The Science of CARES: Communicating Advances in Radiation Education for Shielding

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No Conflicts of Interest

POLICY NUMBER	POLICY NAME	POLICY DATE	SUNSET DATE
PP 32-A	AAPM Position Statement on the Use of Patient Gonadal and Fetal Shielding	4/2/2019	12/31/2024
Policy source			
April 2-3, 2019 Board of Directors Meeting Minutes			
Policy text			
Patient gonadal and fetal shielding during X-ray based diagnostic imaging should be discontinued as routine practice.			

Guidance on using shielding on patients for diagnostic radiology applications

March 2020

BIR The British Institute of Radiology

IPEM Institute of Physics and Engineering in Medicine

Public Health England

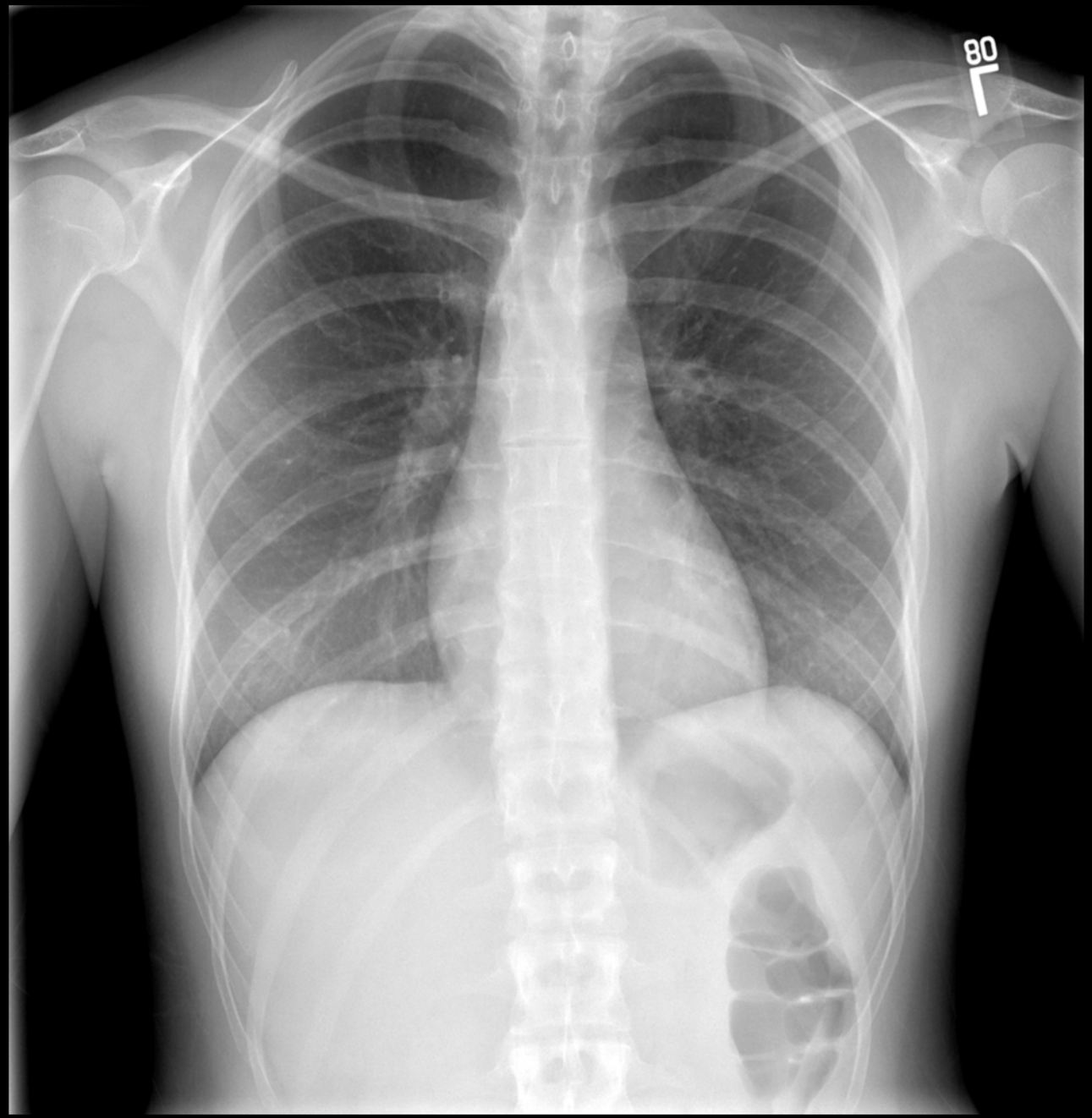
SCoR The Society & College of Radiographers

RCR The Royal College of Radiologists

S R P

https://www.bir.org.uk/media/416143/final_patient_shielding_guidance.r1.pdf

- Why was patient shielding introduced?
- Does shielding patients still make sense?
  - Benefits
  - Risks
- Current & Continuing Work



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1953 1976 2019

SOME POTENTIAL HAZARDS OF THE USE OF ROENTGEN RAYS IN PEDIATRICS

By ROBERT W. MILLER, M.D.

Food and Drug Administration
[21 CFR Part 1000]
[Docket No. 75N-0148]
SPECIFIC AREA GONAD SHIELDING

Radiology articles advocate shielding patients' gonads

21CFR 1000.5

PP 32-A

1953

Radiology articles advocate shielding patients' gonads

1976

21CFR 1000.5

2019

PP 32-A

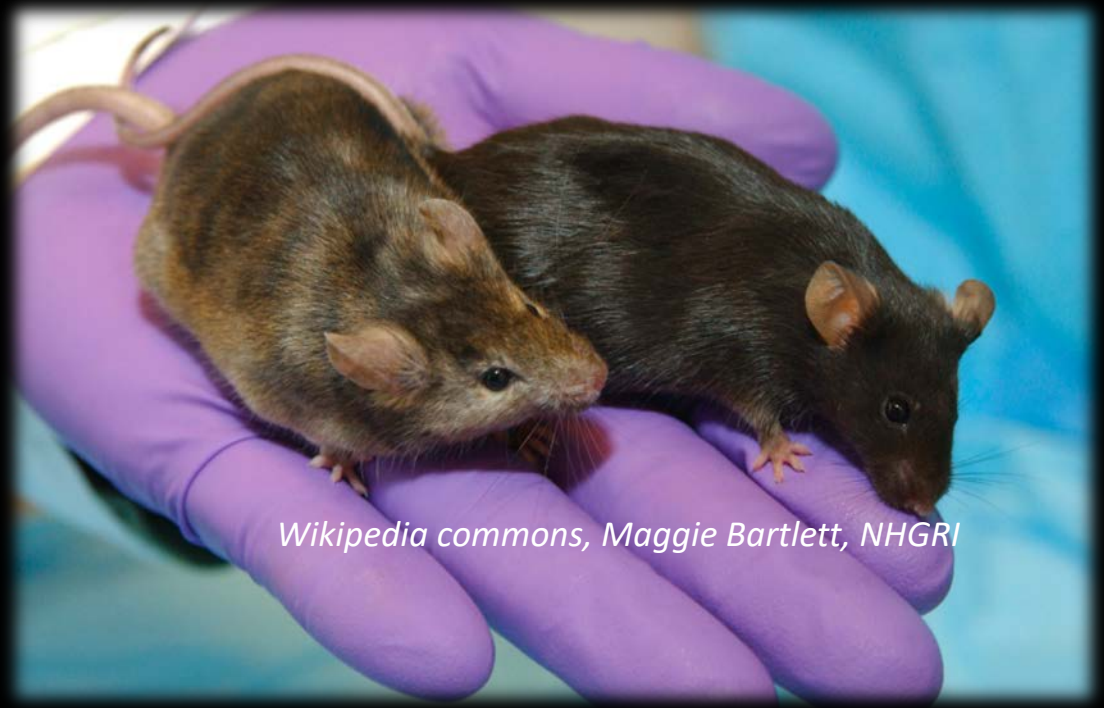
1953

Hereditary Effects & Fertility

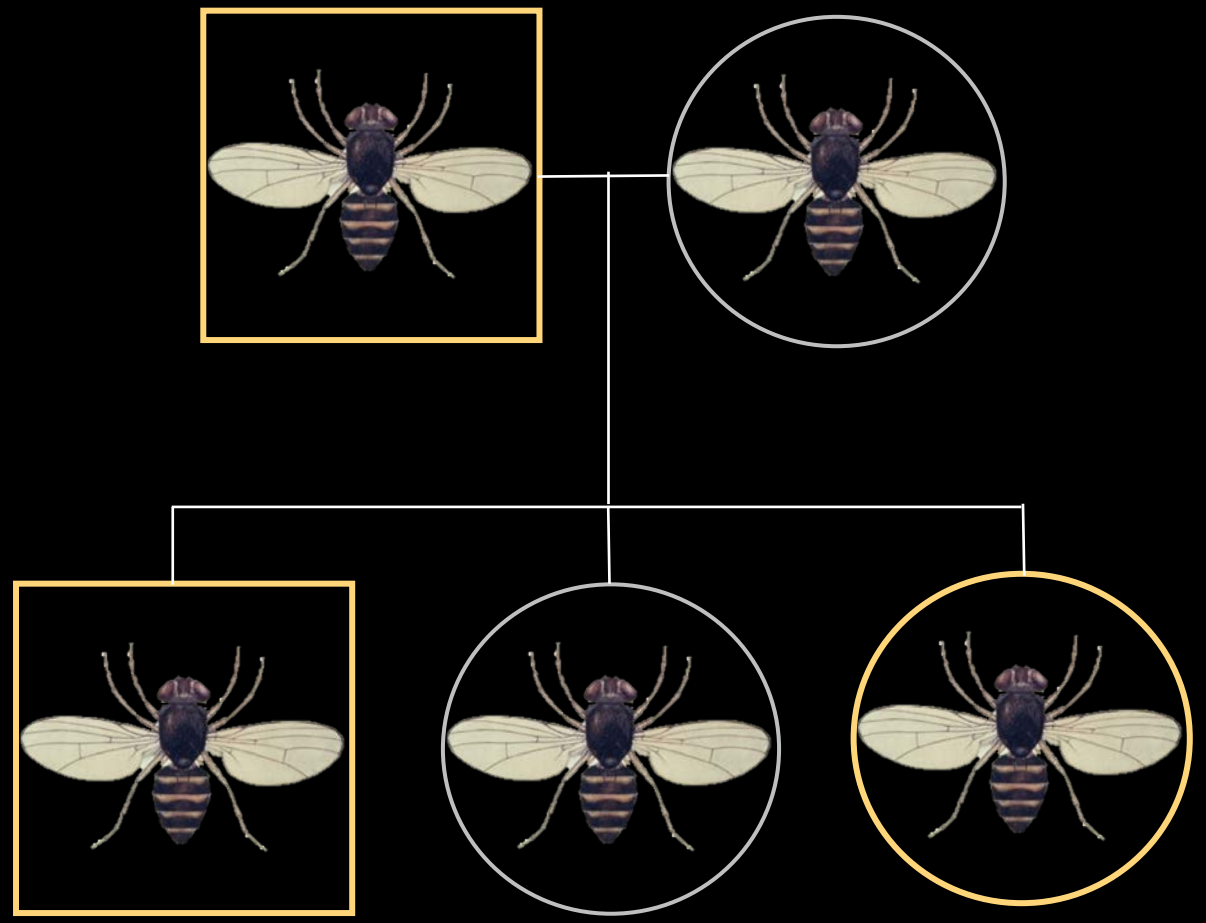
Fetal Harm

Cancer Risk

Hereditary Effects



Wikipedia commons, Maggie Bartlett, NHGRI



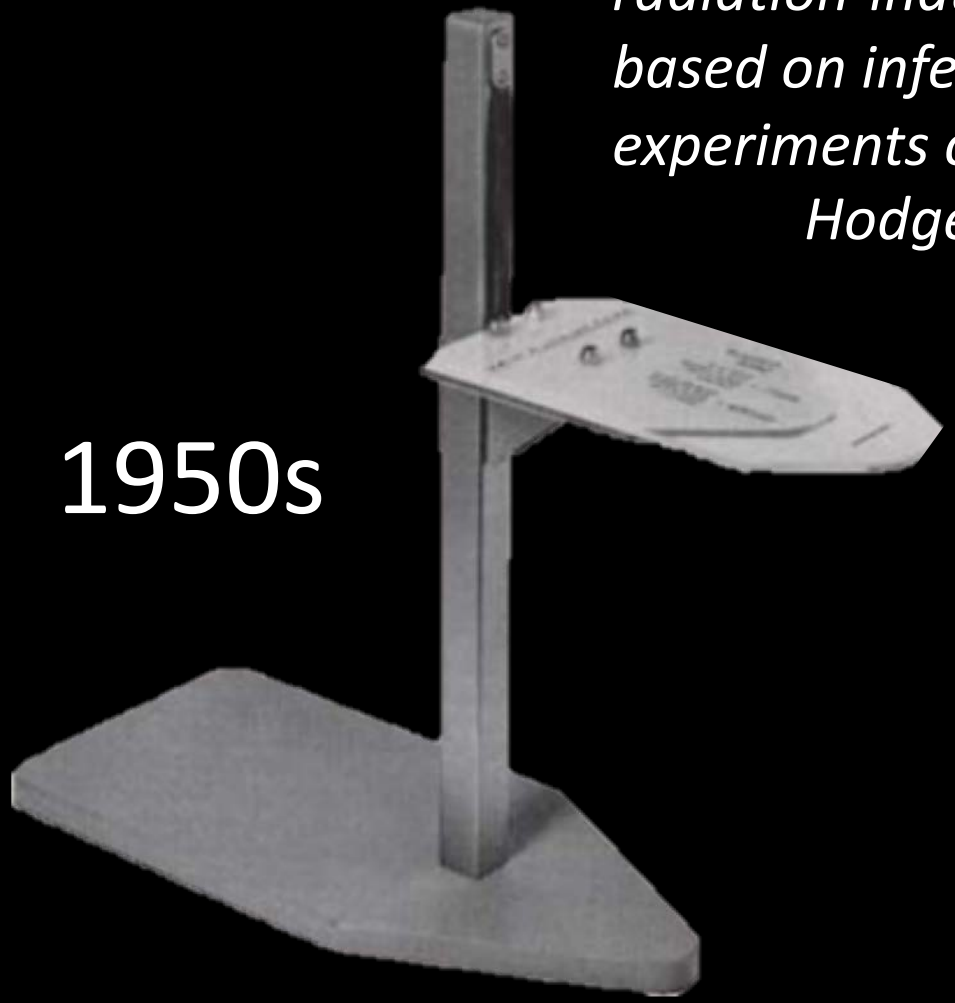
1920s-1930s

Fertility

1900s

Hereditary Effects

1950s



”Without exception, all estimates of the existence, nature, and magnitude of radiation-induced genetic changes are based on inferences from high-level experiments on animals…”

