Review of Clinical Motivations Behind Discontinuing the Use of Gonadal Shielding

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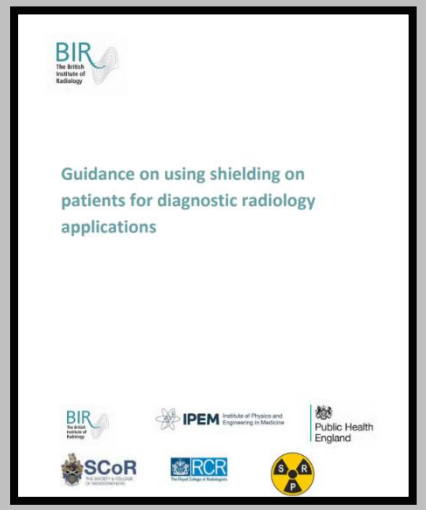
Disclosures:
Chair, NCRP SC 4-11
Chair, Image Gently Alliance

Considering relevant audiences…
MD perspective

http://www.kvballygungeblog.org/wp/index.php/2015/11/22/albert-einstein/

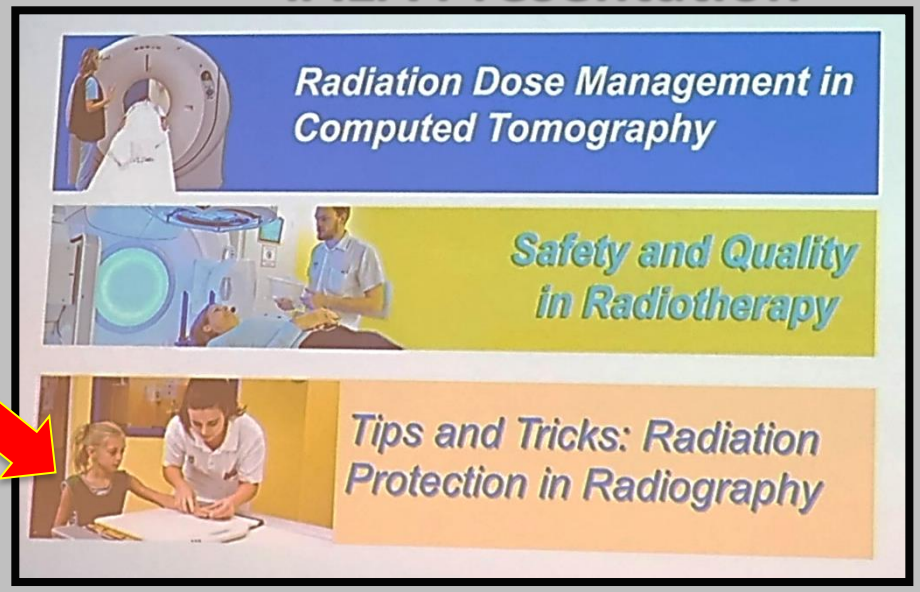
Background:
Radiography and Gonadal Shielding

- Medical radiation (risk) is still relevant
- Radiography is frequent (and *of value*)
- Internationally pertinent
- Lack of current information contributes
- Practice and perspectives vary



