited the outliers

Werner et al J Invasive Cardiol. 2021;33:E146-E54

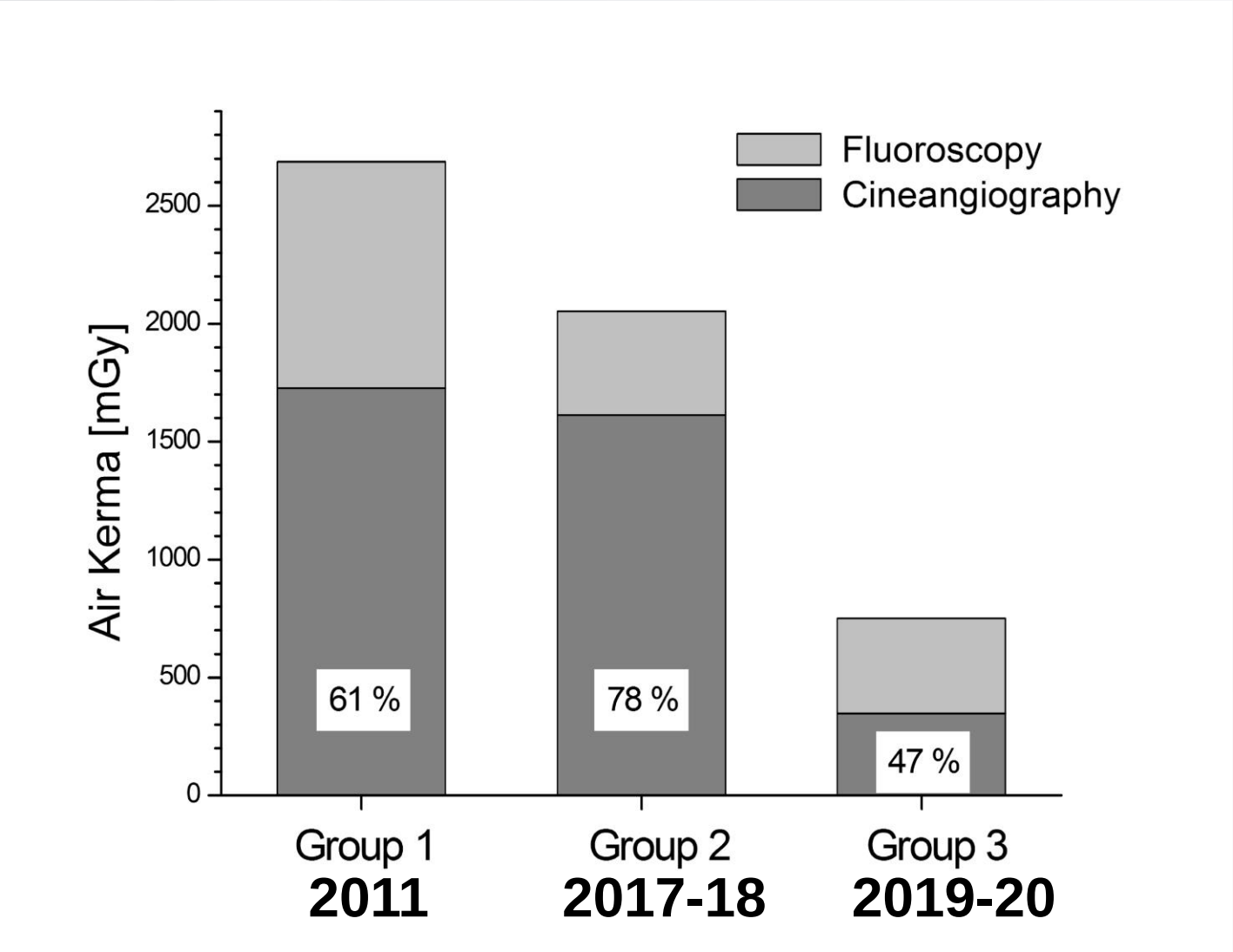
A comparison of noise-reduction protocols still so much operator dependent