Hodges (1959) Radiology

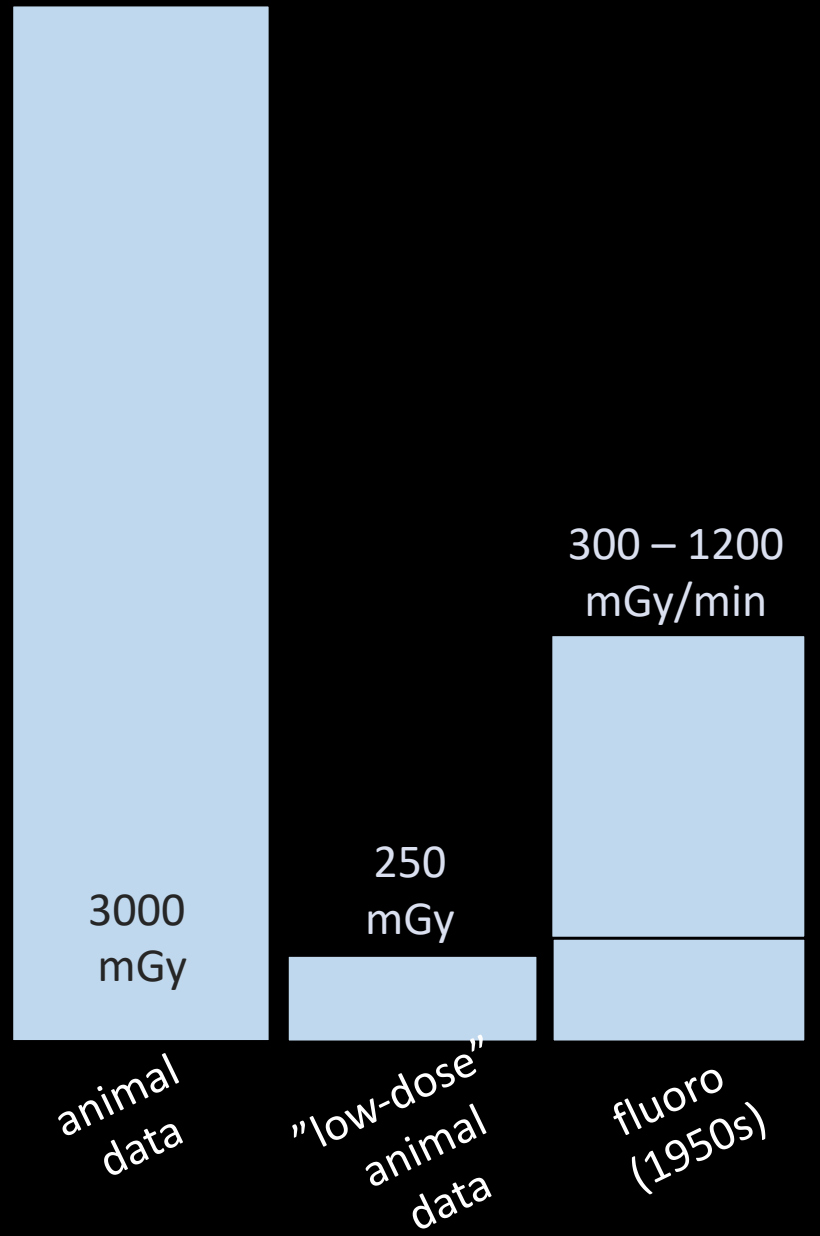
Hodges (1959) Radiology 72(4)

Fetal Harm

Newborn Mice

Radiation Exposure (3 Gy)

No Exposure



Russell & Russell (1952) Radiology 58(3)

Fetal Harm

Science article:

"It is not possible at the present time to estimate with any assurance the effect upon biometrical characteristics of any given level of irradiation on human populations."

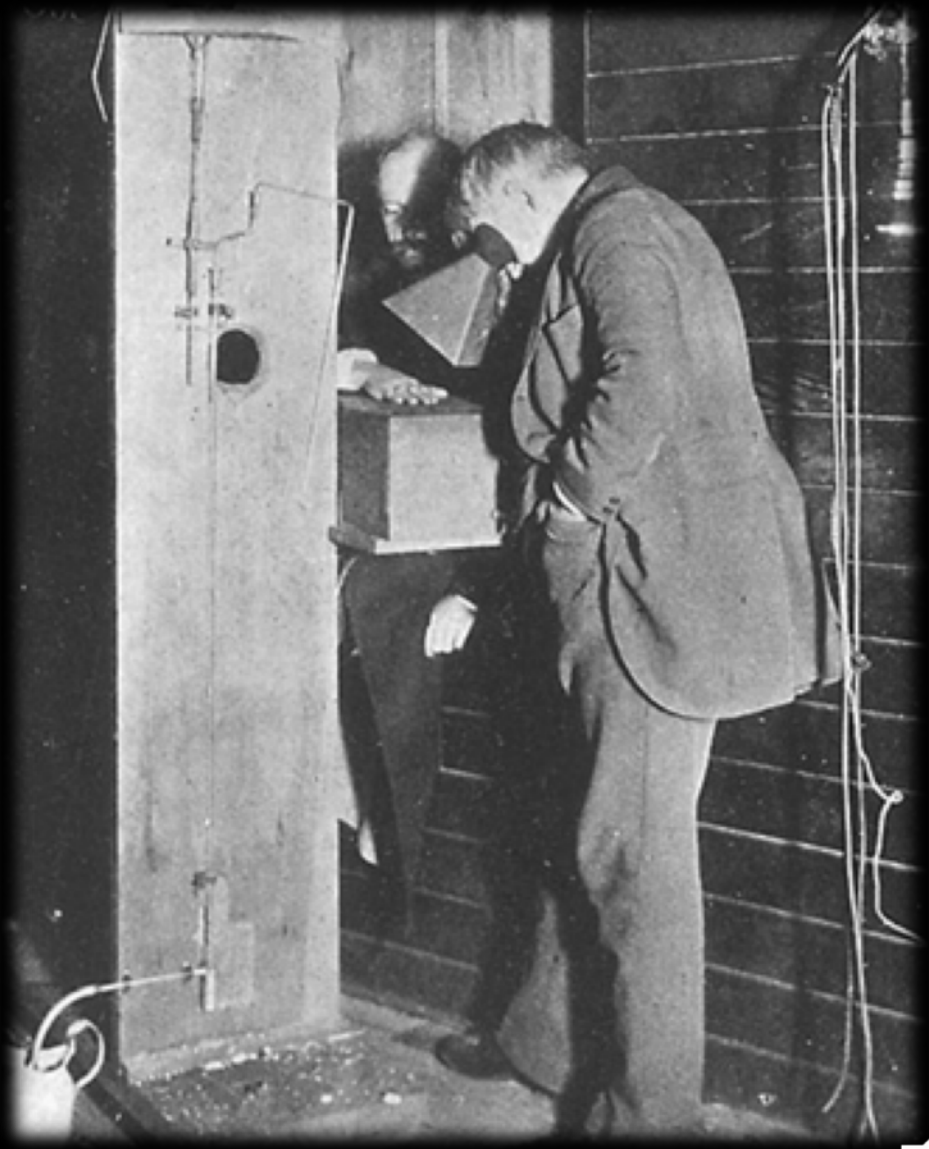
Times magazine:

"Last week…Dr. Howard J. Curtis reported evidence that a single modern fluoroscopic examination of a woman's pelvis will shorten her child's life by 2 weeks.

Hodges (1959) Radiology 72(4)

Cancer Risk

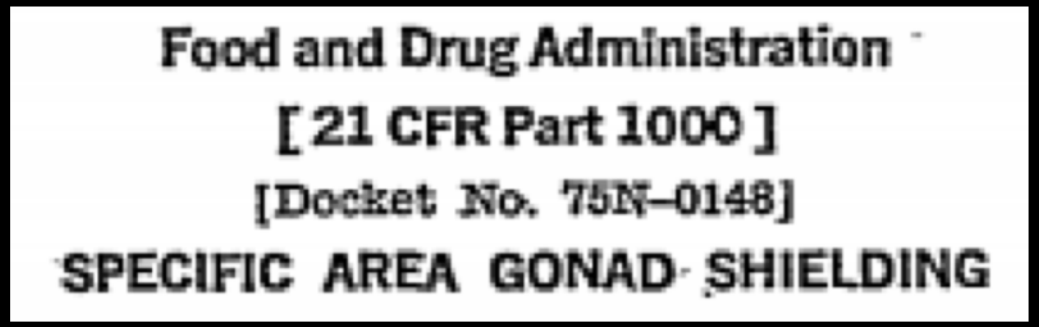
1900s




1945 +

1976

1976


Food and Drug Administration

[21 CFR Part 1000]

[Docket No. 75N-0148]

SPECIFIC AREA GONAD SHIELDING

"It…protects the germinal tissue of patients from radiation exposure that may cause genetic mutations..."

"Gonadal shielding should only be used when the clinical objectives of the exam will not be compromised."

1976

Food and Drug Administration

[21 CFR Part 1000]

[Docket No. 75N–0148]

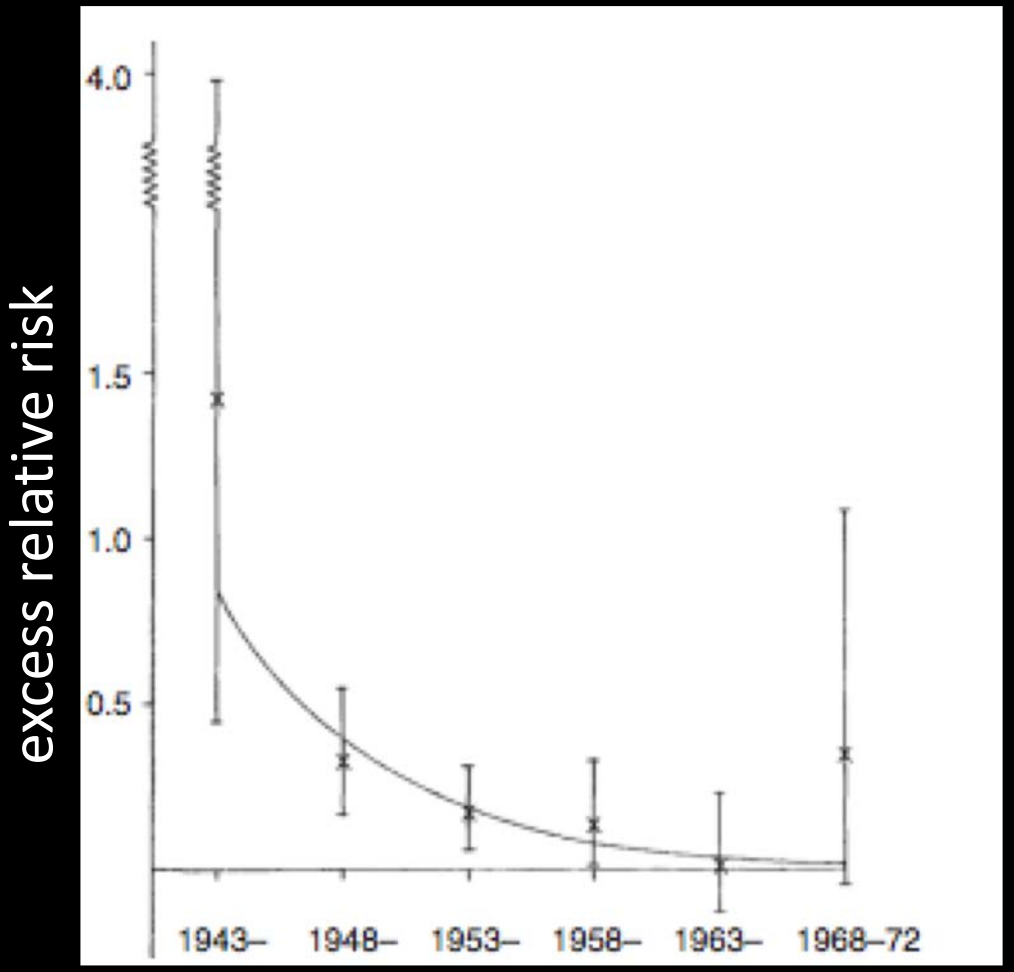
SPECIFIC AREA GONAD SHIELDING

FEDERAL GUIDANCE REPORT NO. 9

October 1976

Operator Responsibility:
"…to properly collimate the X-ray beam and to use shielding where appropriate and practicable."

