
# Radiation exposure in the cath lab

## *safety* and *precautions*

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**Korea University Medical Center**

**“*Radiation*** **is one of those things that people *talk about***

**But**

***Never*** **really pay much *attention to*”**

# Fukushima Accident

## Magnitude 9.0 (2011.3.11)

**Japan : 11 mSv per hour radiation dose**

**IAEA : 400 mSv per hour radiation dose**

**(2011.3.15)**

***Sievert*** *:* The biological effect of ionizing radiation (SI unit)

# 진단 방사선 피폭량, 연간 한도 넘어

YTN 2014-01-22

CT 검사 등으로 방사선 피폭량은 늘어나는데 환자들에게는 피폭 기준조차 마련되지 않았다는 사실, YTN이 보도해드렸는데요.
연구해보니 우리 국민의 방사선 피폭량이 연간 한도를 넘어선 것으로 나타났습니다.

[인터뷰:석길칠, 심근경색 수술 환자 (80세)]
"병원에서 하라는 대로 하는 거죠. 시키는대로 하는 거지 뭐.
검사를 받아야 한다니까 하는 거죠. (CT 촬영) 2~3번 한 거죠."

최근 5년 동안 진단용 방사선 사용량을 분석했더니, 검사 건수가 35%나 늘었습니다.

엑스레이나 CT, 치과촬영 등을 합쳐 국민 한 사람이 1년에 4.6번이나 받았습니다.

1년 피폭량도 5년 전 0.9밀리시버트에서 1.4밀리시버트로 51%나 높아졌습니다.

일반인의 피폭량 한도인 1밀리시버트를 넘어선 것입니다.

특히 방사선을 가장 많이 발생하는 CT 촬영이 절반 이상을 차지합니다.

It’s a Serious Problem


It’s a Negligible Problem

# It's a Serious Problem

Radiation Induced *Cancer* Risk

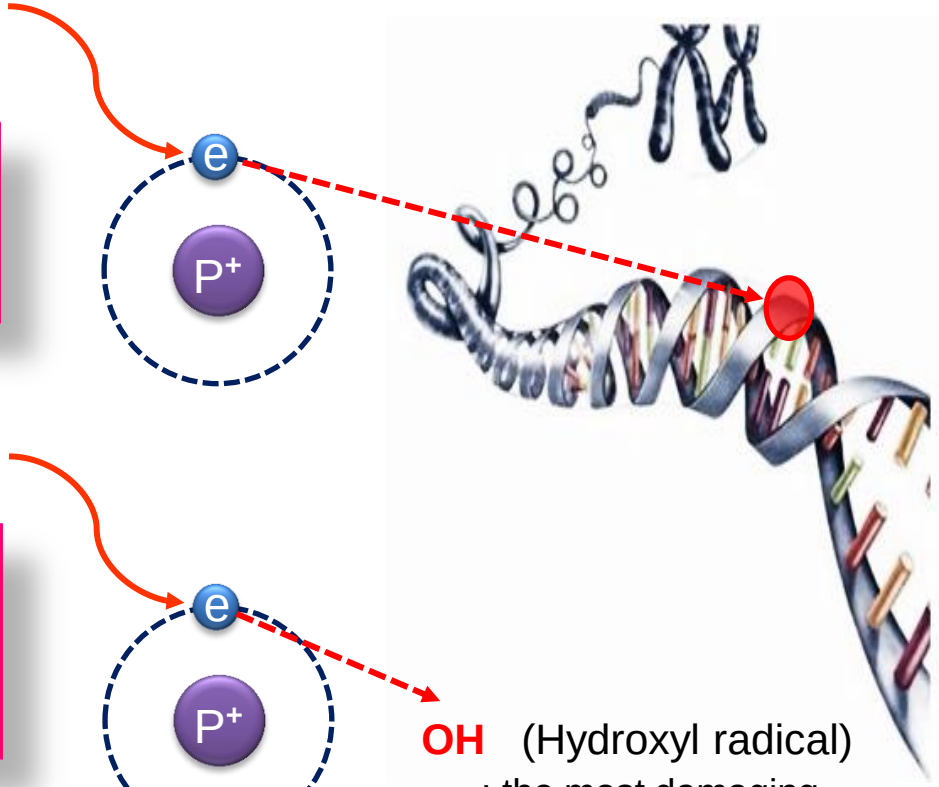
# Biologic effect of radiation

**Radiation** ⟶ **Cancer**

**Radiation** ⟶ **DNA damage(DSBs)** ⟶ **Cancer**

## Direct action : 25%

- Direction interact with target
- High LET




## Indirect action: 75%

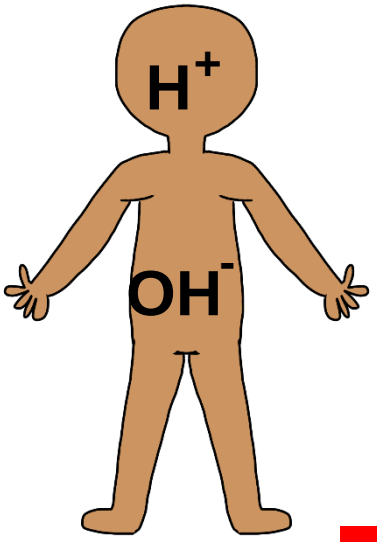
- Formation of reactive free radical-> DNA damage