	Balter [24]	2012–14	2012–14	Busse[27]	2013–14	Maccagni[29]		Present study	
Years	2012–14	14	14	2011	14	2016	2017	2018–19	2019
Number of patients	53	152	71	98	98	60	127	366	186
System	Philips FD10	FD20	FD20 clarity	Philips FD10	FD clarity	Philips FD10	FD10 clarity	Siemens Artis Zee	Modified protocol
Body mass index (kg/m^2)	30	30	28	28	28	27	28	29	29
Fluoroscopy time (min)	30[a]	32[a]	53[a]	18	16	44[a]	52[a]	33[a]	34[a]
Air kerma (mGy)	3410[a]	1930[a]	1760[a]	770[a]	459[a]	3256[a]	2853[a]	2040[a]	655[a]
Dose–area product (cGy/cm^2)	23500[a]	18000[a]	16900[a]	5350[a]	2640[a]	20350[a]	18900[a]	12719[a]	3704[a]
Dose rate index (mGy/min)	113	60	33	43	35	74	55	65[a]	20[a]
Efficiency index (min/Gy)	9.1	17.0	26.3	23.4	28.7	13.1[a]	17.5[a]	15.3[a]	50.1[a]

Dose Rate Index normalizes AirKerma per min Fluoroscopy time

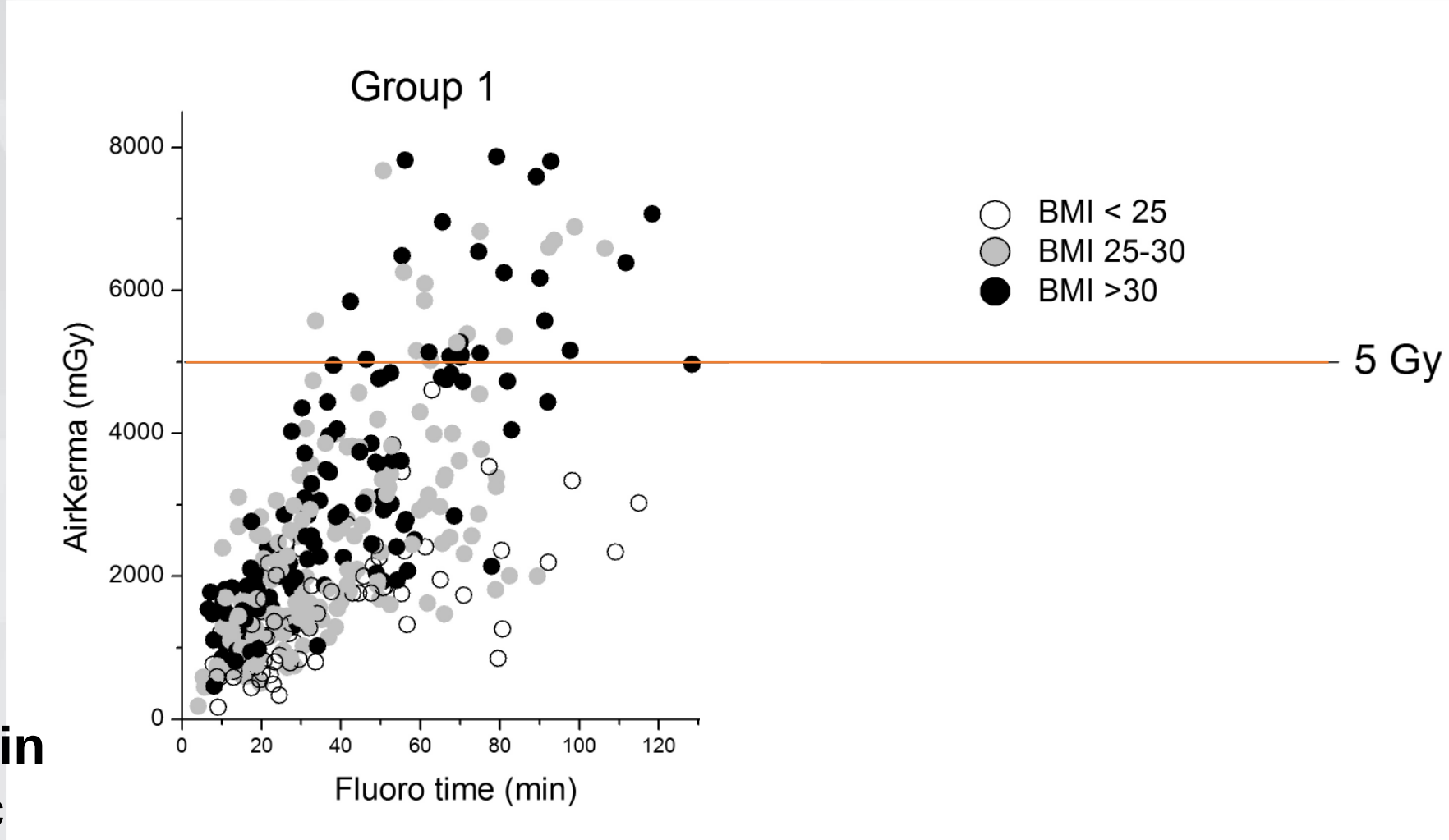
Werner et al Catheter Cardiovasc Interv. 2021;97:1196-206