1976



Bithell (1988) A new calculation of the carcinogenic risk of obstetric X-raying. Stat. Med. 7.

1976-2019

Decrease in patient doses

More information about radiation risks

Image Detection

intensifying screens!

rare earth screens!

digital detectors!

AG Haus & JE Gullinan (1989) Radiographics 9(6)

Where is that radiation coming from?

primary beam

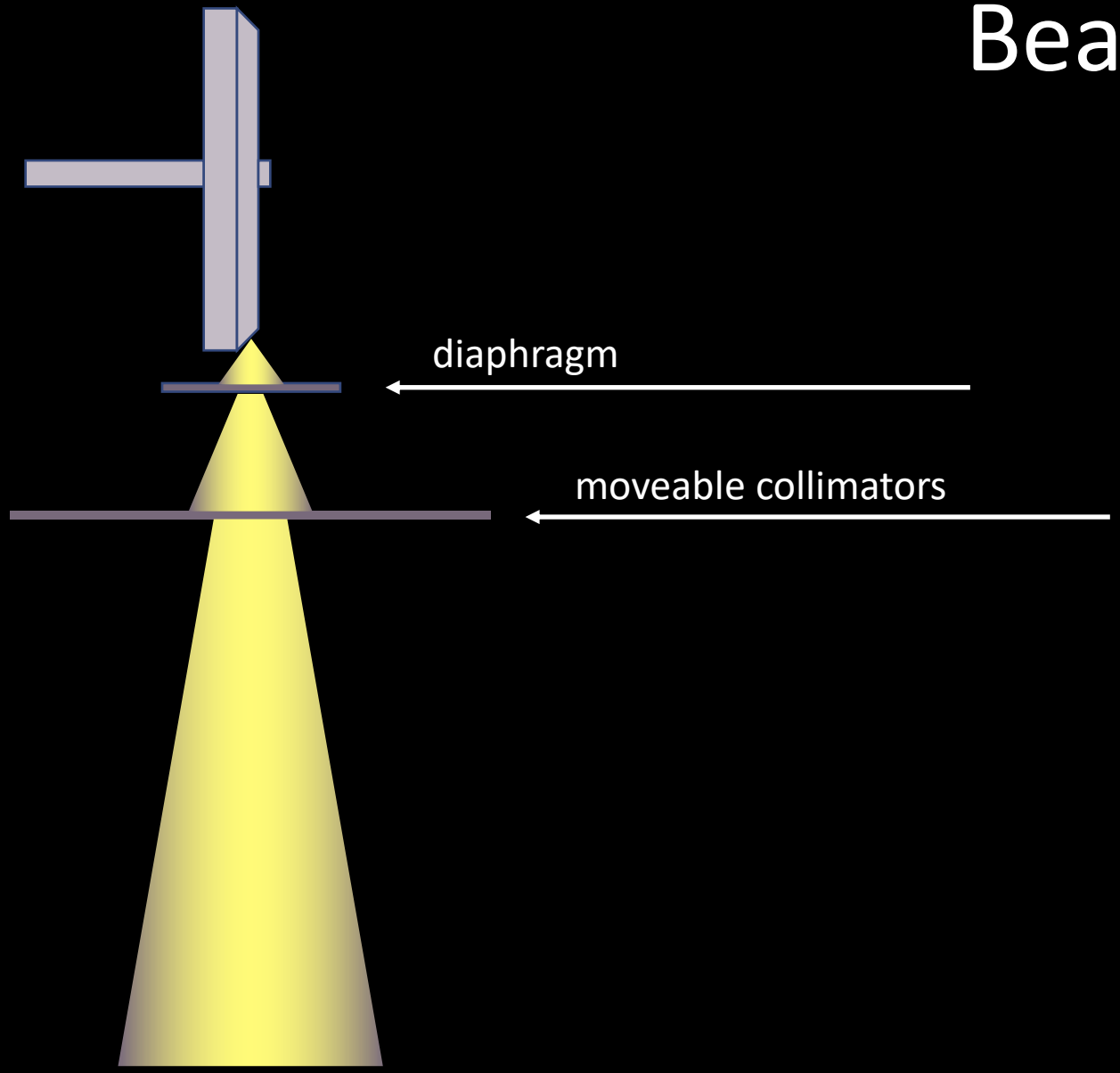
extra-focal radiation

scatter from irradiated objects

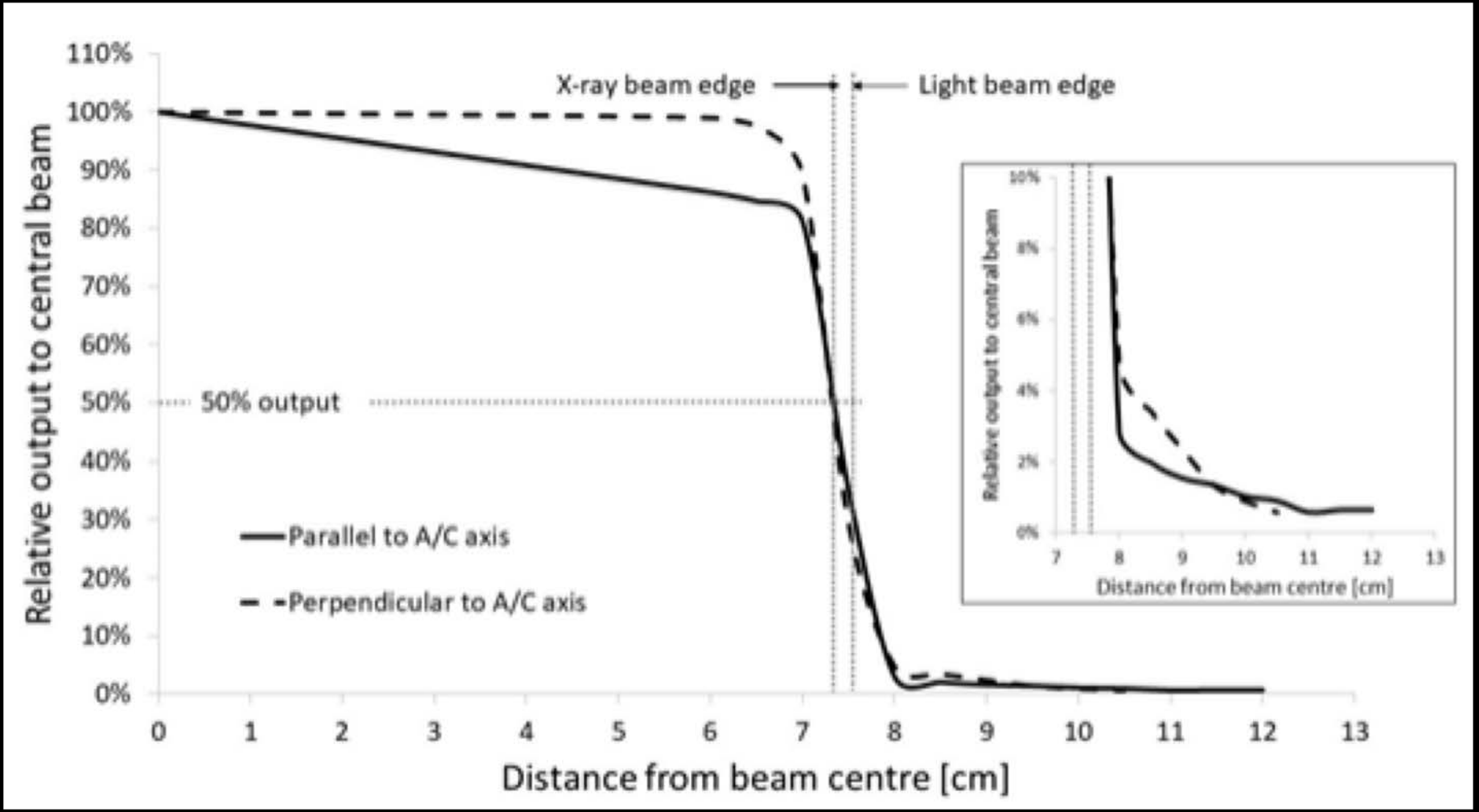
tube housing leakage

From BIR Guidance on Patient Shielding (2020)

Beam Collimation



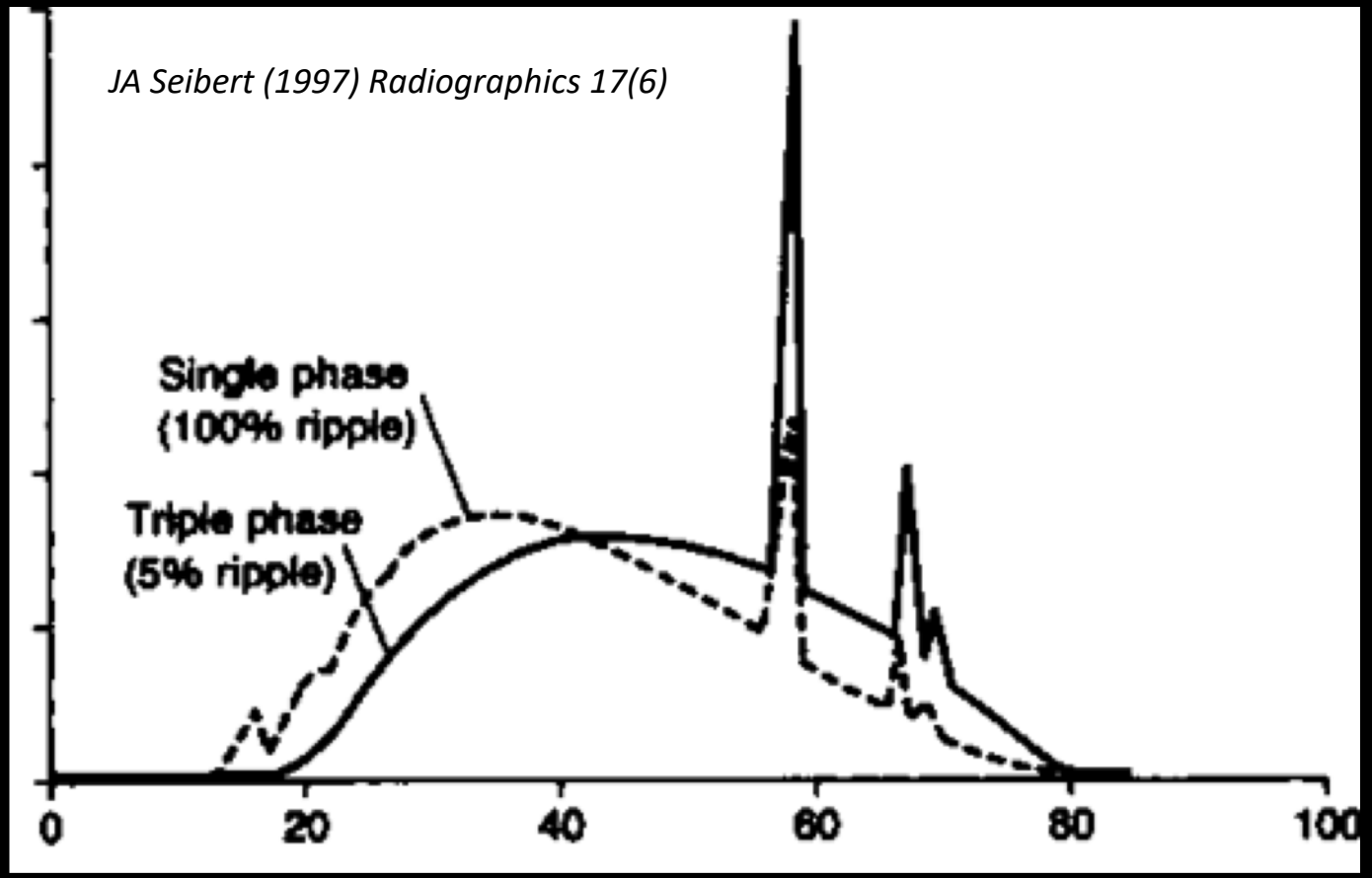
Out-of-field doses



From BIR Guidance on Patient Shielding (2020)

Beam Spectra

better generators!



more filtration!