**OH** (Hydroxyl radical)
: the most damaging
(⅔ of all effects)

*Radiobiology for the Radiologist, 6nd (2006)*

# Indirect Effect (Radiolysis)

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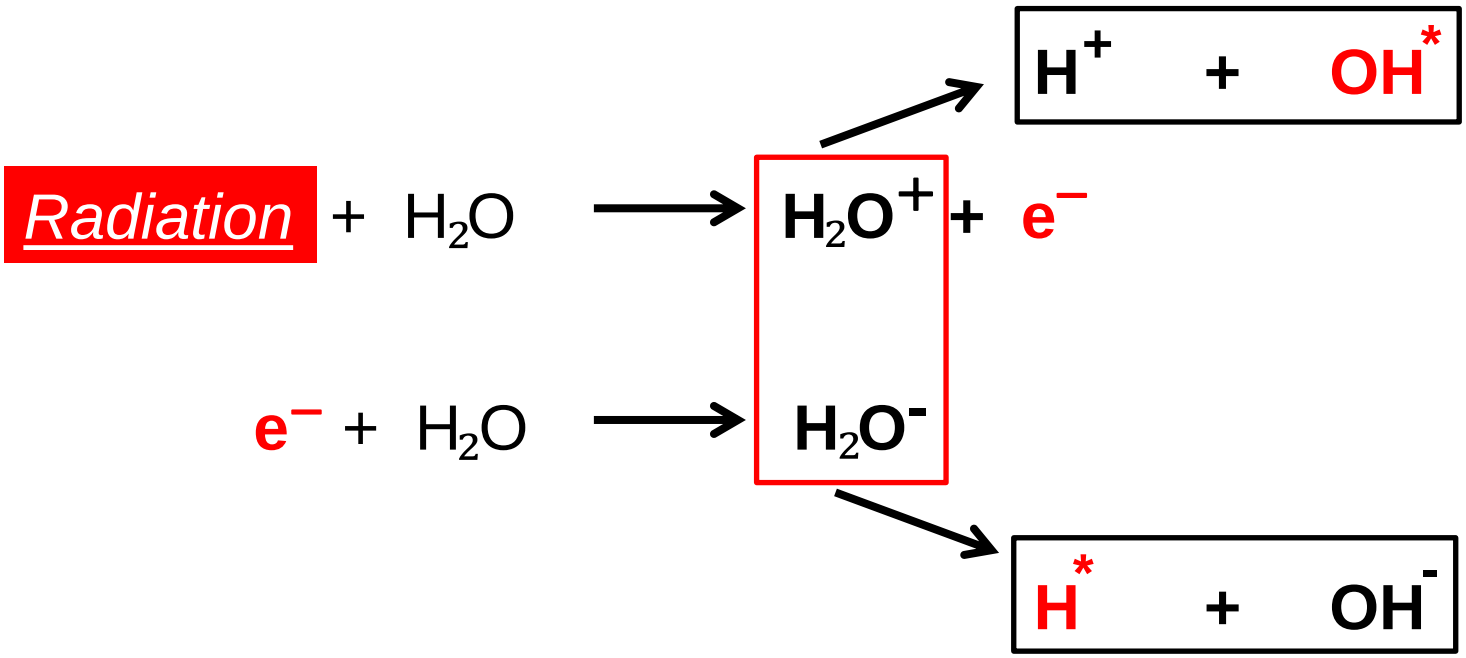
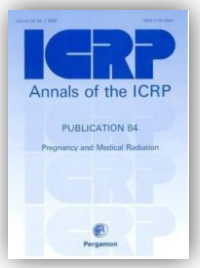


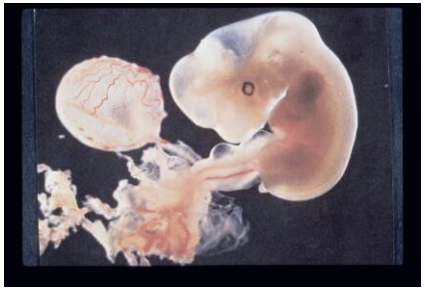

*Prog Nucl Acid Res Mol Bio 1988;35:95*
*Medical imaging and radiation protection p80*




# Fetal radiation risk

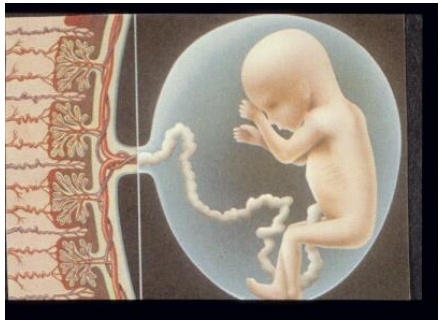
Radiation risks are most significant during organogenesis and in the early fetal period, somewhat less in the 2nd trimester, and least in the 3rd trimester