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

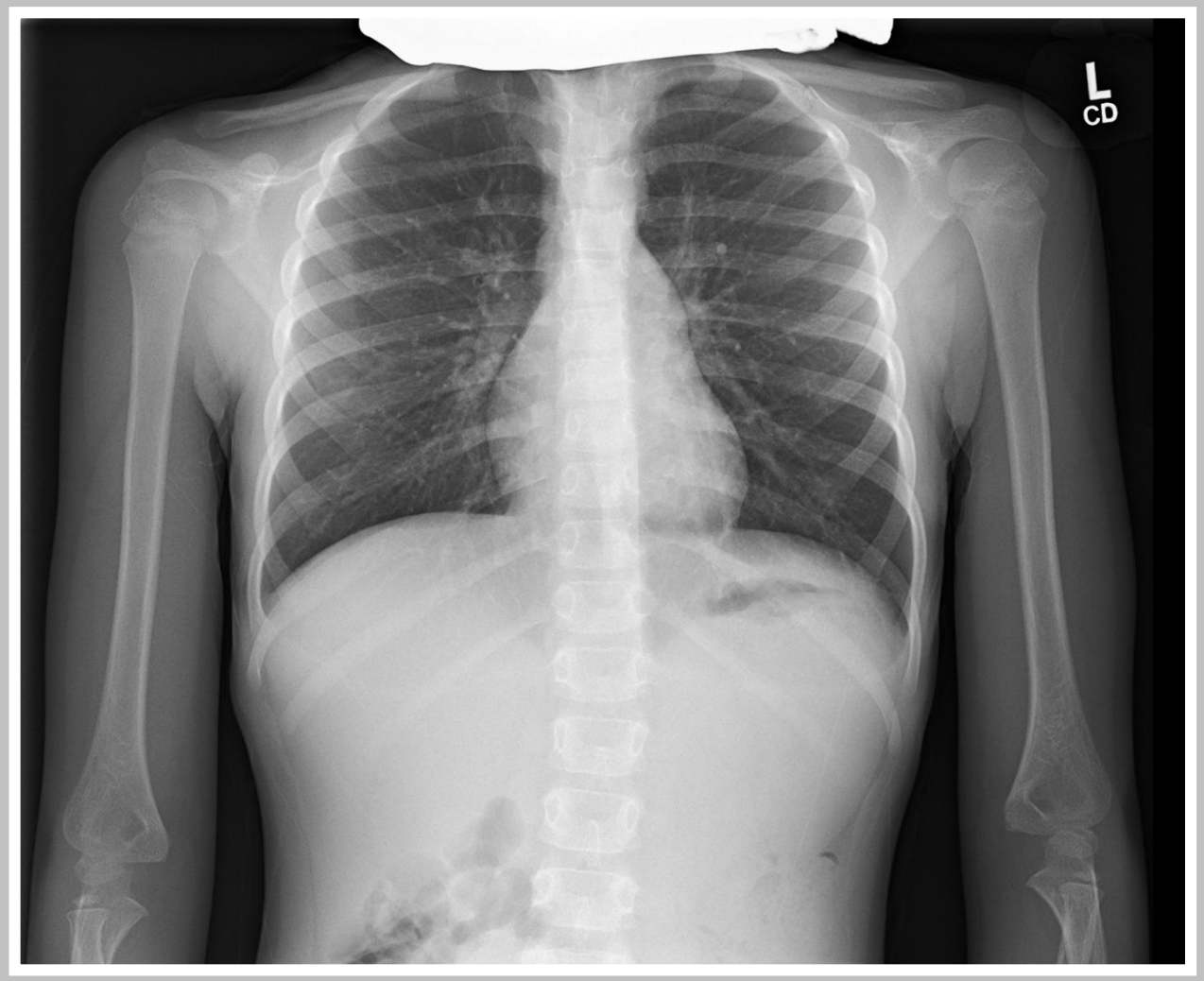
IAEA Presentation



5.5.20: "I am under treatment from a psychiatrist because with this … I got a guilt syndrome"

5.15.20: "I'm still afraid of the consequences of radiations on my children and I'm under treatment from a psychiatric [sic]."

Mother requested thyroid shield for CXR



Percentages of ionizing radiation examinations performed

(age range up to 18 yrs)

- Radiography 86%
- CT 9.5%
- Fluoroscopy 3%
- Nuclear imaging 1%
- interventional procedures 0.5%