Fluoroscopy

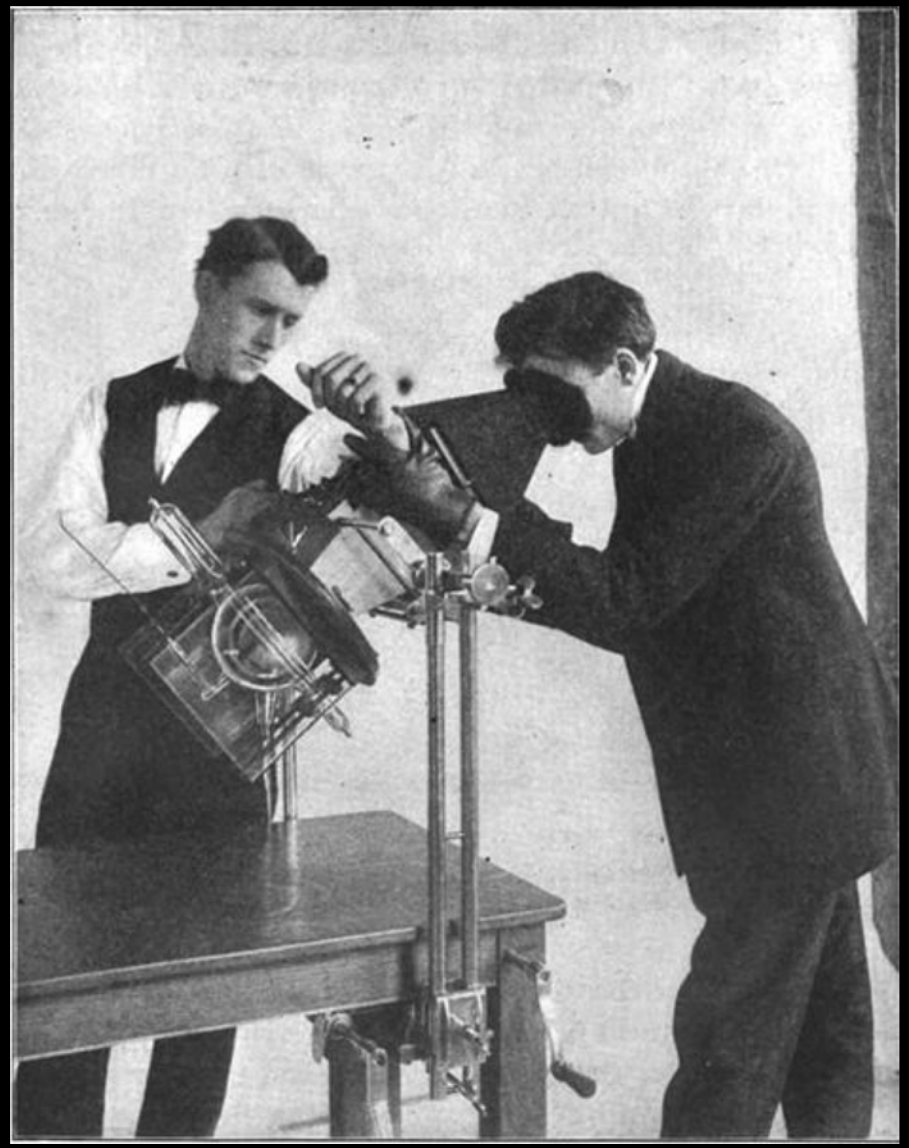


image intensifiers

output to TVs

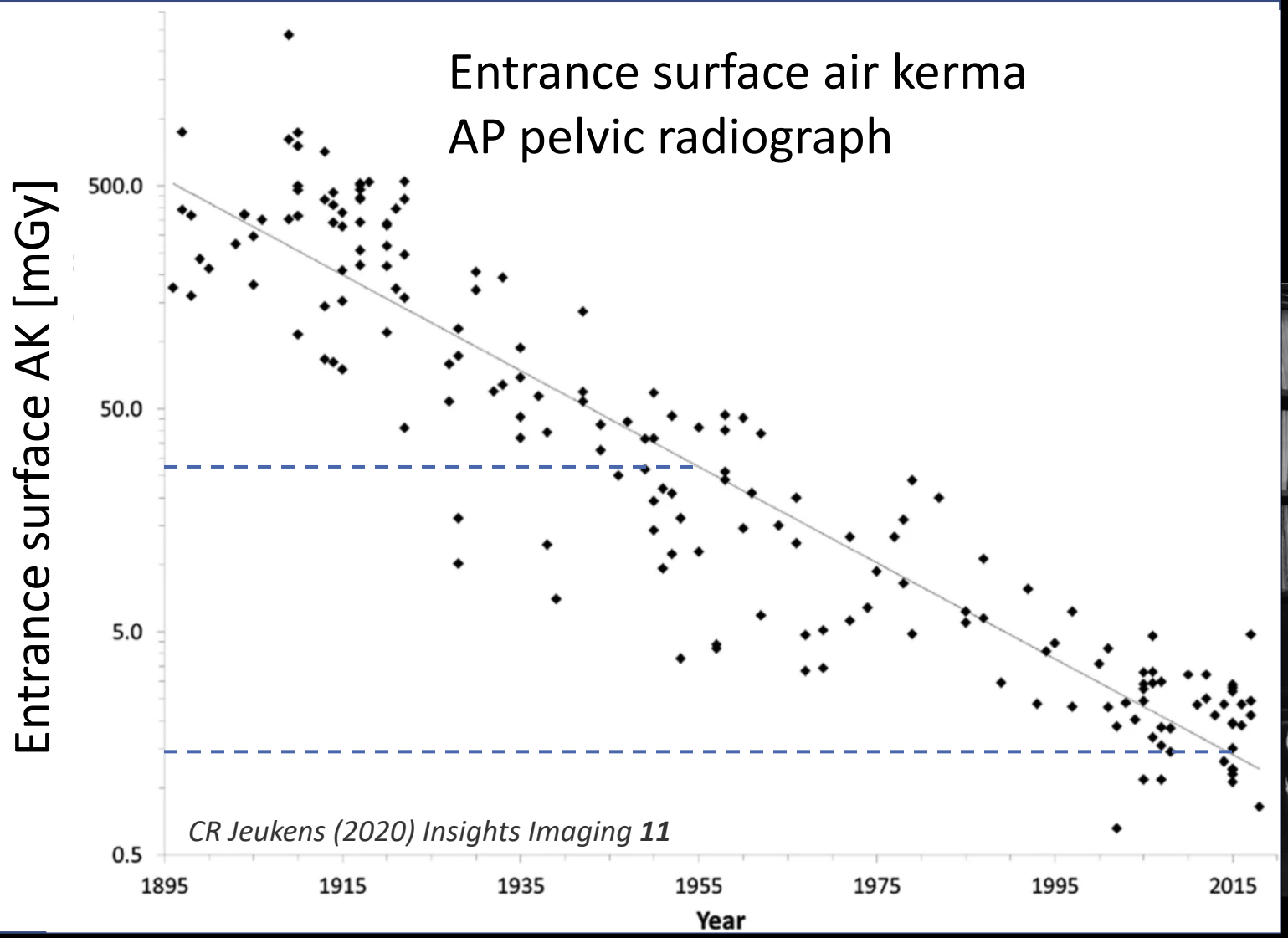
last image hold

pulsed fluoro

temporal averaging

DSA

ABC



1955 → 2015
95% dose reduction

≠

Drosophila: This image is licensed under public domain. http://www.freestockphotos.biz/stockphoto/15433
FDA: http://cdn.loc.gov/service/ll/fedreg/fr040/fr040180/fr040180.pdf

permanent damage
(2000 mGy)

temporary damage
(100 mGy)

Below 100 mGy:

- No evidence that the risk of tissue reactions increases, *at any stage of pregnancy.*
- Risks of cancer has not fully been resolved.

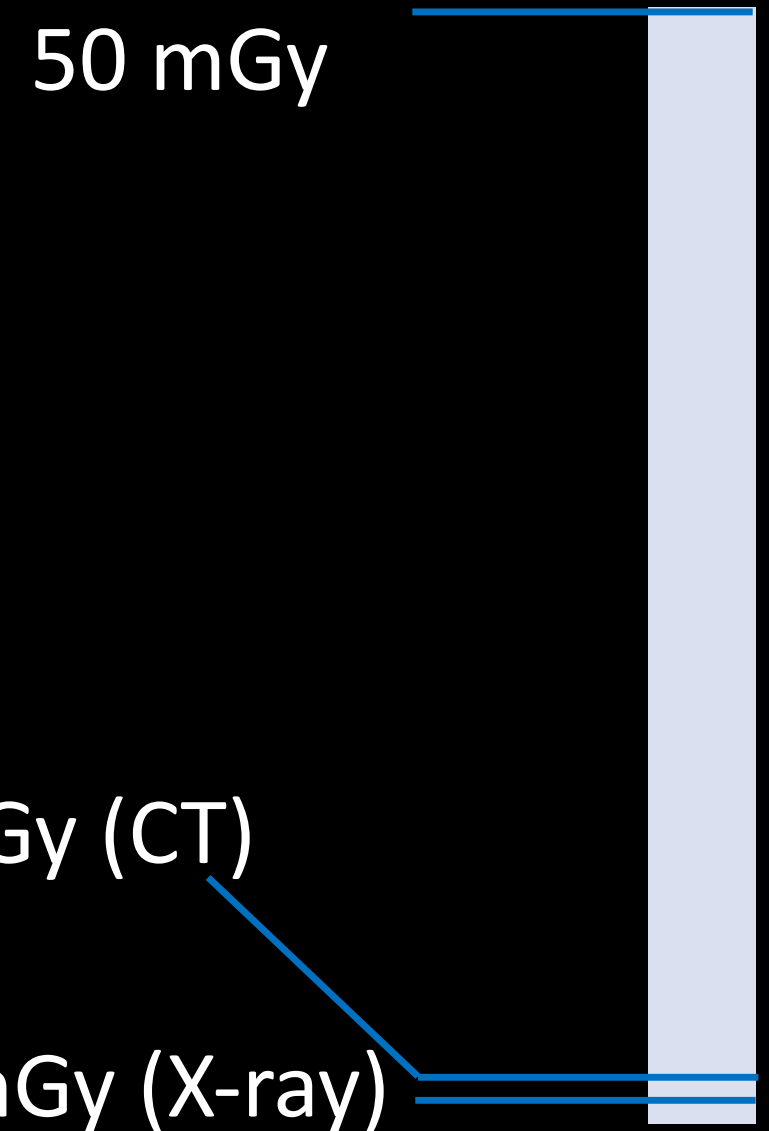
NCRP REPORT No. 174

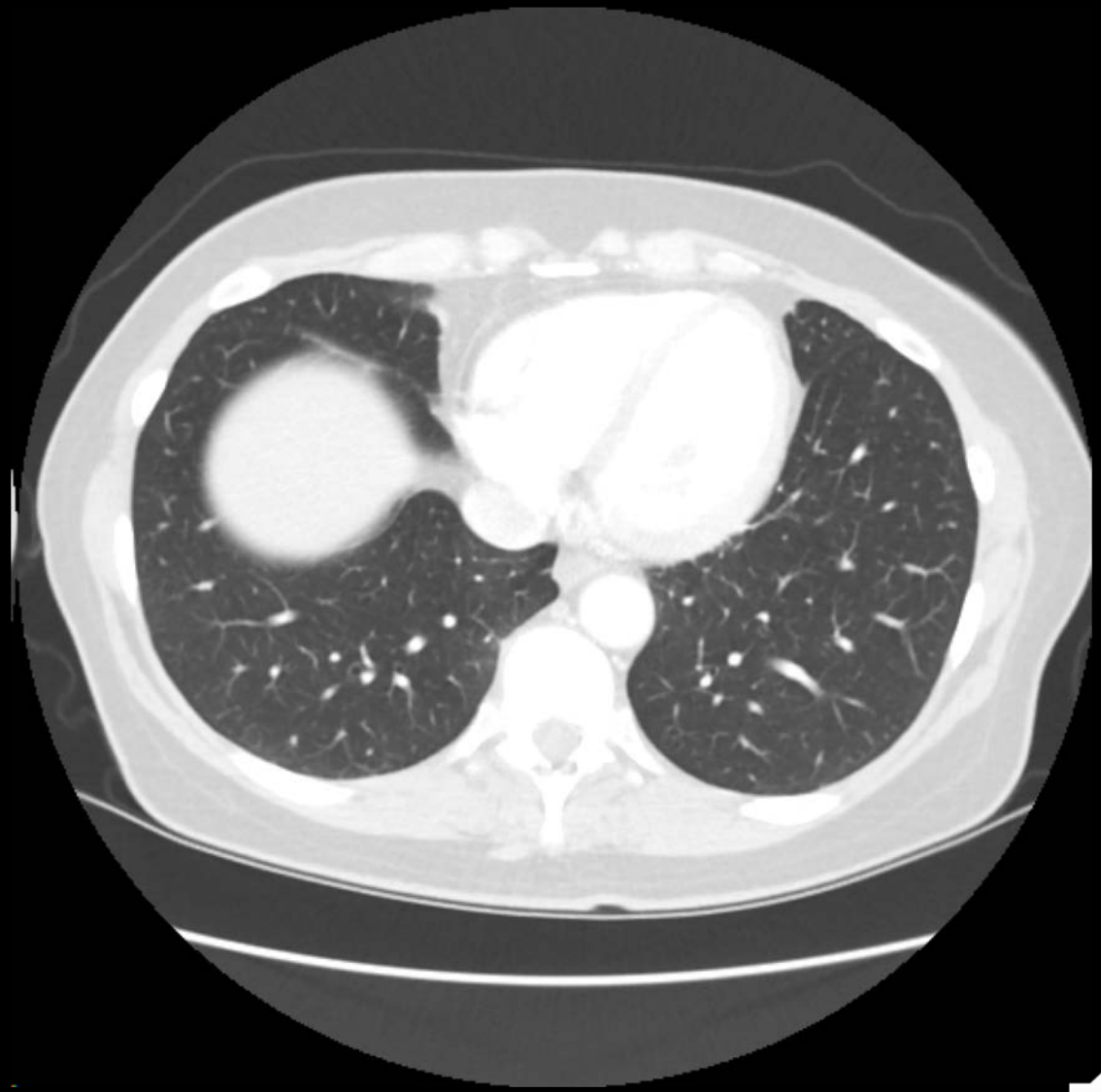
ACOG
The American College of Obstetricians and Gynecologists

"With few exceptions, radiation exposure through radiography, computed tomography scan, or nuclear medicine imaging techniques is at a dose much lower than the exposure associated with fetal harm."