Most risk



Less

Least



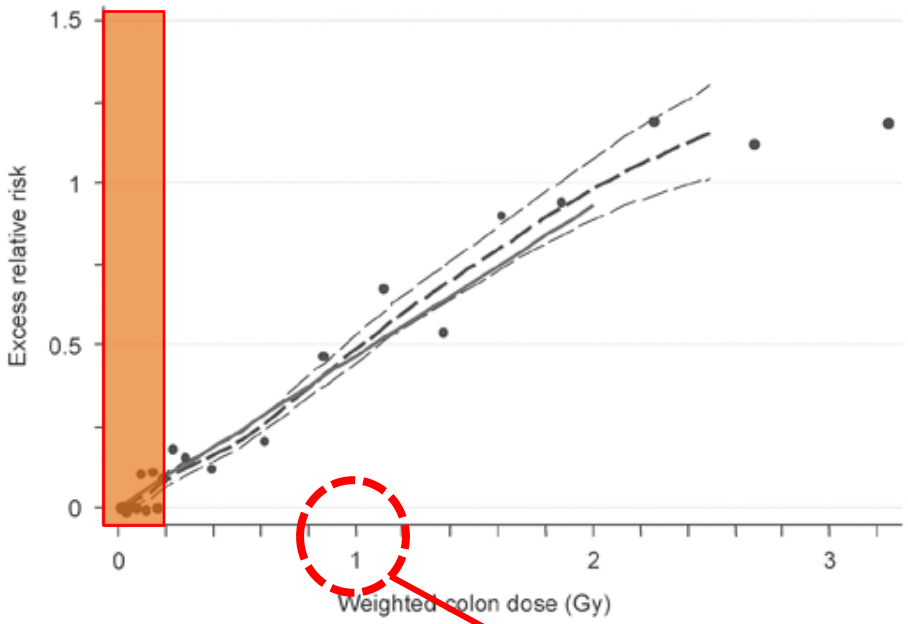
from ICRP 84, Pregnancy and radiation

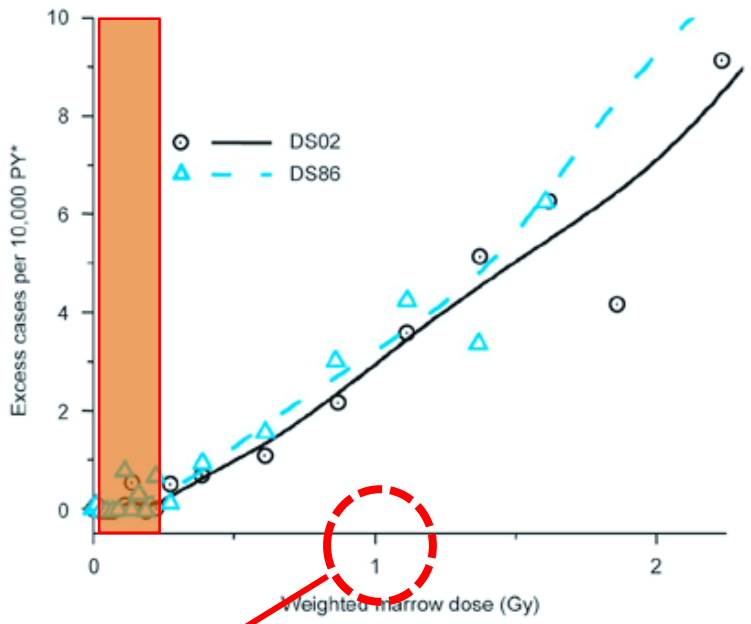
# It’s a Negligible Problem

Medical Exposure

# Excess risk of developing ***solid cancer*** in LSS

**Solid cancer risks among atomic-bomb survivors 1958-1998**



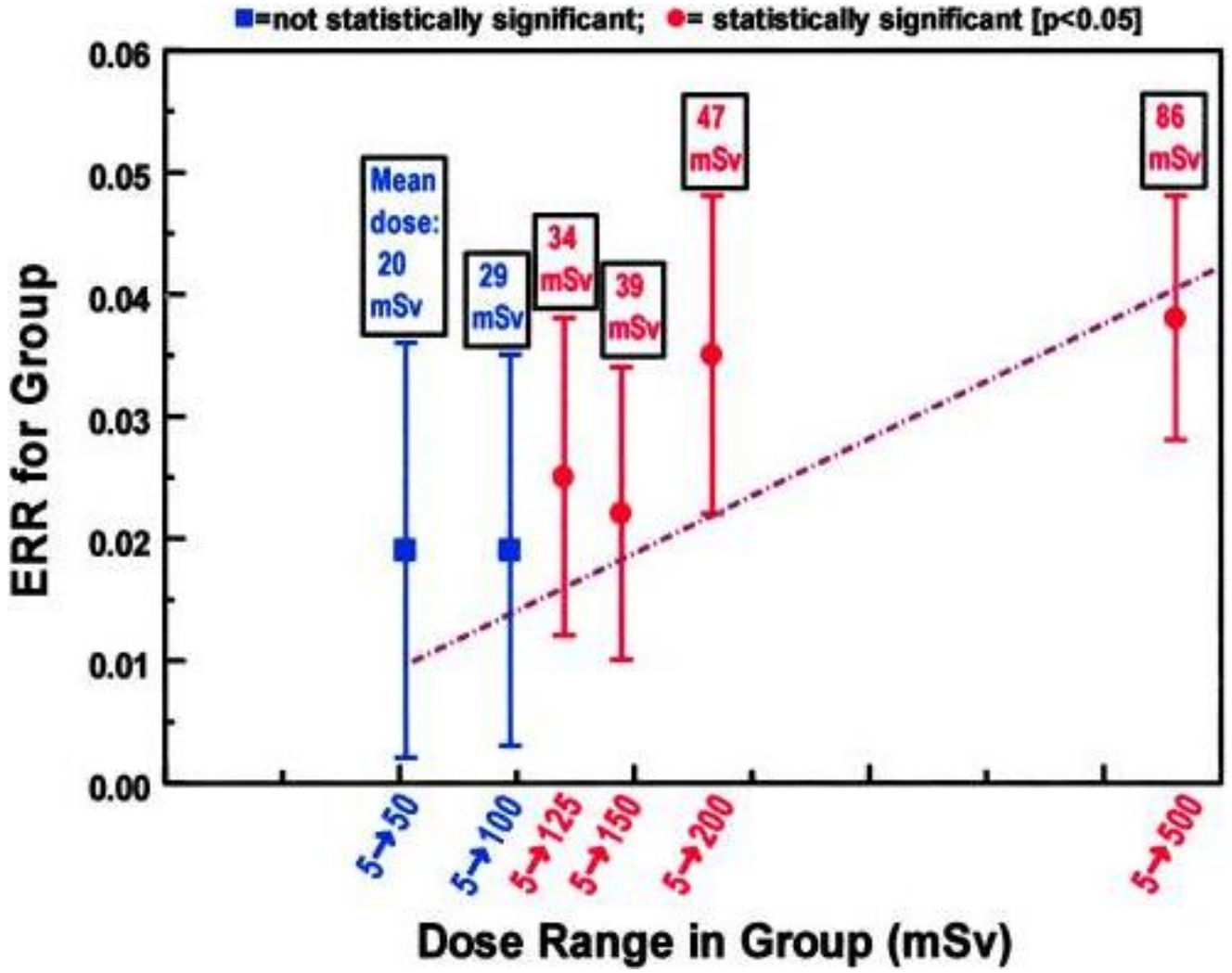




**Solid cancer**

**Leukemia**

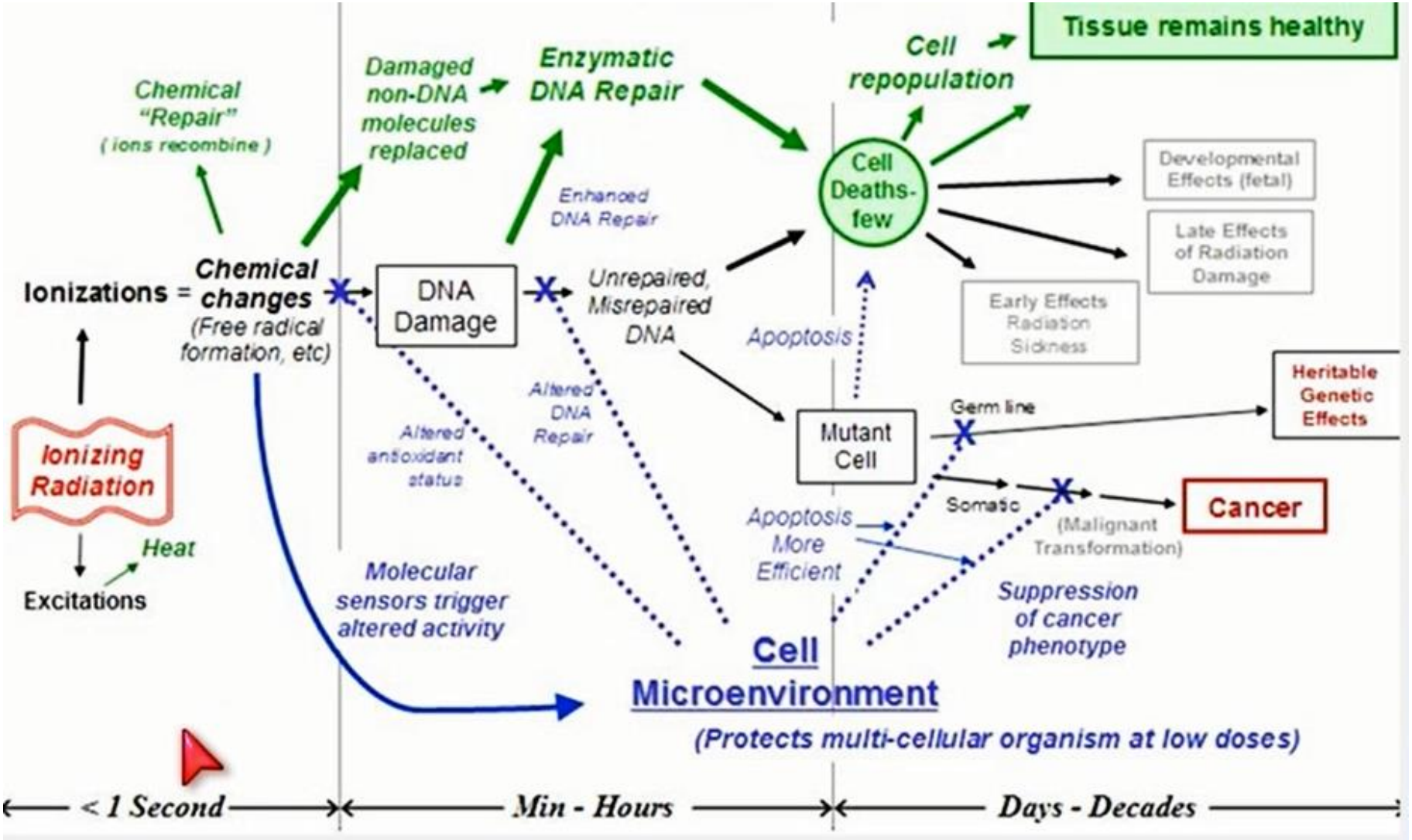
**1 Gy = 1000 mGy**

# Estimated excess relative risk of mortality from ***solid cancer*** in A-bomb survivor (< 500 mSv)

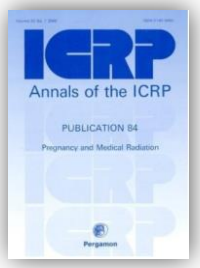



*Brenner et al.(2003) PNAS 100(24) :13761-13766*

# Classic Paradigm of Radiation Injury




*U.S. Department of Energy*




# Risks in a pregnant population *Not exposed* to radiation

## Risks:

| | |
|---|---|
| - Spontaneous abortion | > 15% |
| - Incidence of genetic abnormalities | 4-10% |
| - Intrauterine growth retardation | 4% |
| - Incidence of major malformation | 2-4% |

from ICRP 84, Pregnancy and radiation

# Probability of bearing healthy children as a function of radiation dose

| Dose to conceptus (mGy) above natural background | Probability of no malformation | Probability of no cancer (0-19 years) |
|---|---|---|
| 0 | 97 | 99.7 |
| 1 | 97 | 99.7 |
| 5 | 97 | 99.7 |
| 10 | 97 | 99.6 |
| 50 | 97 | 99.4 |
| 100 | 97 | 99.1 |
| >100 | Possible | Higher |