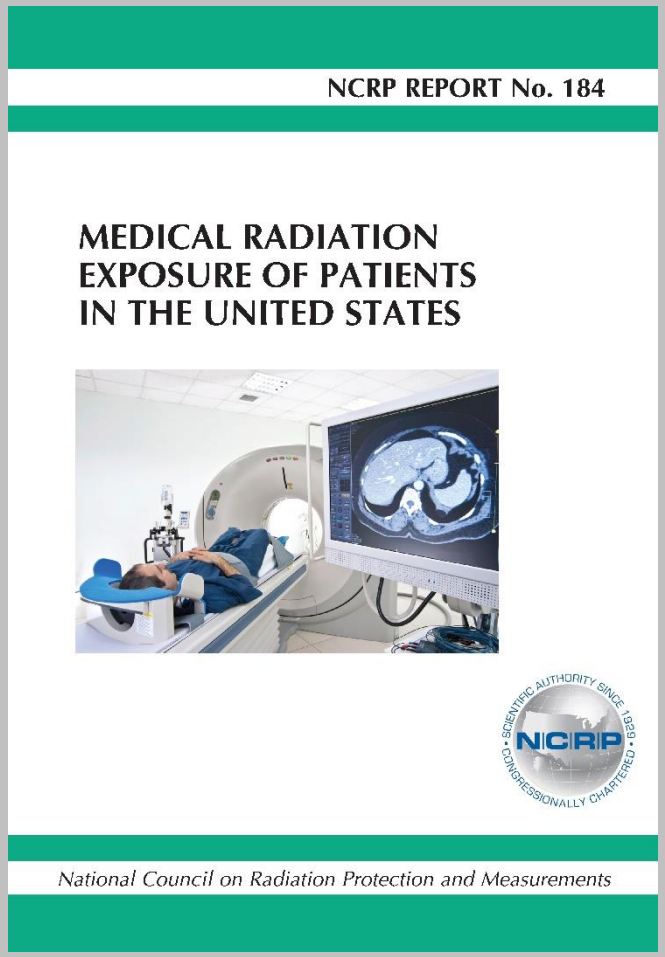


image gently® FDA

Pediatric Digital Radiography Safety Checklist

Safety Steps to Do and Verify for Your Pediatric Patient

www.imagegently.org

Prior to Starting the Exam	Image Capture During the Exam	Image Critique	Following Completion of the Exam
1. Patient name selected from the worklist.	1. Beam →body part →image receptor aligned, SID checked.	1. Cassette transported to and processed in reader, if applicable*.	1. Post-processing performed only if necessary.
2. Patient properly identified.	2. Grid only used when thickness greater than 10 - 12 cm.	2. Images displayed and reviewed, identification confirmed.	2. Exam verified and images archived to PACS for reporting.
3. Appropriateness of request checked.	3. Patient positioned and body part measured, cassette positioned if applicable*.	3. Image quality reviewed.	
4. Explained the exam to patient/parent.	4. Beam collimated to body part before exposure taken.	4. Exposure indicator/index checked, deviation index compared to target exposure index.	
5. Verified LMP/pregnancy if appropriate.	5. Technical factors selected based on body part thickness.	5. Image reprocessed or repeated as necessary.	
	6. Shielding and markers placed. Verify correct side of body part.		
	7. Final adjustment of tube and settings made.		
	8. Breathing instructions given.		
	9. Exposure taken.		
*For Computed Radiography only			

Fig. 1. The Image Gently Pediatric Digital Radiography Safety Checklist lists the most critical steps for ensuring patient safety and is divided into 4 main phases. This checklist design is intended to allow the technologist to carry out each phase of the procedure in its entirety before pausing. The checklist can be used on a daily basis for quality assurance and to ensure best practice, to train new radiologic technologists, or as a practice quality improvement project.