What is radiation usually used for: Cine or Fluoro ?
Dramatic changes over time with the same equipment !!!



Werner et al Cardiovasc Revasc Med. 2022;36:58-64

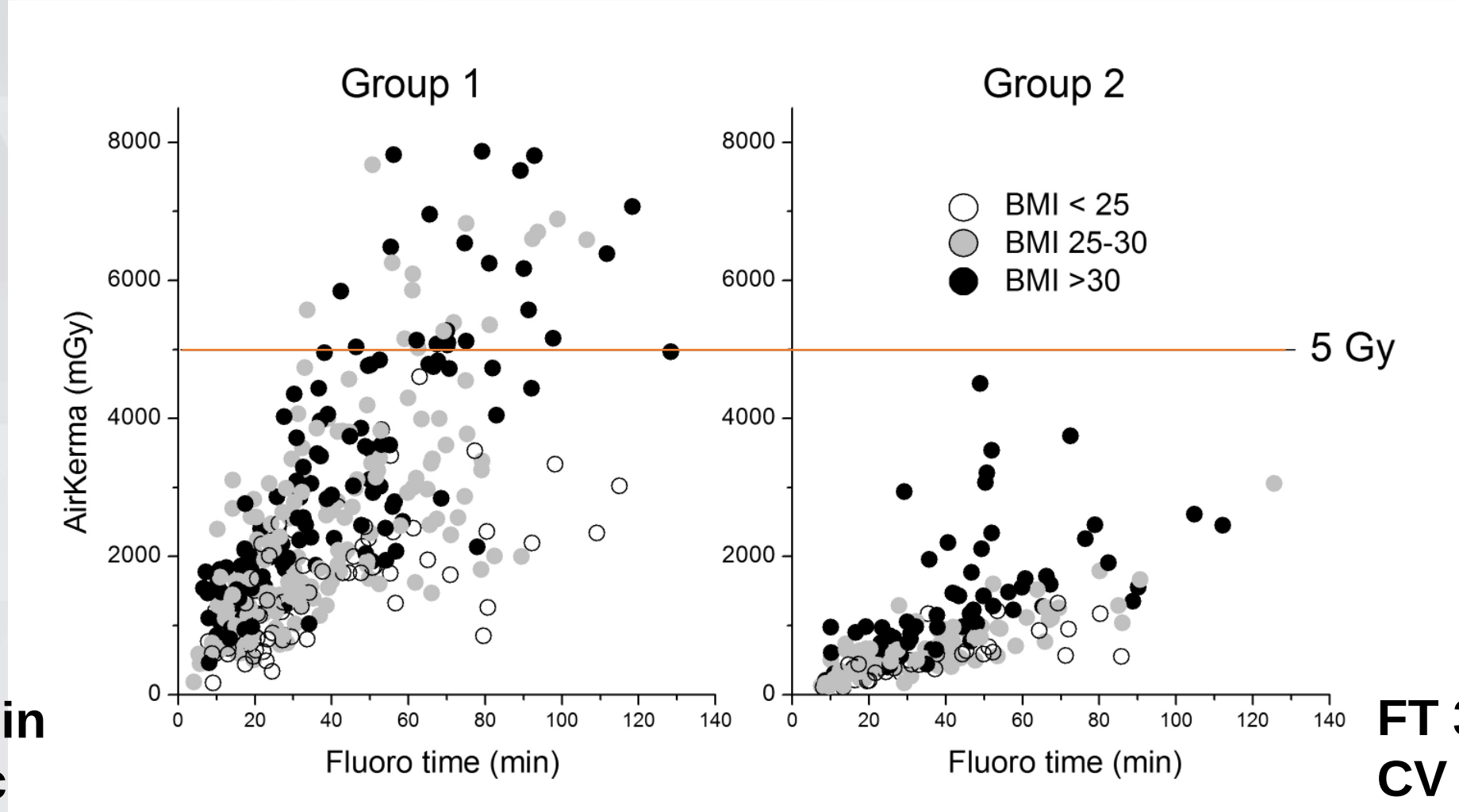
We exceeded the 5 Gy limit in 10.4 % of patents !