from ICRP 84, Pregnancy and radiation

# It’s a Negligible Problem

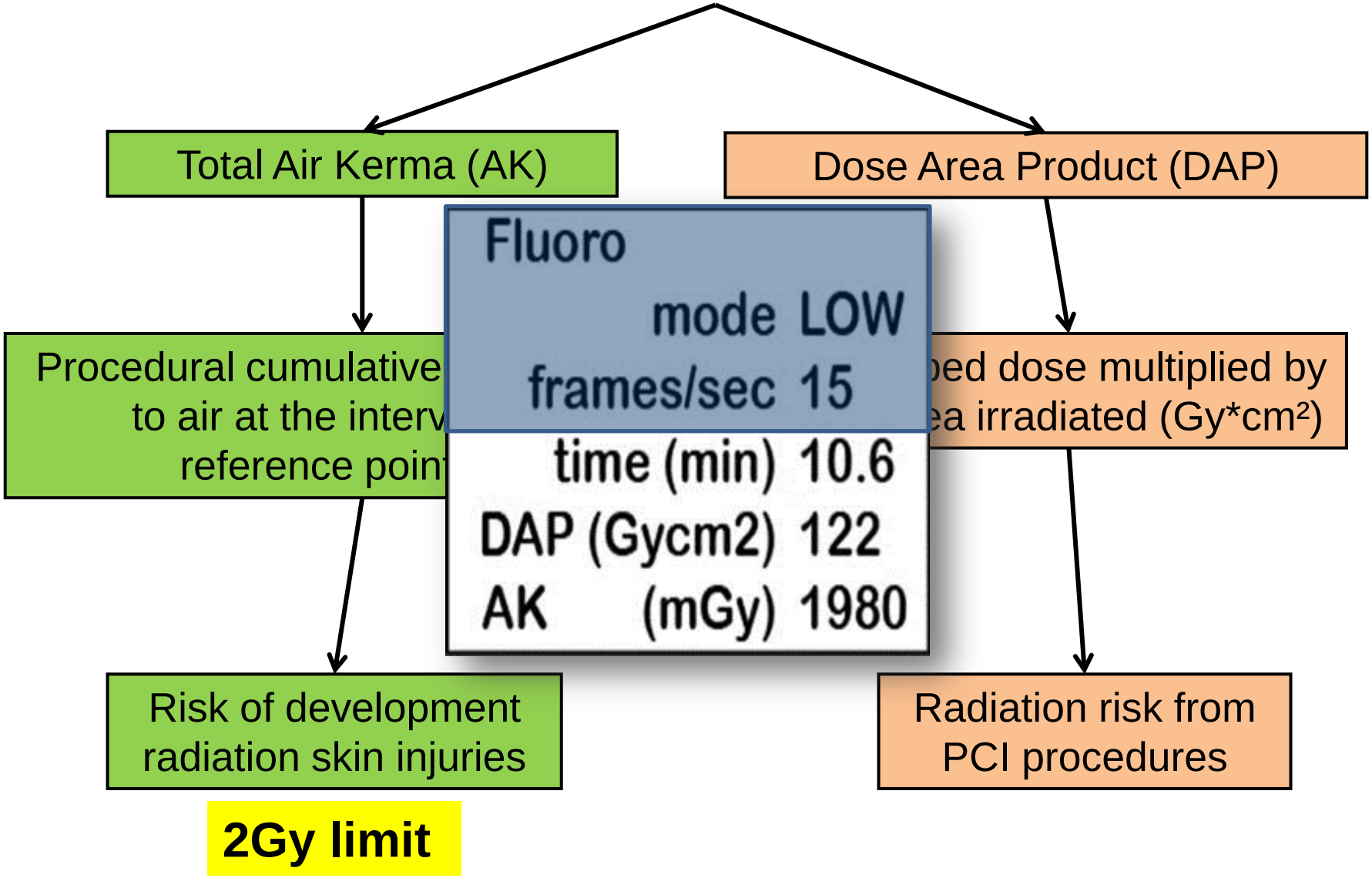

# Benefit vs Risk

Negligible

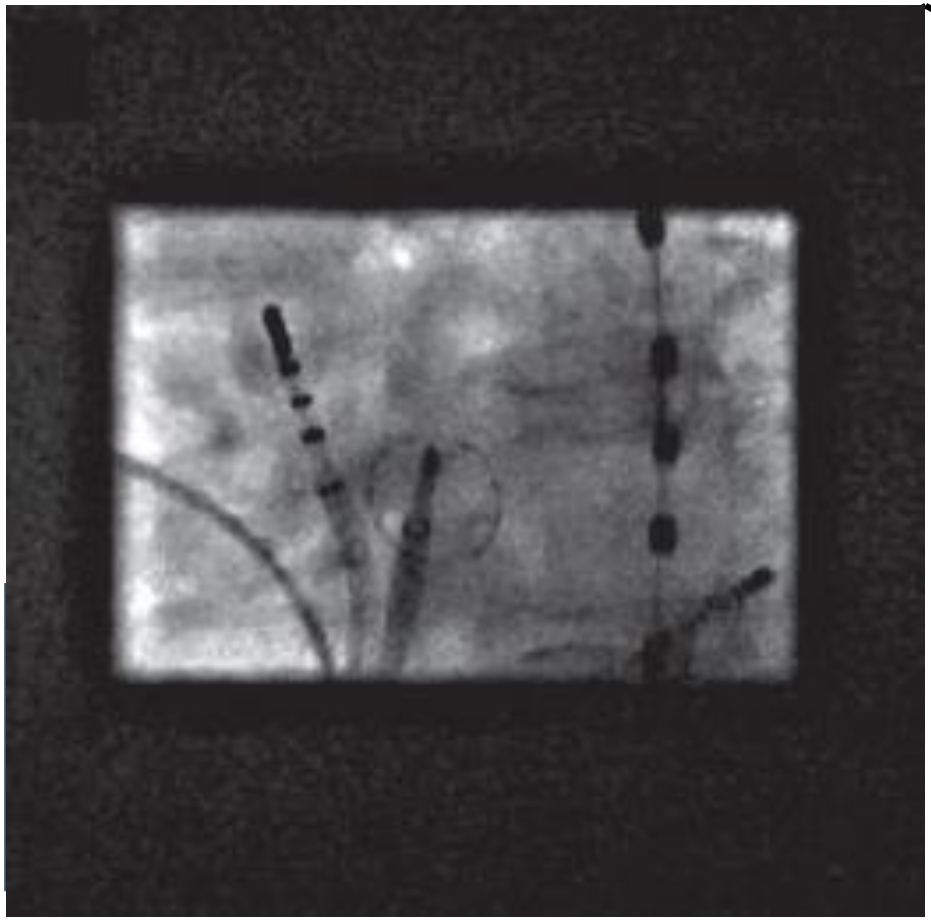


Serious

# Two standard parameters to evaluate pt X-ray exposure during PCI



# X-ray tube operation time



….. need to minimize fluoroscopy time
but mainly the number of cine images

# Practical ways to reduce radiation dose for **patients & staff** during **Device implantations** and **Electrophysiological procedures**

| Type of study | Dose to patient mSv median and range |
|---|---|
| Diagnostic EP study | 3.2<br>1.3–23.9 |
| Ablation procedure | 15.2<br>1.6–59.6 |
| AF | 16.6<br>6.6–59.6 |
| AT – AVNRT – AVRT | 4.4<br>1.6–25 |
| VT | 12.5<br>3–≥45 |
| VVI/DDD PM or ICD implant | 4<br>1.4–17 |
| CRT implant | 22<br>2.2–95 |
| Coronary angiography | 7<br>2.0–16 |
| Percutaneous coronary intervention | 15<br>7–57 |