ACOG Guidelines-for-Diagnostic-Imaging-During-Pregnancy-and-Lactation, 2016

Scenario 1: The fetus is outside the FOV



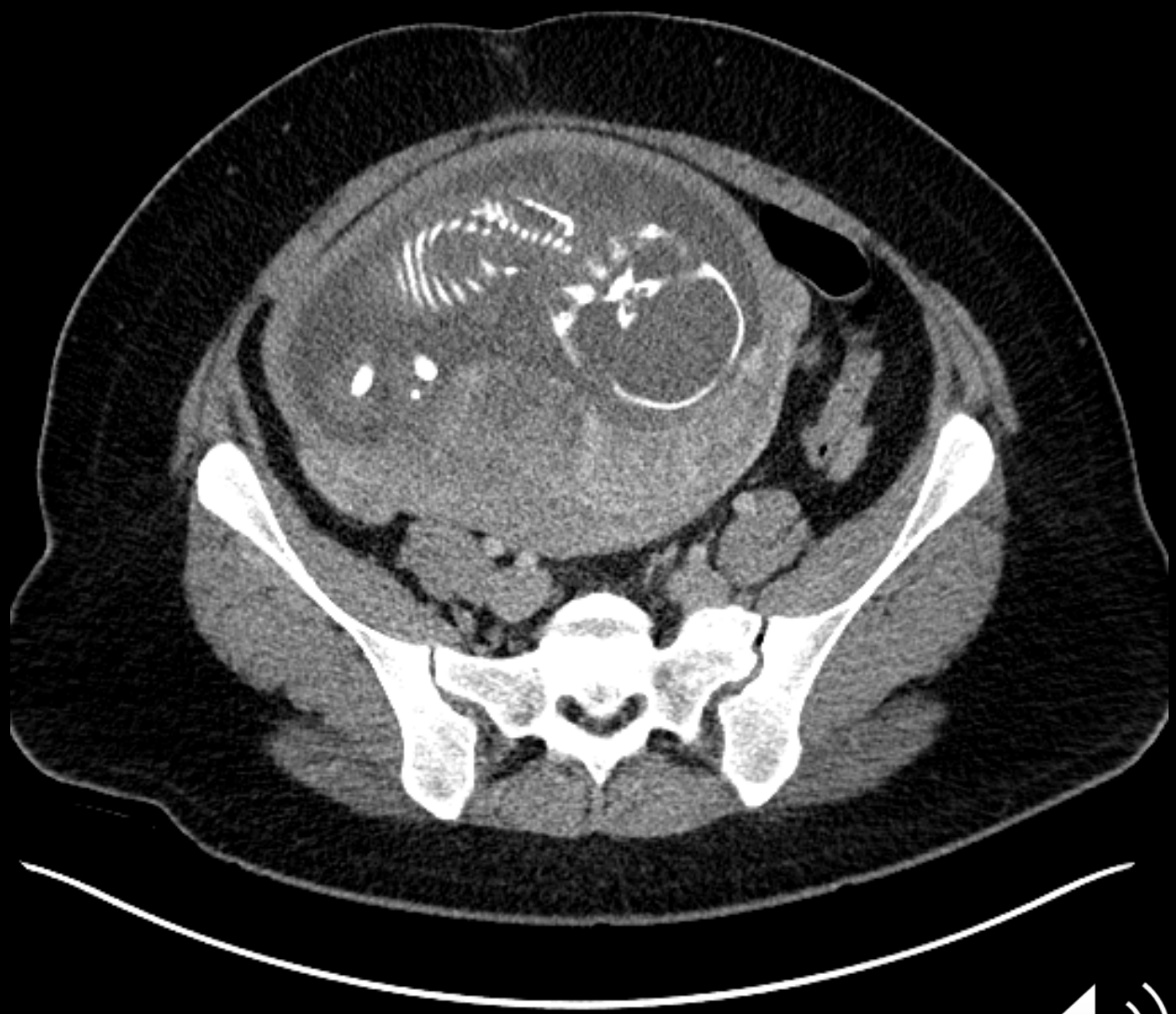


Scenario 2: The fetus is inside the FOV

50 mGy

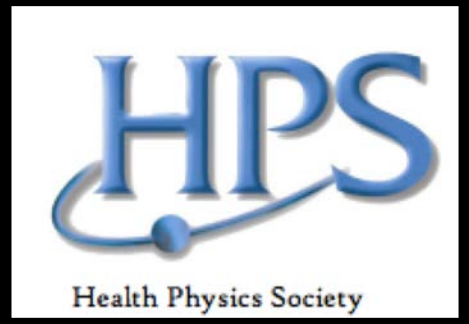
20 mGy (CTA pelvis)

1.5 mGy (pelvis X-ray, 2-view L-spine)



Evidence for increased cancer risk at doses below 100 mSv…

"inconclusive"



"not statistically different from zero"

"lacks statistical power to directly reveal cancer risks"

Does shielding patients still make sense?

Gonadal Shielding

Scenario 1: The gonads are in the FOV

Typical dose to the gonads (AP pelvis)[1,2]:

5-10yo: ~ 0.1 mGy

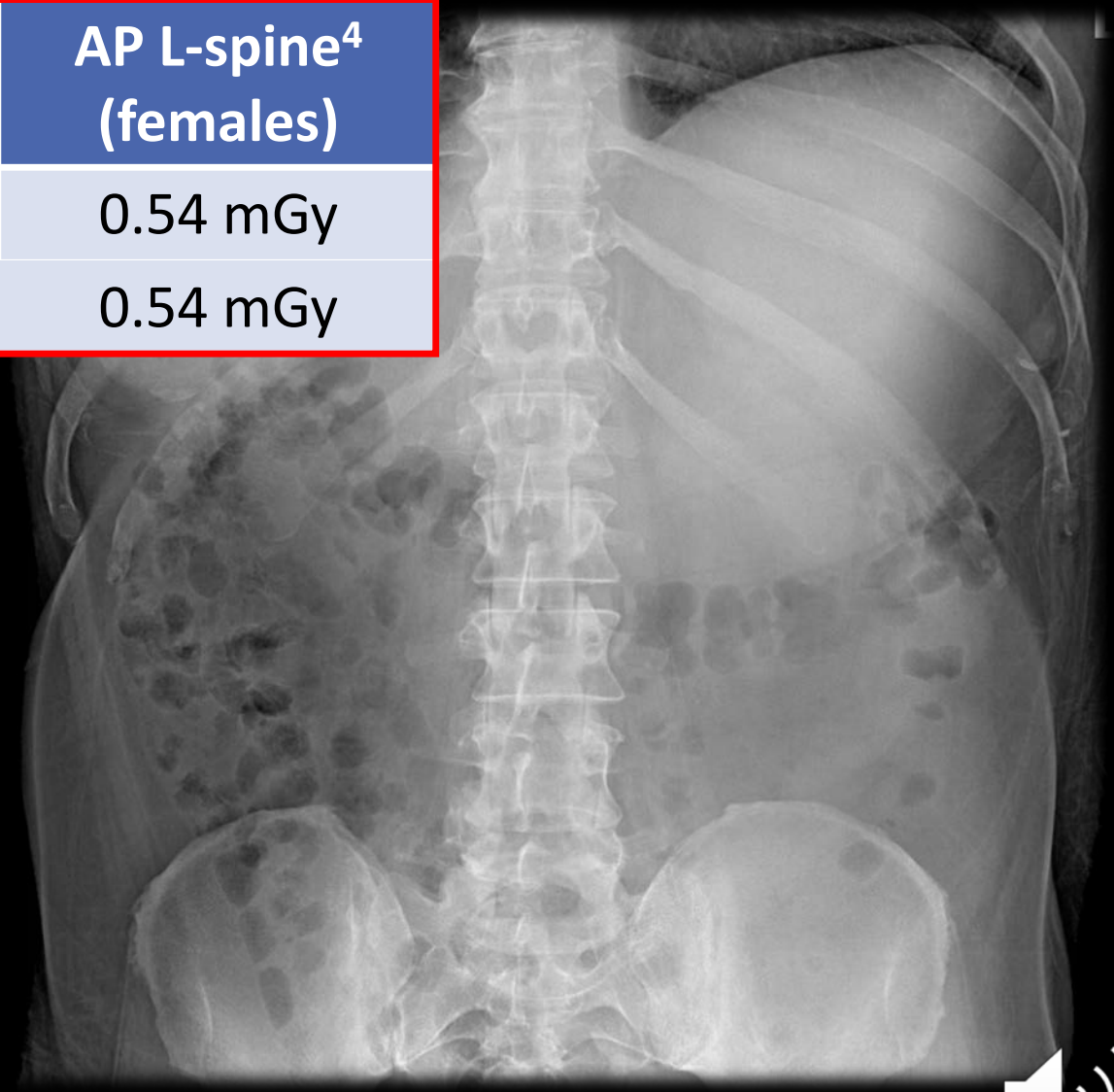
adult: ~ 0.8 mGy

[1] *Frantzen (2012) Insights Imaging 3*

[2] *Kaplan (2018) Pediatr Radiol 48*

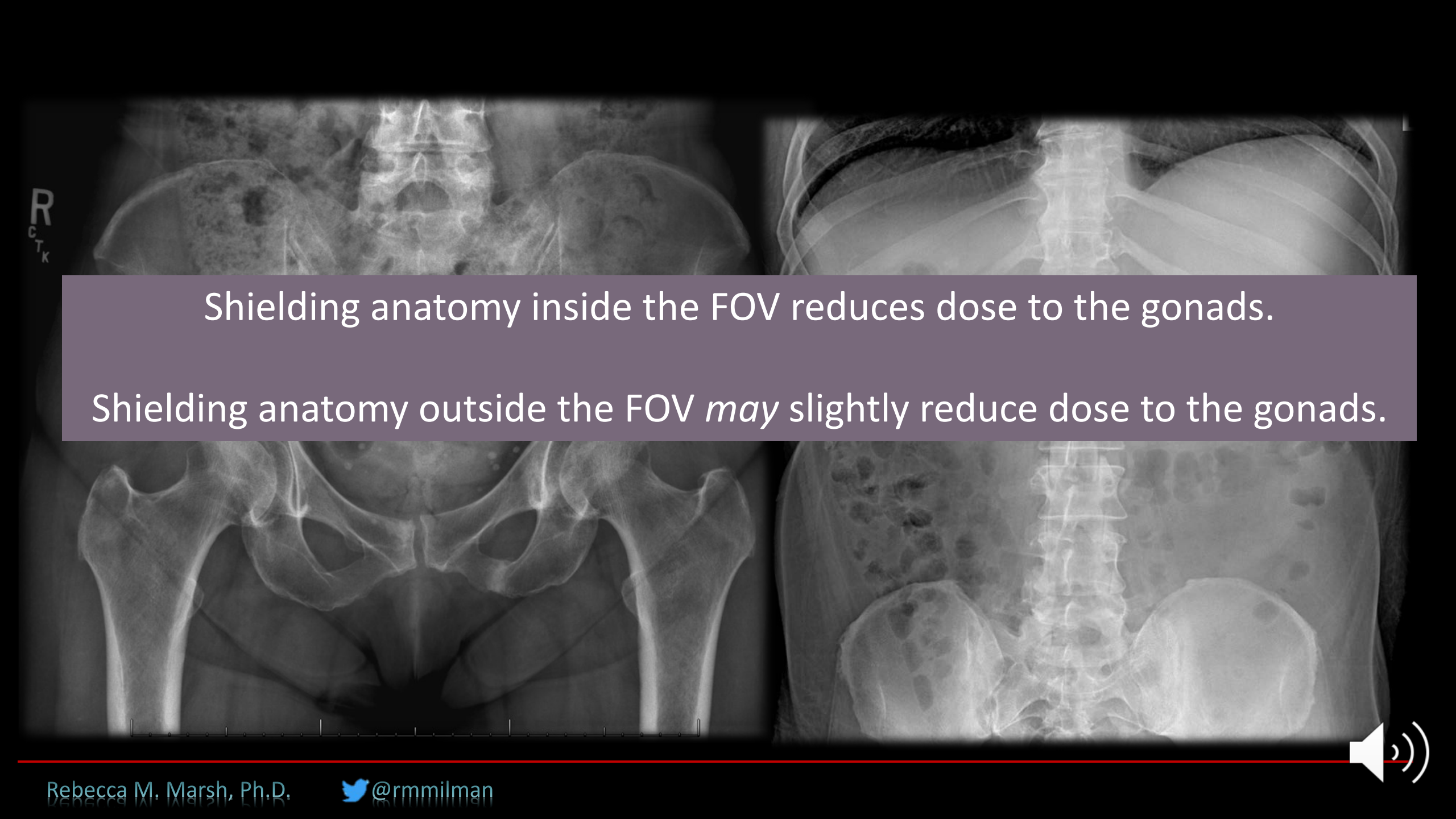
Scenario 2: The gonads are **NOT** in the FOV