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

Werner et al Catheter Cardiovasc Interv. 2021;97:1196-206

Never exceed the 5 Gy limit ever again !!!



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

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

Werner et al Catheter Cardiovasc Interv. 2021;97:1196-206

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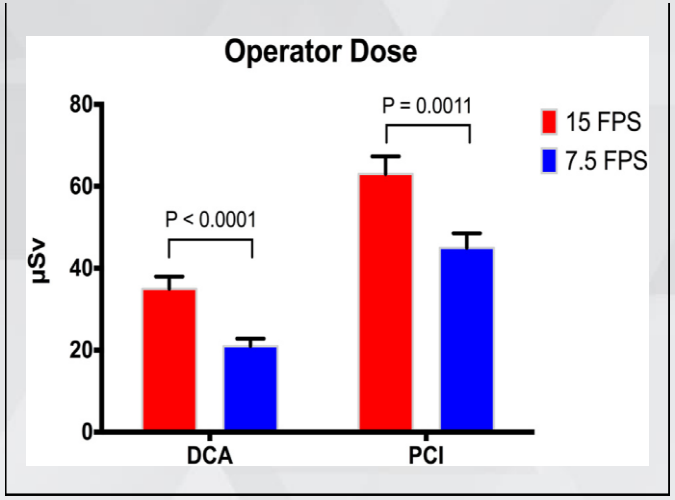
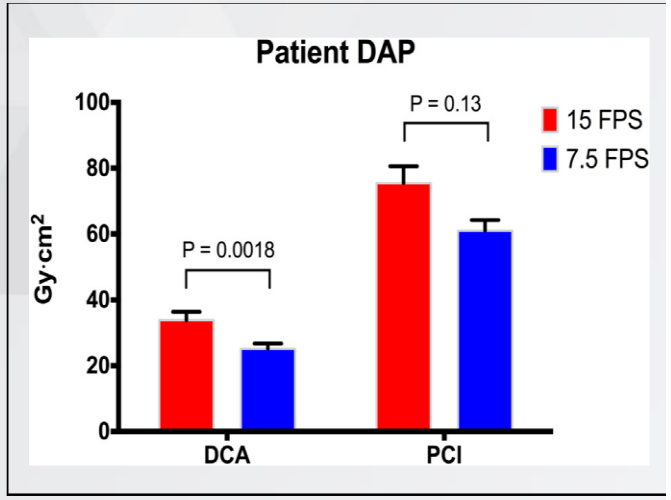
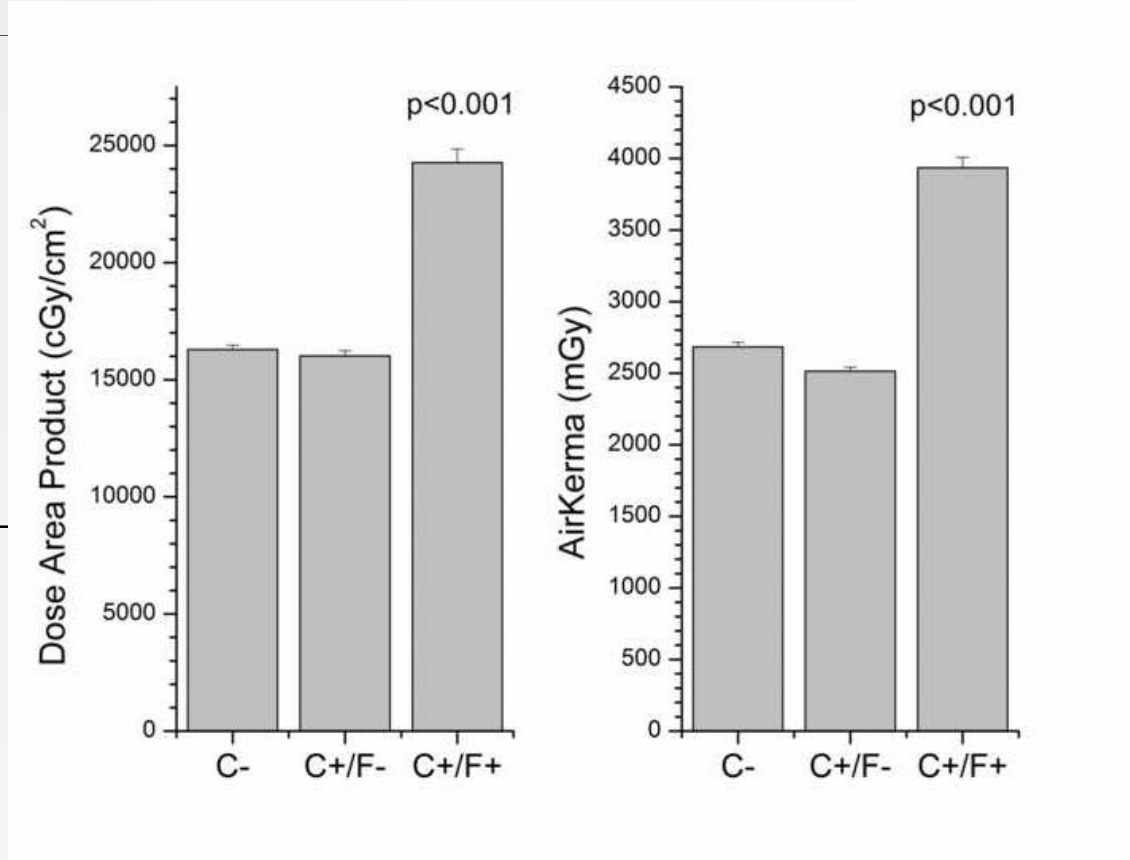
Lower fluoro frame rate 7.5 vs 15, but…