*Europace (2014) 16, 946–964 doi:10.1093*

# EP Procedure time

(AF, AFL, PSVT, PVC, VT……)

ex) **AF**

Cumulative fluoroscopy time: 132min

DAP (fluoroscopy) : 183,695 mGycm$^2$

DAP (exposure) : 10,861 mGycm$^2$

Total DAP :194 Gy.cm2 * 0.2 = 39mSv

Cumulative Air Kerma : 1,320 mGy


# PCI Procedure time

(Simple PCI,CTO,PTA……)

ex) **CTO**

Cumulative fluoroscopy time: 119min

DAP (fluoroscopy) : 294,821 mGycm$^2$

DAP (exposure) : 258,437 mGycm$^2$

Total DAP :553 Gy.cm2 * 0.2 = 111mSv

Cumulative Air Kerma : 7,391 mGy


mSv = DAP (Gy. cm2) ×0.20

*Radiation Protection Report 154*

# Fluoroscopically Guided Interventional Procedures: A Review of Radiation Effects on Patients' Skin and Hair[1]

**Table 2**

**General Advice to Be Provided to Patients and Treating Physicians**

| Band | Skin Dose Range (Gy) | Advice to Patient |
|---|---|---|
| A1 | 0–2 | No need to inform patient, because there should be no reports skin changes, then treat in response to the signs and symptoms |
| A2 | 2–5 | Advise patient that erythema may be observed Advise patient to call you if skin changes cause physical discomfort |
| B | 5–10 | Advise patient to perform self-examination or ask a partner to examine for skin effects from about 2 to 10 weeks after the procedure; tell patient where skin effects would most likely occu patient should call radiologist's off conservatively; might advise pati other treating physician and to in due to radiation; radiologist should also provide that physician with medical details of where the radiation-related skin effects are likely to occur |
| C | 10–15 | Medical follow-up is appropriate; advice is same as that for band B but also advise dermatologist or other treatin prolonged due to radiation dose and and monitoring of wound progression mat be required; pain could become a concern if doses were in the higher range of this band |
| D | >15 | Medical follow-up is essential, nature and frequency of which depending on estimated radiation dose; advice is same treating physician that the wound could progress to ulceration or necrosis |

No need to inform patient

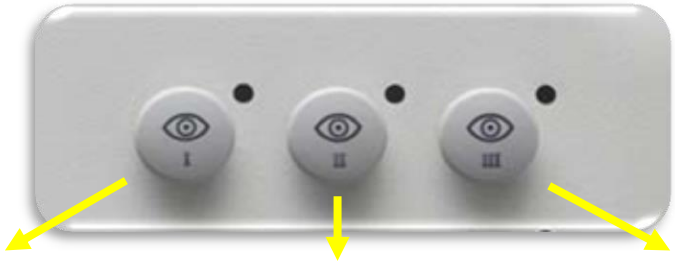
Advise patient that erythema

self-examination or ask a partner

2 to 10 weeks after the procedure

Medical follow-up is appropriate

Medical follow-up is essential



| Philips FD 10 Default Setting | Fluoro flavor 1(Low) | Fluoro flavor 2 (Normal) | Fluoro flavor 3 (High) |
|---|---|---|---|
| Pulsed Fluoro Frame speed | 15 | 15 | 30 |
| Dose rate limitation (microGy/s) | 697 | 1395 | 1395 |
| Focus | Smalllest | Smalllest | Smalllest |
| Spectral Filter CU | 0.4 | 0.1 | 0.1 |
| Spectral Filter Al | 1 | 1 | 1 |

| 현재 FD 10 (#1) Setting **CAG** | Fluoro flavor 1(Low) | Fluoro flavor 2(Normal) | Fluoro flavor 3(High) |
|---|---|---|---|
| Frame speed | 7.5 | 15 | 15 |
| Dose rate limitation (microGy/s) | 349 | 697 | 1395 |
| Focus | Smalllest | Smalllest | Smalllest |
| Spectral Filter CU | 0.9 | 0.4 | 0.1 |
| Spectral Filter Al | 1 | 1 | 1 |

| (#3 EP) Setting = Philips FD 10 EP Default **EP** | Fluoro flavor 1(Low) | Fluoro flavor 2(Normal) | Fluoro flavor 3(High) |
|---|---|---|---|
| Frame speed | 7.5 | 15 | 15 |
| Dose rate limitation (microGy/s) | 140 | 349 | 697 |
| Focus | Smalllest | Smalllest | Smalllest |
| Spectral Filter CU | 0.9 | 0.9 | 0.4 |
| Spectral Filter Al | 1 | 1 | 1 |