When gonads are NOT in the FOV	AP abdomen[3] (males)	AP L-spine[4] (males)	AP L-spine[4] (females)
	0.25 mGy	0.04 mGy	0.54 mGy
With shielding	0.19 mGy	0.02 mGy	0.54 mGy



[3]*Fauber (2016) Radiologic Technology 88(2)*

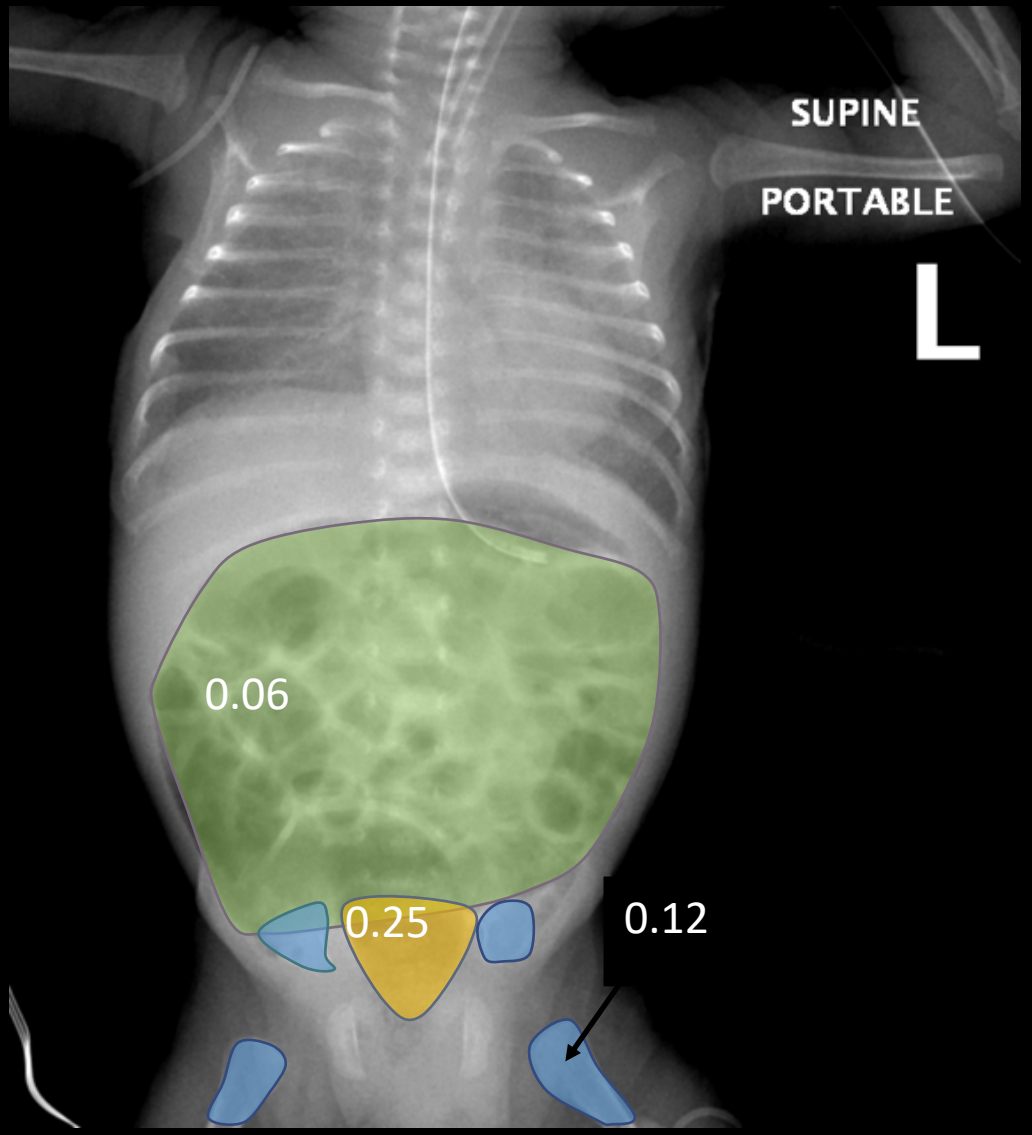
[4]*Clancy (2010) Radiography 16*



Shielding anatomy inside the FOV reduces dose to the gonads.

Shielding anatomy outside the FOV *may* slightly reduce dose to the gonads.

Overall Dose

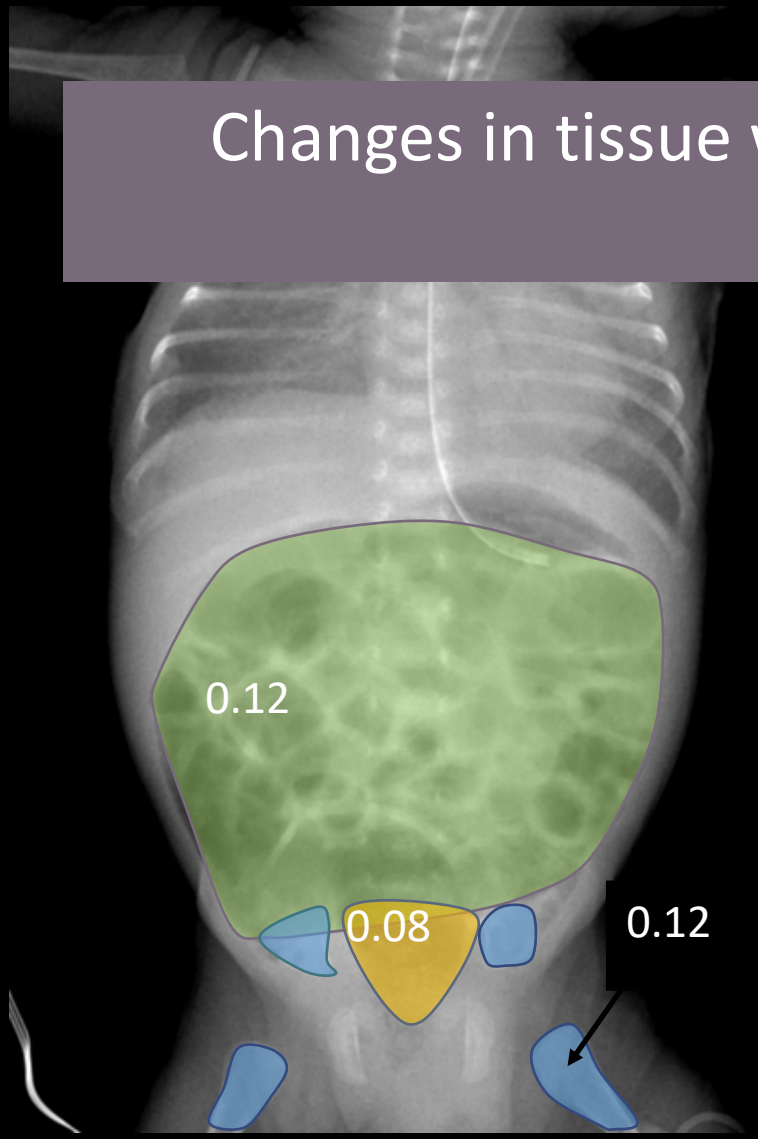


1977

Reduction in gonadal dose: 100%

Potential reduction in effective dose: 20%

Overall Dose



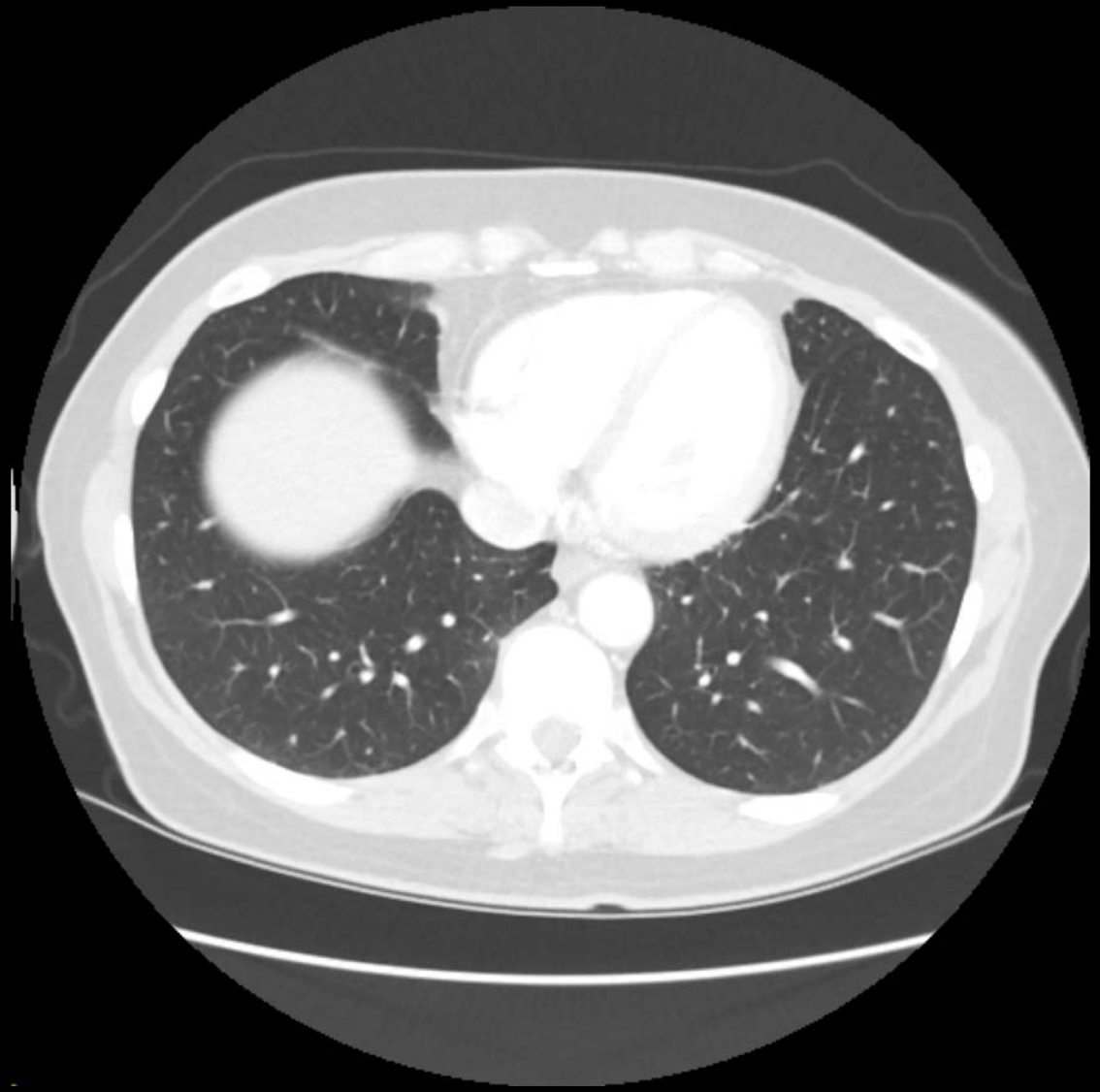
Changes in tissue weighting factors have reduced the *effectiveness* of reducing gonadal dose.

Reduction in gonadal dose: 100%

Potential reduction in effective dose: 6%

Shielding the Fetus

Scenario 1: The fetus is outside the FOV



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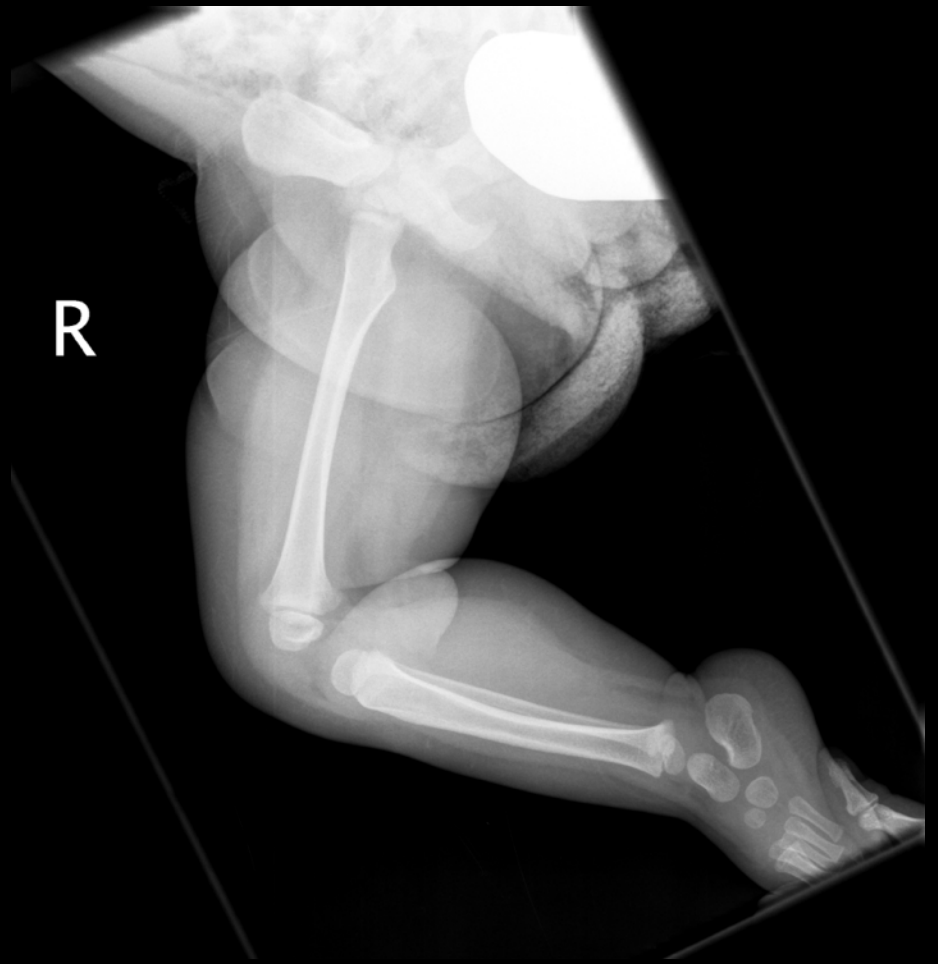
So What?