Image Gently Alliance even a few years ago…

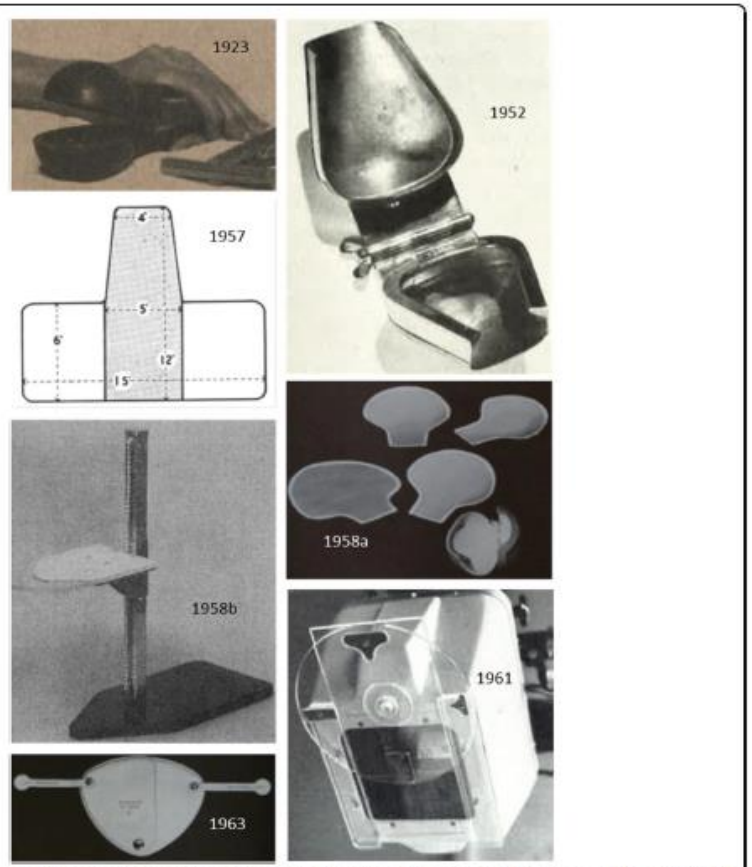


Fig. 1 Some early gonad shields with the year they were described in the literature. Testes capsules are seen on the photographs from 1923 [45], 1952 [46] and 1958a (at the right bottom of the image) [47]. A PMMA T-shaped board with 2-mm lead (shaded) for testes shielding is shown on the 1957 drawing [48]. Flexible contact-type shields for females are seen on the 1958a [47] and 1963 [55] images. The devices on the photos from 1958b [52] and 1961 [53] are of the projection type, the first to be positioned somewhere above the patient and the latter was fixed to the X-ray diaphragm

http://ffffound.com/image/c35f51a2931e9d21a7bfa7550b7905bc9a13cafc

Clinical Motivations:
How Did We Get to this Point?

- Medical radiation awareness
- Medical radiation accountability
- Medical physicists
  - ie, Strauss; Marsh
  - AAPM: McCullough, Marsh
- Growing (body) of literature

AJR FOCUS ON:

Patient Shielding in Diagnostic Imaging: Discontinuing a Legacy Practice

Rebecca M. Marsh[1]
Michael Silosky

OBJECTIVE. Patient shielding is standard practice in diagnostic imaging, despite growing evidence that it provides negligible or no benefit and carries a substantial risk of increasing patient dose and compromising the diagnostic efficacy of an image. The historical rationale for patient shielding is described, and the folly of its continued use is discussed.

CONCLUSION. Although char
medical physicists, and radiologists to

Patient shielding is an integ
of radiology. Its practice
portance are so deeply in
that when a group of ra
technologists was recently asked wh
would do if their institution adopted
to not provide patient shielding, 86%
spondents stated that they would sh
tients anyway. (One percent of resp
said that such a policy change woul
them to quit their job [1].) This raises
portant question: why do we shield p
The assumption is that shielding inspi
tient safety [2–6]. This belief is often
as fact, with little consideration given
racity. However, a review of the histor
tient shielding and the current role of
shielding in radiology provides evide
the associated risks are substantial,
the benefits are negligible or nonexist

Patient Shielding Was Intended to Alleviate Hereditary Risks

Patient shielding was first introdu
the U.S. Code of Federal Regulations
[7]. Around this time, it was recognize
radiation exposure from diagnostic ex
tions was too low to affect fertility,
even temporary decreases in sperm
do not occur at doses of less than 25
and because female fertility is not affe
doses of less than 3000 mGy [8]. Conv
ly, the regulation cited only a concern
ing hereditary risks (i.e., mutations
cells that may affect future generatio
addressed gonadal shielding only. Th
ing in the April 2018 version of title 2

Keywords: gonadal shielding, patient safety, patient shielding, radiation, shielding

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RADIATION SENSIBILITIES

RICHARD L. MORIN, PhD, DONALD P. FRUSH, MD

Reconsidering the Value of Gonadal Shielding During Abdominal/Pelvic Radiography

Keith J. Strauss, MSc, Eric L. Gingold, PhD, Donald P. Frush, MD

Shielding the gonads, especially when imaging children with ionizing radiation, has been widely accepted as good radiologic practice since it was introduced approximately 60 years ago [1, 2], when some of the first estimates of radiation dose to the reproductive organs were presented [3, 4]. Less than 10 years ago, some began questioning the value of this "best" practice [5]. In this column we address a few basic questions about the efficacy of gonadal contact shielding.