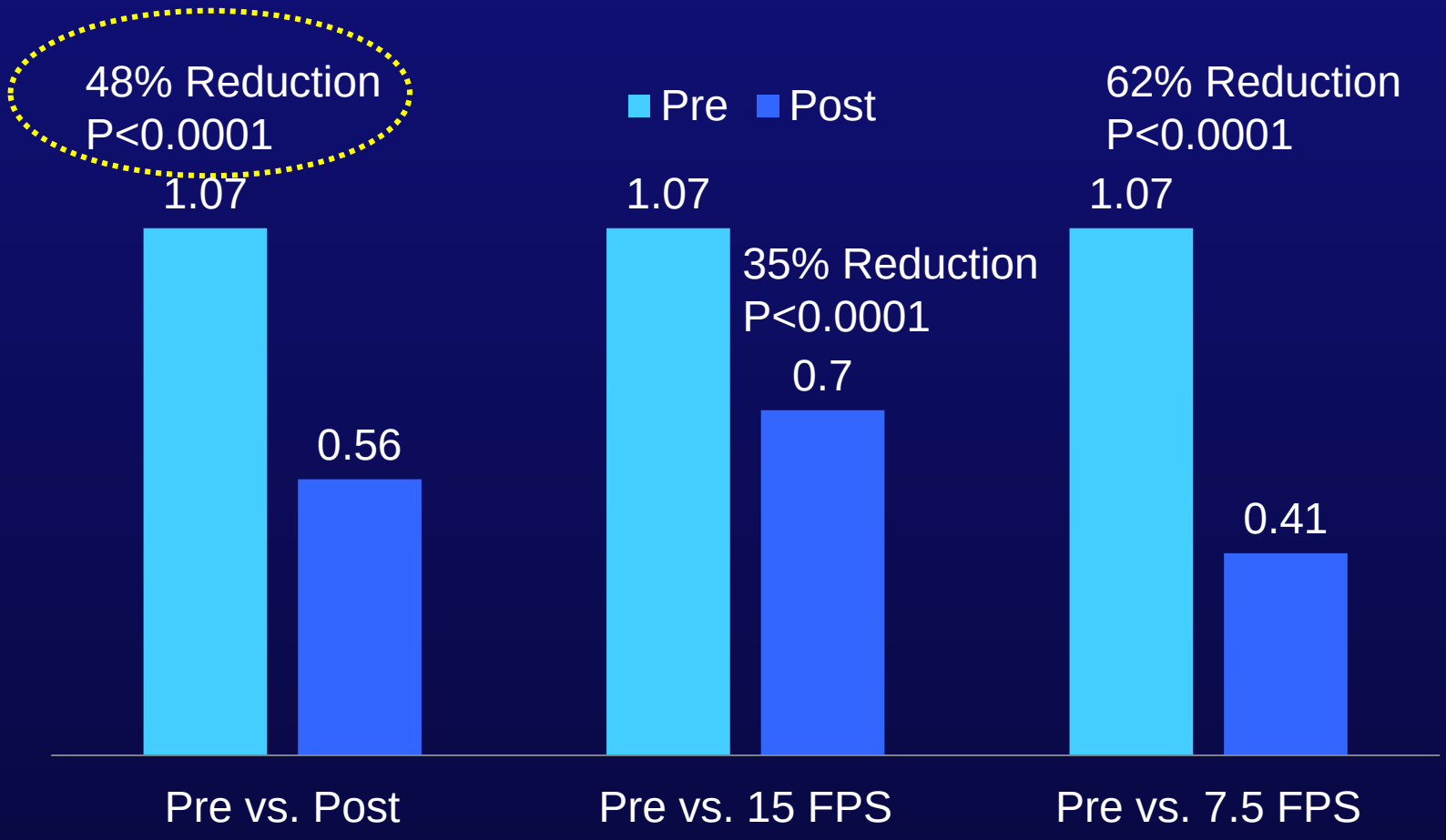
# New Equipment can reduce Dose

- Before and after study, Phillips Allura (n=605)
- Algorithms to reduce dose include:

- ✓ Reduces *Detector dose* rate
- ✓ Increased *thickness of filters*
- ✓ Automatically uses *lowest dose* possible based on patient
- ✓ Reduce FPS from 15 to *7.5 FPS*

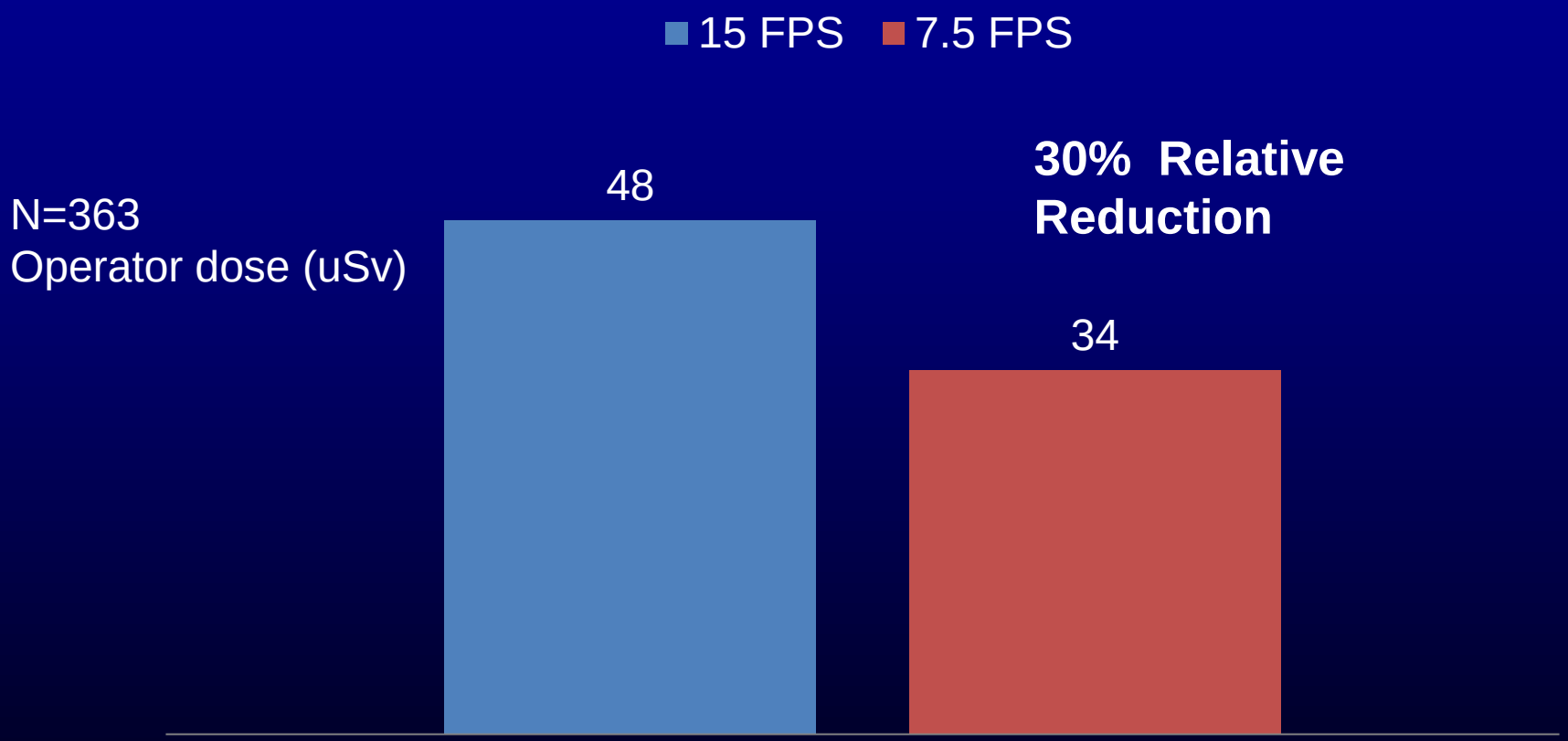
*Wassef AW, et al. JACC Interv. 2014;7:550-7.*