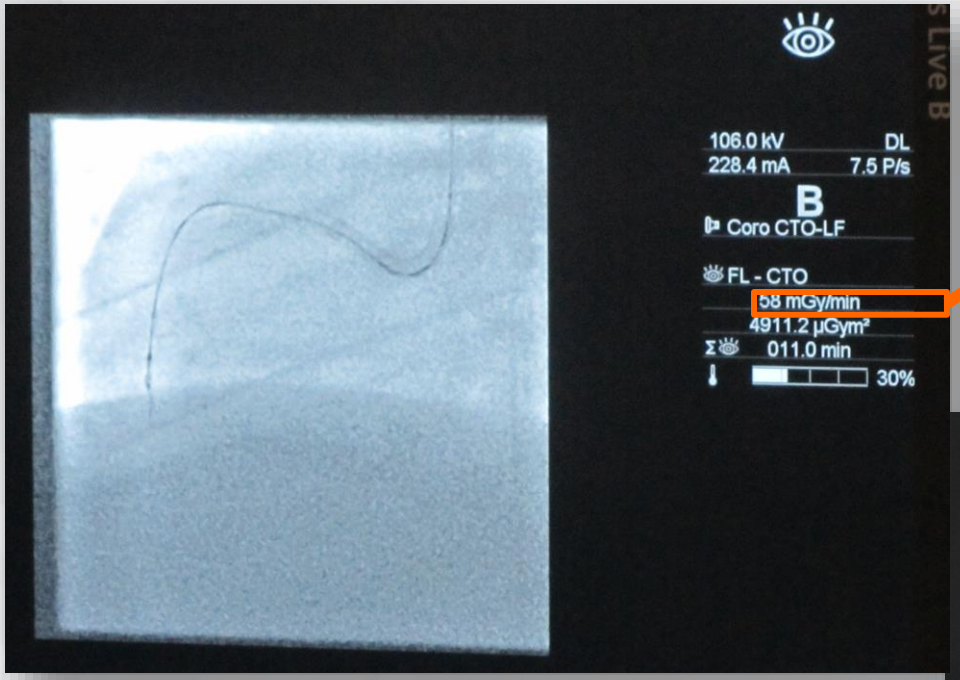
Why is there not more of a difference ?

- **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

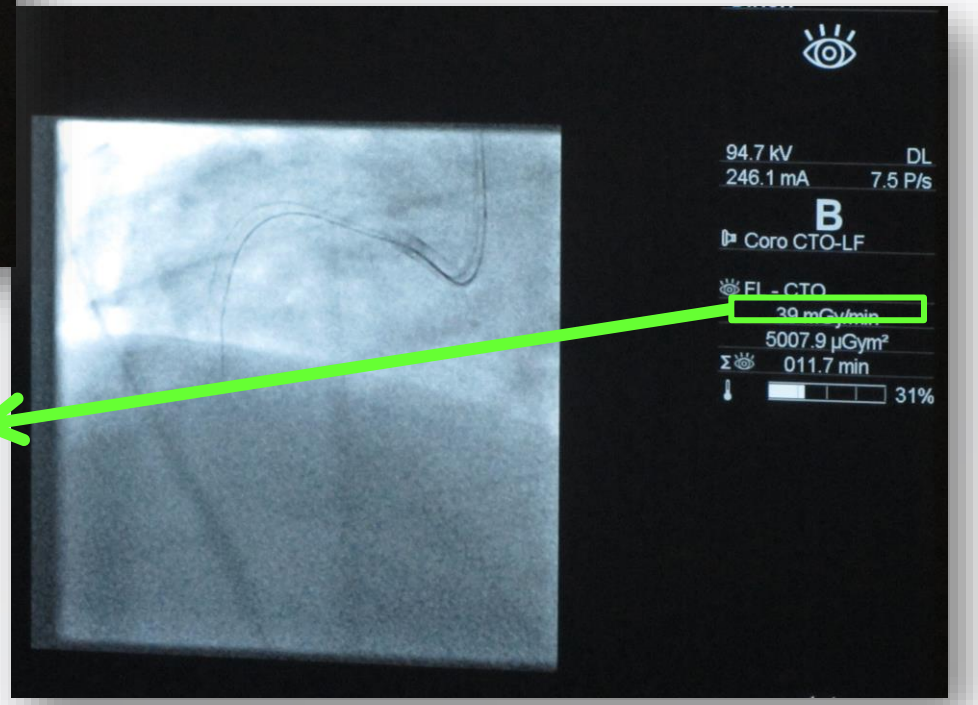
Abdelaal et al JACC Interv 2014; 7: 567– 74