Shielding patients can cause problems.

Shielding can:

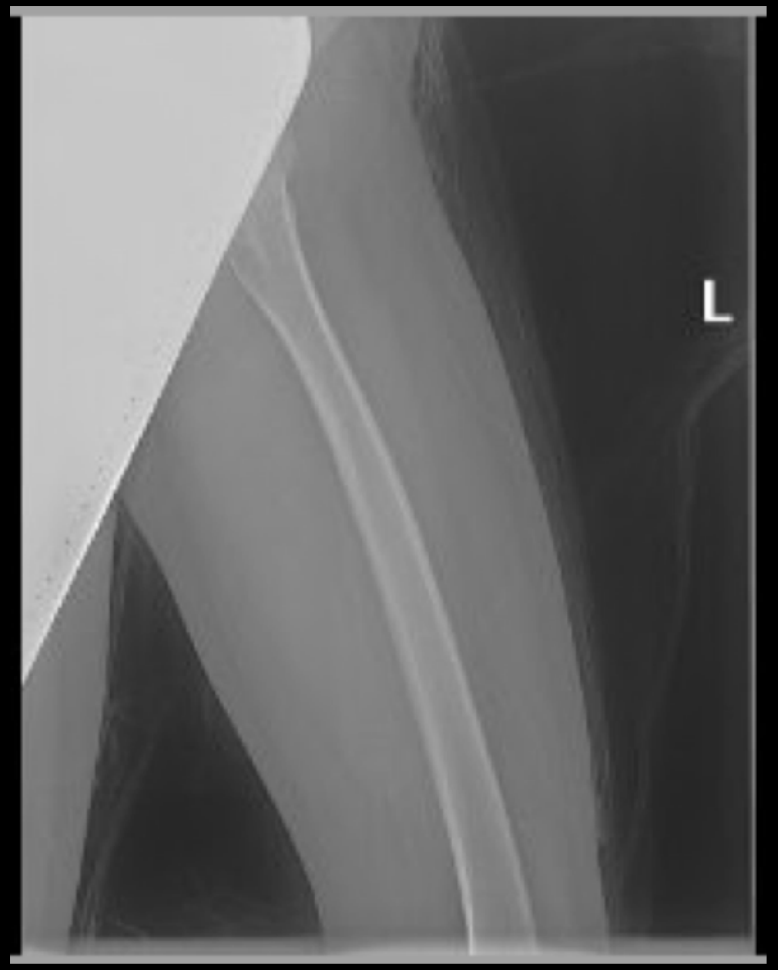
- Not fully cover the gonads



females: up to 91%
males: up to 66%

Shielding can:

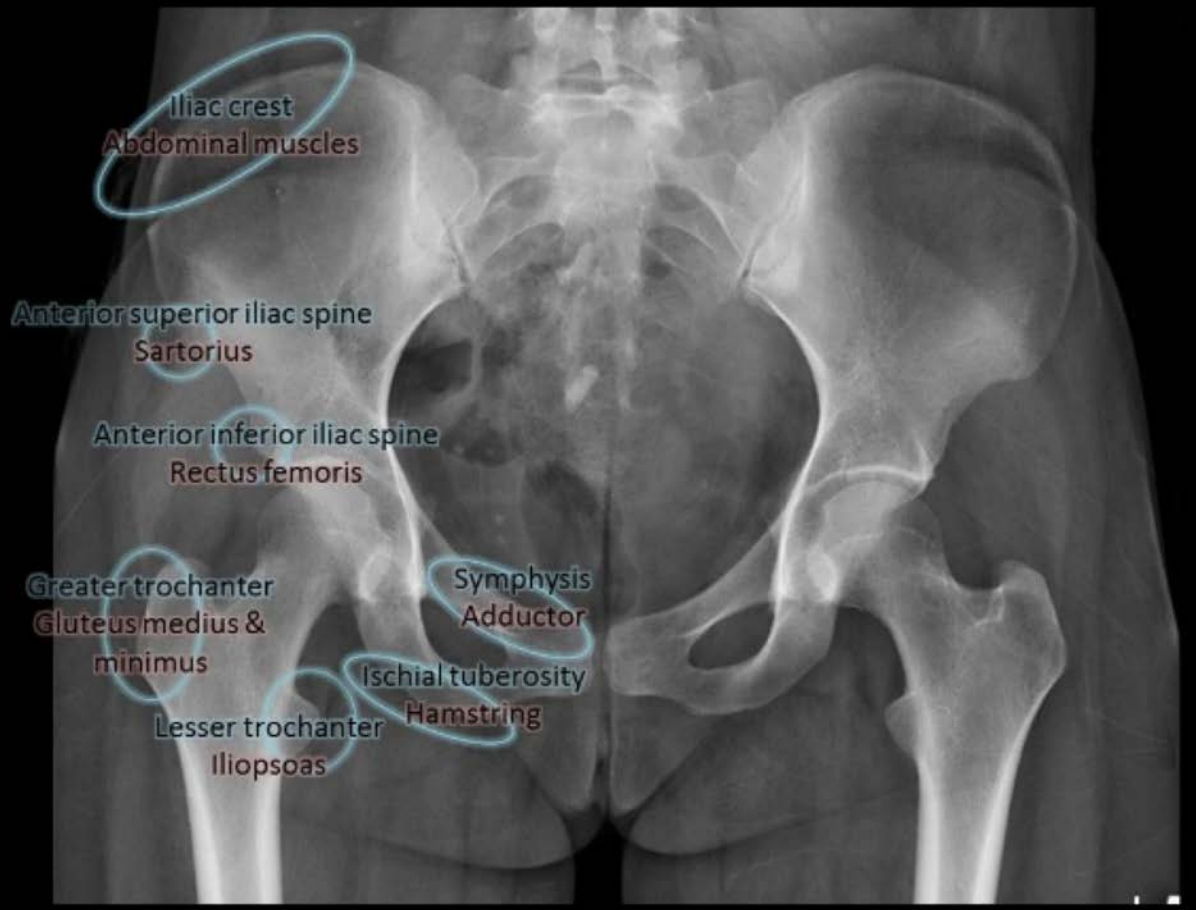
- Not fully cover the gonads



Published Studies:

1992

2013



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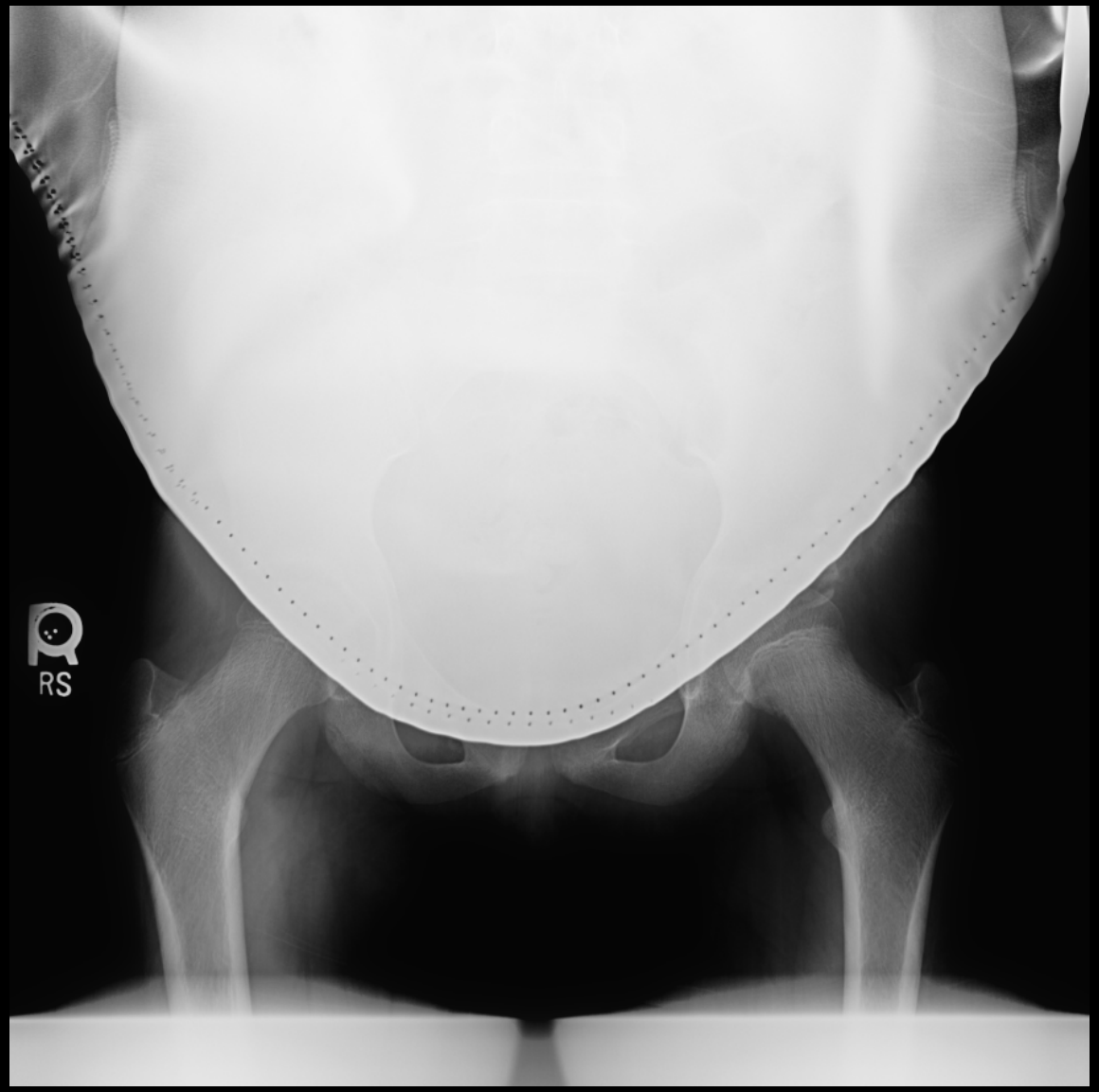
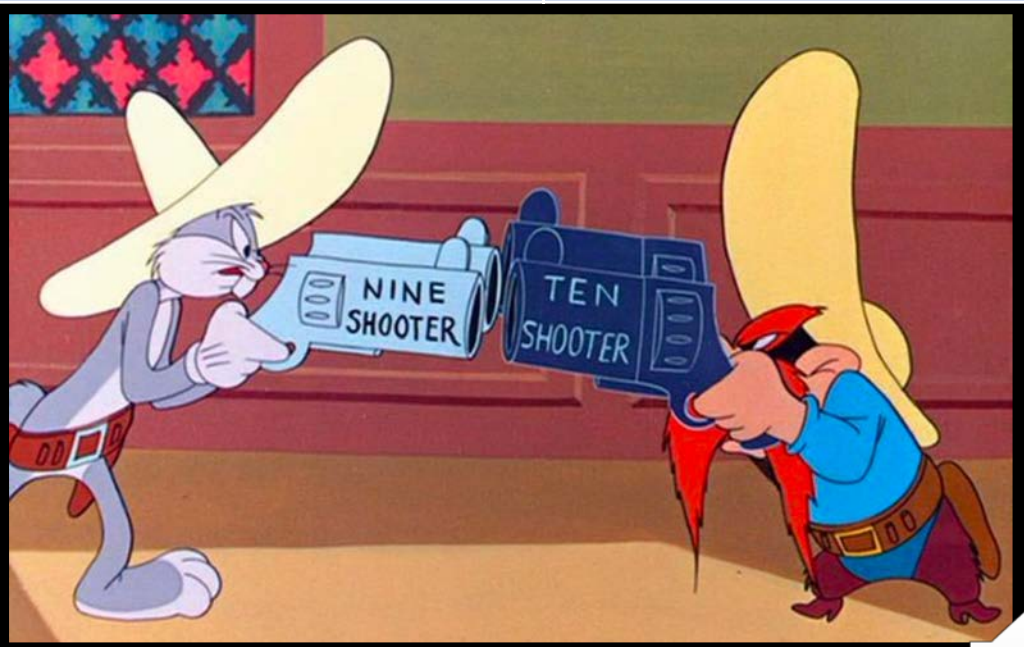
74yo patient