# Radiation Dose Reduction in the Cardiac Cath Lab Utilizing a Novel Protocol

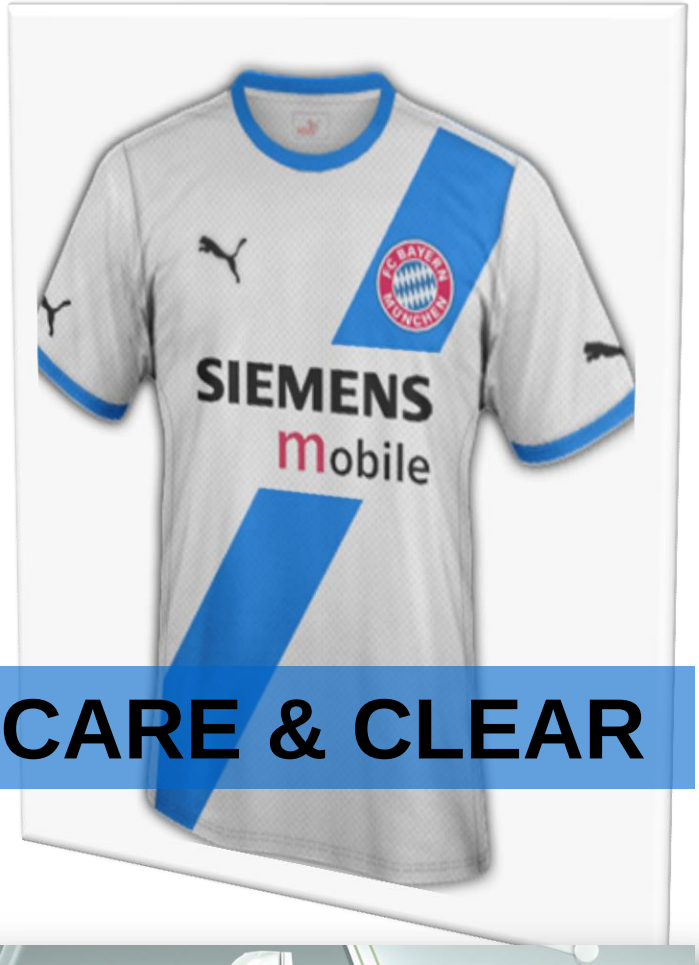



*Wassef AW, et al. JACC Interv. 2014;7:550-7.*

# Randomized Trial of 15 FPS vs. 7.5 FPS for Fluoro



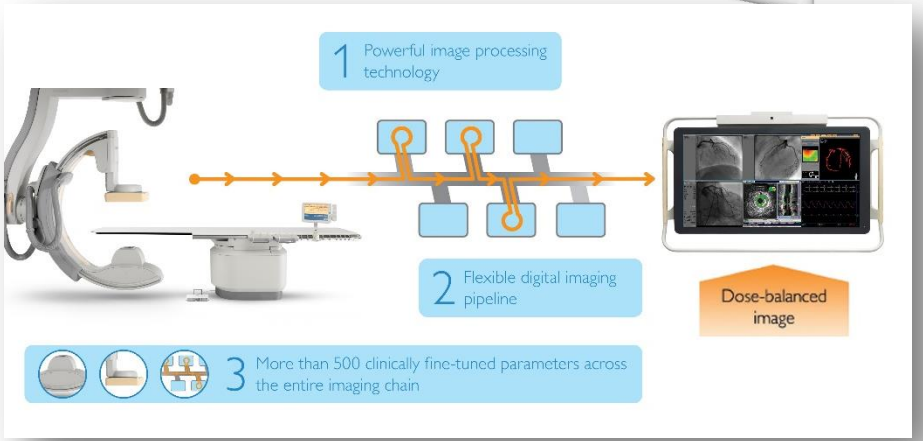

*Abdelaal E, et al. JACC interv. 2014;7:567-74.*




VS


# CARE & CLEAR

# Allura Clarity

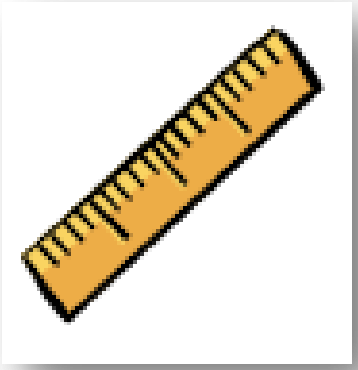


# TIME

**Minimize time**

**DAP/AK**

# Distance



**Patient - Table**

**Staff - Maximize**

# Shield


**0.5 mm**

**(90~95% protection)**

Europace (2014) 16, 946–964
doi:10.1093/europace/eut409



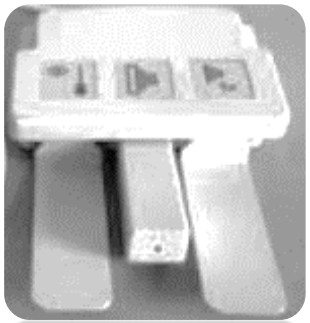
# Practical ways to reduce radiation dose for patients and staff during device implantations and electrophysiological procedures

Hein Heidbuchel[1]*, Fred H.M. Wittkampf[2], Eliseo Vano[3], Sabine Ernst[4], Richard Schilling[5], Eugenio Picano[6], and Lluis Mont[7]

| | | Lower doses | Higher doses |
|---|---|---|---|
| Operator-dependent | Operator background | Expert | Beginner |
| | Training with simulators | Yes | No |
| | Awareness | Radiation aware | Radiation unaware |
| | Written report | Includes KAP/DAP | Omits KAP/DAP |
| | Projection | RAO | AP or LAO |
| | Pulsed fluoroscopy | Low rate (≤6 fps) | High rate (>12.5 fps) |
| | Cine duration | Short | Long |
| | Cine substitution by stored fluoroscopy | Yes | No |
| | Fluoroscopy during catheter withdrawal | No | Yes |
| | Collimation | Optimized, and adapted | Wide open, and fixed throughout the procedure |
| | Pelvic radiation | Avoided | During introduction and removal of the catheters |
| | Anaesthesiologists/AP | Allowed to halt the procedure | Also exposed when in close proximity |
| Patient-dependent | Body habitus | Lean | Obese |
| | Arrhythmic lesion to be ablated | Supraventricular tachycardia | Atrial fibrillation or VT |
| Technology-dependent | X-ray system | Tuned for the EP, inspected for QC and maintained | No specific EP settings, not tested, not maintained |
| | Combination with CT (pre-procedural/rotational) | No | Yes |
| | Non-fluoroscopic mapping systems | Yes (Ensite; Carto; Mediguide; . . .) | No |
| | Shielding | Above and below the table; cabin | Minimal, only above the table |

*Europace (2014) 16, 946–964*

# “Heavy Foot” Syndrome



Do Not step on fluoroscopy pedal
when not looking at screen

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# Benefit versus Risk

Benefit

Remember

Controlling dose to ***patient*** will help control dose to ***staff***


# Thank you for your time!

KU MC

The Korean Society of Cardiology