Werner et al J Invasive Cardiol. 2021;33:E146-E54

Changing angulation influences dose



58 mGy/min
LAO 45°



39 mGy/min
LAO 30°

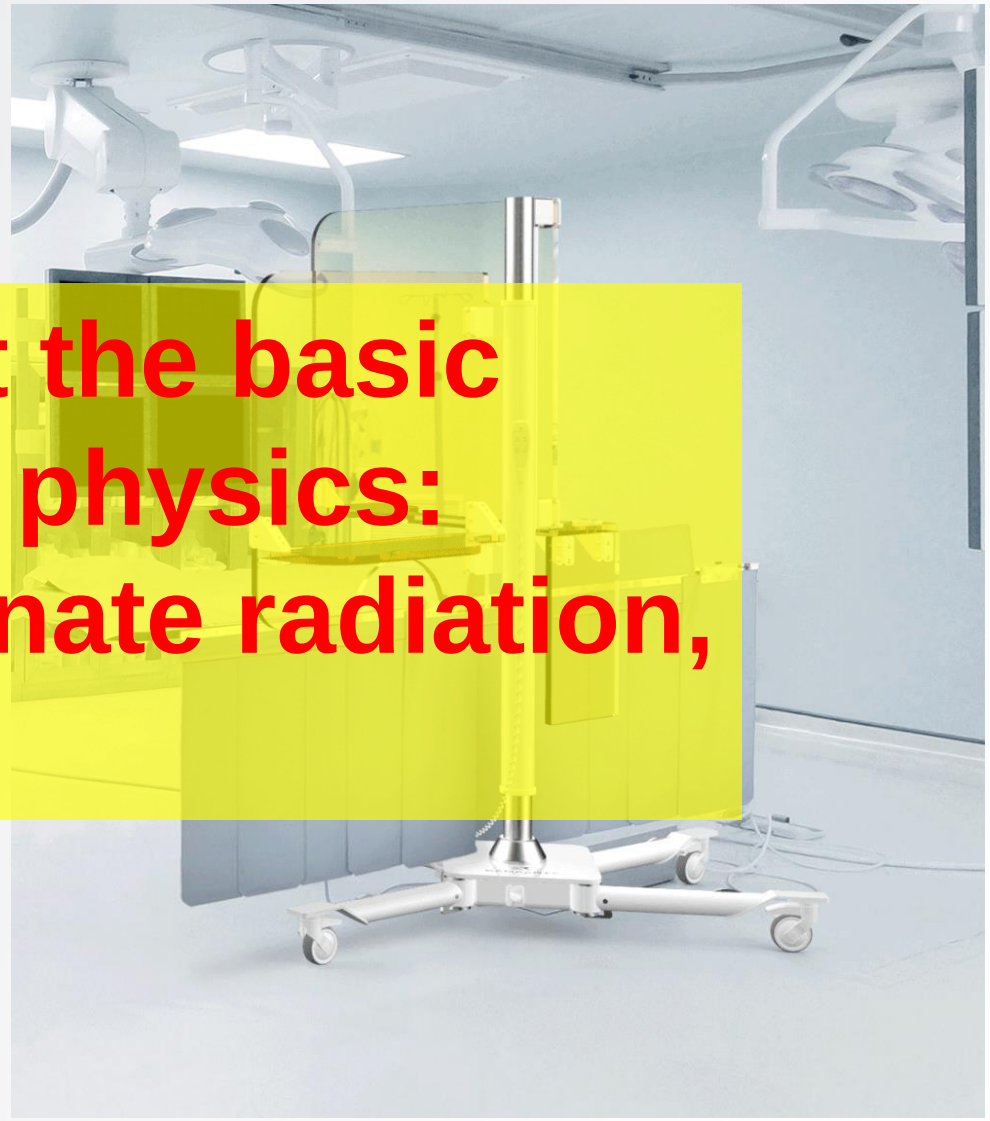
Radioprotection for the operator

RADPAD protection reduces scatter to operator:
Randomized study in 60 patients (40 CTOs)

Murphy JC, et al Am J Cardiology. 2011;108:1408-1410

There is never too much protection for the operator

But do not forget the basic rule of Radiation physics: you cannot eliminate radiation, only attenuate it.



Zero-Gravity

Rampart^{IC}

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 is no longer the reason for abandoning a procedure