typical technique	technique used
77 kV 8 mAs	85 kV 109 mAs



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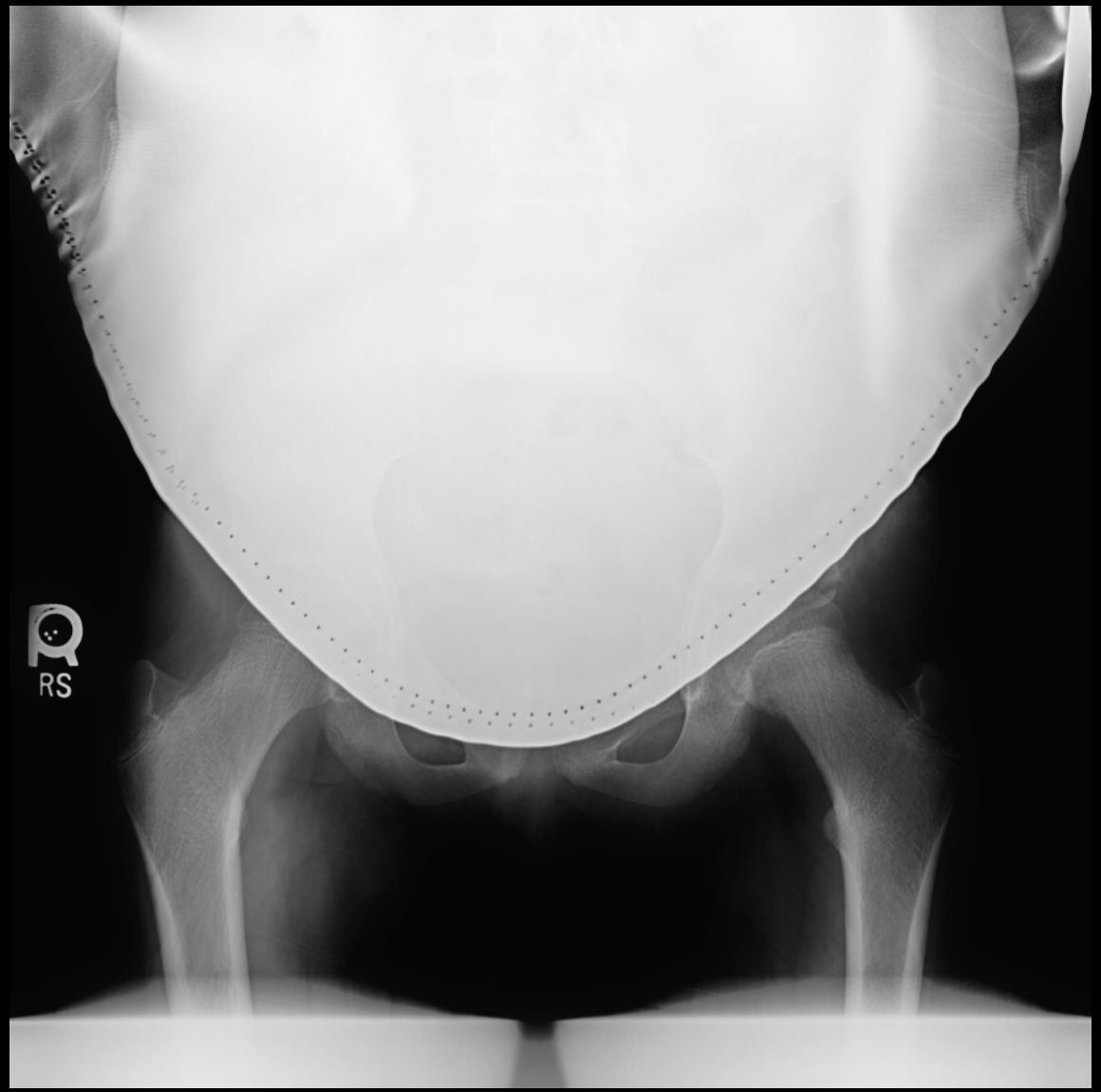

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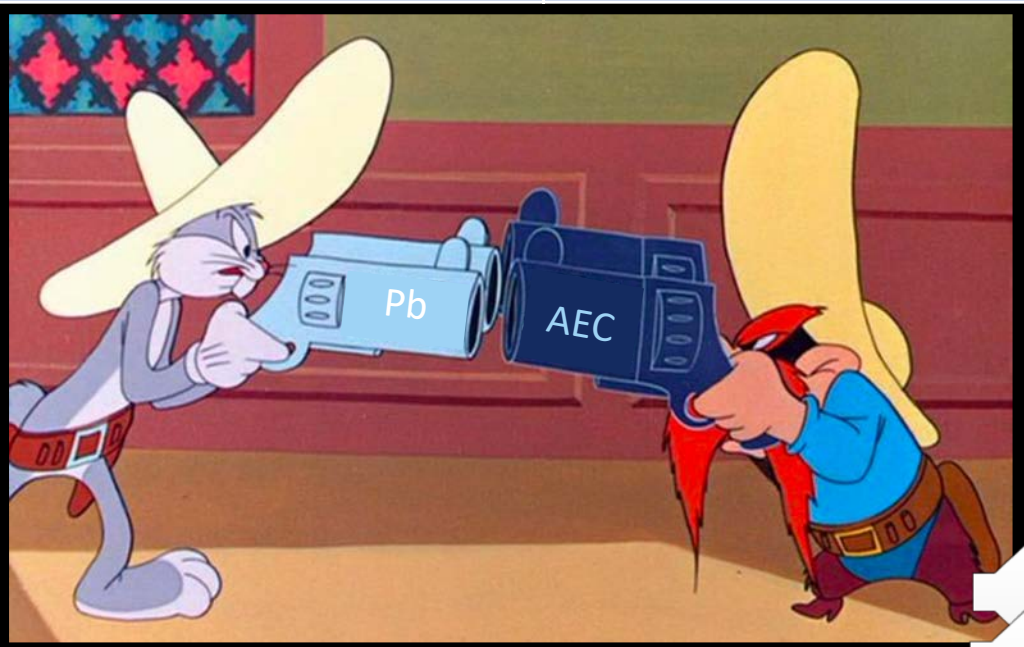
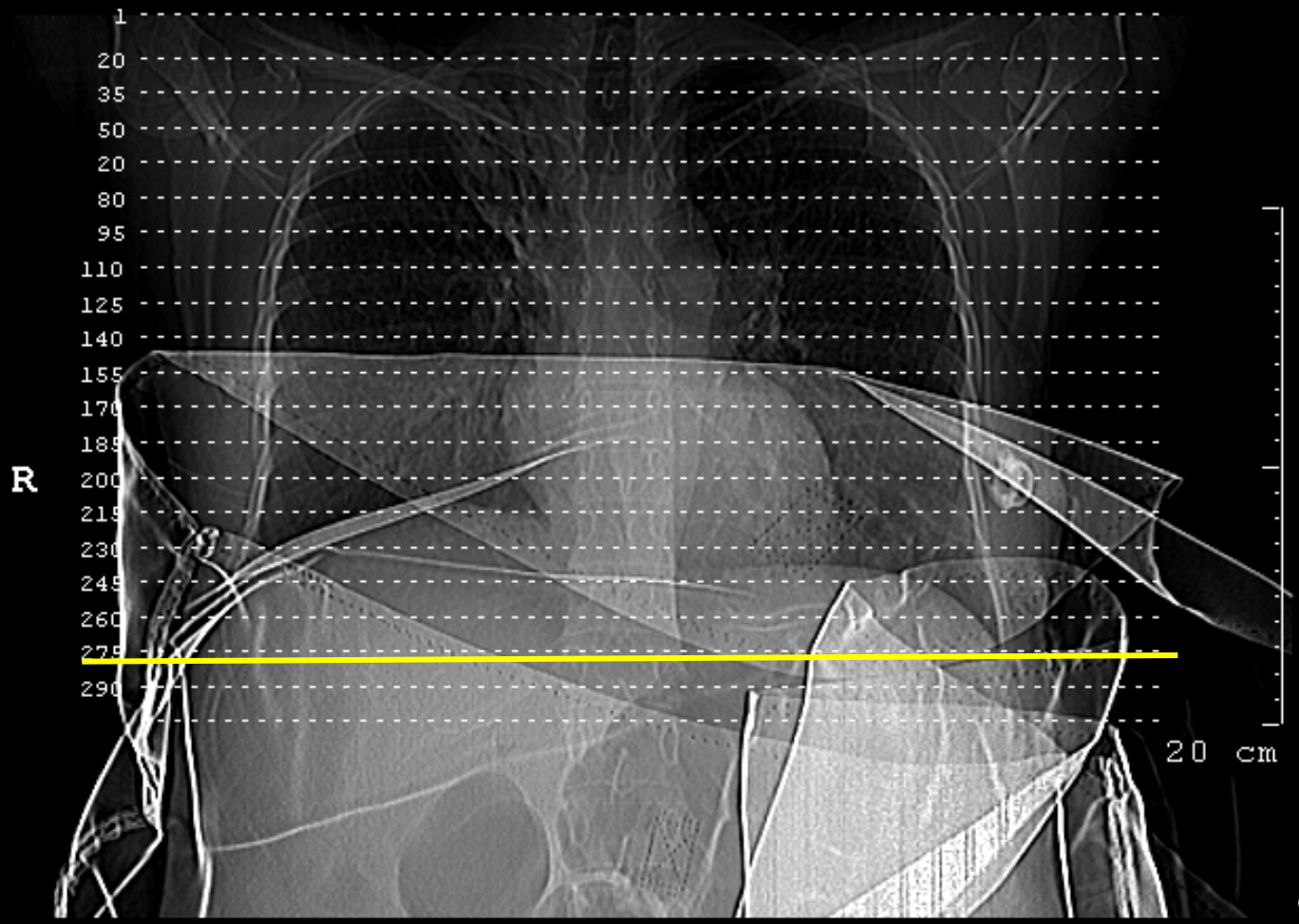
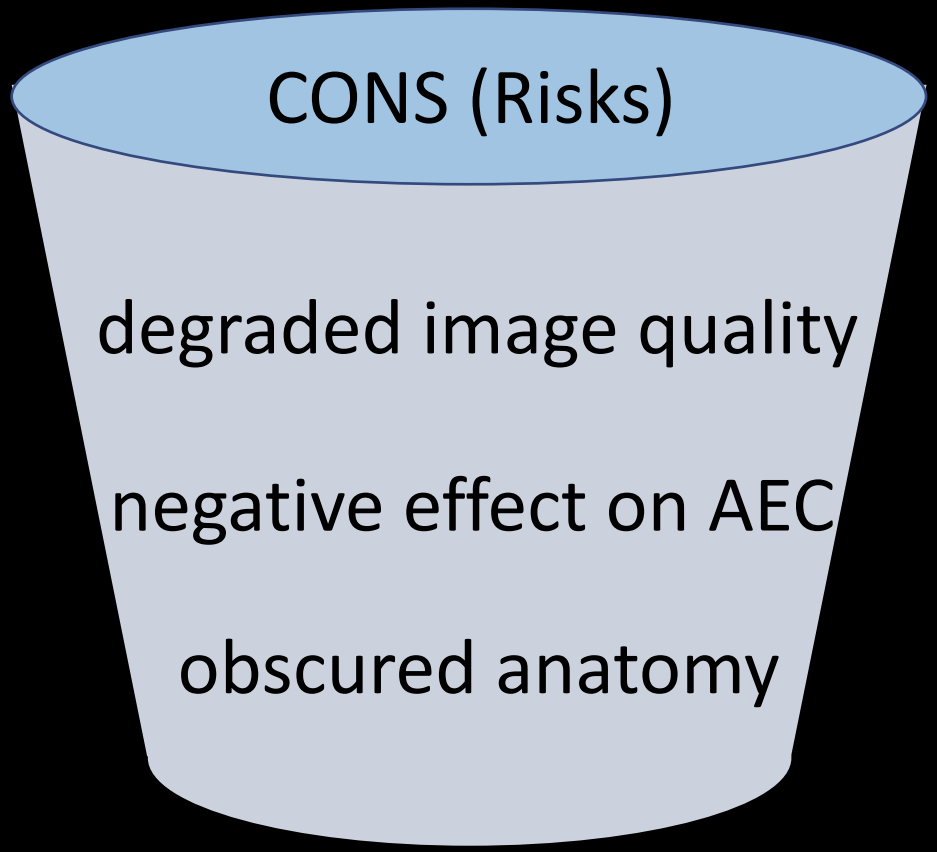



1
20
35
50
20
80
95
110
125
140
155
170
185
200
215
230
245
260
275
290
R
20 cm
F


KVP 120
mA 500
Slice Location 288

TL;DR


CONS (Risks)
degraded image quality
negative effect on AEC
obscured anatomy


PROS (Benefits)
makes us feel better

Patient

Us

Misinformation is poor patient care.

We cannot let fear guide the practice of medicine.

Consistency is important.

Consistency is important.

REGULATORS

PHYSICIANS

RADIOLOGIC TECHNOLOGISTS

PHYSICISTS

CARES –
Communicating Advances in Radiation Education for Shielding

TECHS & EDUCATORS

PHYSICIANS

PHYSICISTS

REGULATORS

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aapmCARES

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FAQs – Released December

Educational Modules & Materials – In progress

Communications with state regulators – Ongoing

Summary

Clinical practice should be based on current scientific knowledge.

The data exist.

Gonadal and fetal shielding are *not* ALARA.

We need to understand what the risks are

…and what the risks are *not*.

Acknowledgements

- Mike Silosky & my kids
- UCH Radiologic Technologists
- CARES Committee Members