Do accurately placed shields reduce the dose received by reproductive organs? A gonadal shield on an adult male phantom reduced the dose to the testes during manual pelvic exposures by 36% in a recent study (from 254 to 186 μGy, a savings equal to 8 days of natural background radiation) [6]. The shield reduced the dose from primary x-rays, but the majority of the gonadal dose is from internal scatter radiation, unaffected by the shield. Furthermore, as the gap between the shield on the surface of the body and the gonads increases, the ratio of scatter to primary dose to the gonads increases. This reduces the effectiveness of a shield for the ovaries at a depth below the surface. This problem is compounded by the variance in the actual location of the ovaries within the abdomen [7]. These data suggest that the effectiveness of the shield for the ovaries may be less than 20%.

Can a shield be placed accurately over the reproductive organs without interfering with critical anatomy? Anatomic variance in the location of the ovaries does exist, and accurate placement of shields is challenging [7]. However, the testes can be accurately located and shielded; a recent article concluded that the continued shielding of adult male gonads during radiologic imaging of the pelvis remains a best practice [6]. For both genders, the need to repeat an exposure because the shield obscured critical anatomy results in increased dose to the patient.

Is gonadal shielding effective when automatic exposure control (AEC) is used? The majority of radiography today, except for children younger than 5 years, is performed using AEC. The exposure automatically terminates when a predetermined radiation dose is received by sensors in front of the image receptor. This manages the radiation dose to the patient required to provide a good-quality image. If the shadow of gonadal shielding impinges on the AEC sensor to any degree, attenuation of x-rays that should have reached the AEC sensor occurs. The machine reacts by extending the exposure, which increases the radiation dose to the patient. A recent study [8] verified that increases in dose to the stomach or iliac crest were as great as any decreases to the reproductive organs.

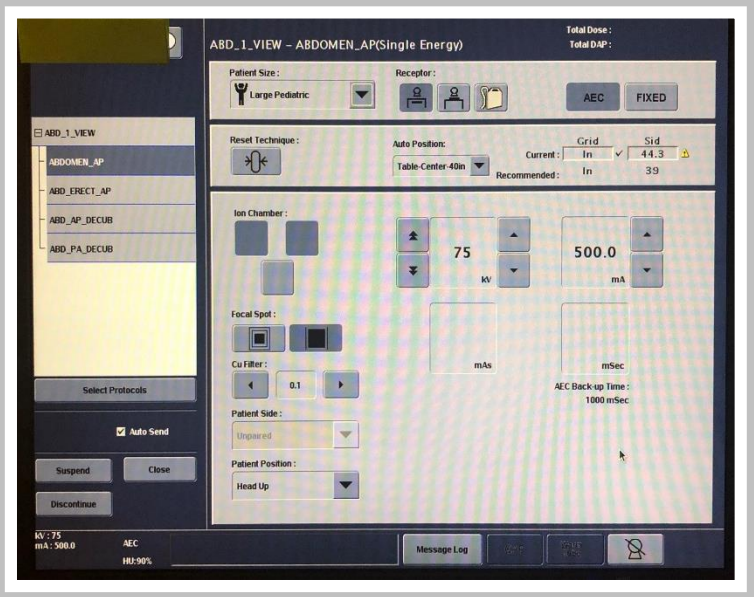
How radiosensitive are reproductive organs? The consensus opinion among radiation biologists regarding this question has shifted. The risk for hereditary effects in humans, based on animal models because genetic effects in humans have never been observed, is lower than previously believed [9]. The International Commission on Radiological Protection [10], in response, reduced the tissue weight factor for the gonads from 0.2 to 0.08 in Publication 103. The weighting factor of the colon, stomach, and bone marrow is currently 0.12 because these abdominal organs are believed to be more radiosensitive than the gonads. Logically, the organs assigned the highest radiosensitivity (highest tissue weighting factor)—bone marrow, colon, lung, stomach, and breast—would need to receive priority with respect to shielding.

Is there a psychological benefit from the use of contact gonadal shields for "radiation protection"? Some patients and/or their parents expect to be shielded when imaged. "Peace of mind" was derived from shielding practices during their previous imaging. These patients may have been told that shielding provided important protection during their examinations. This may cause

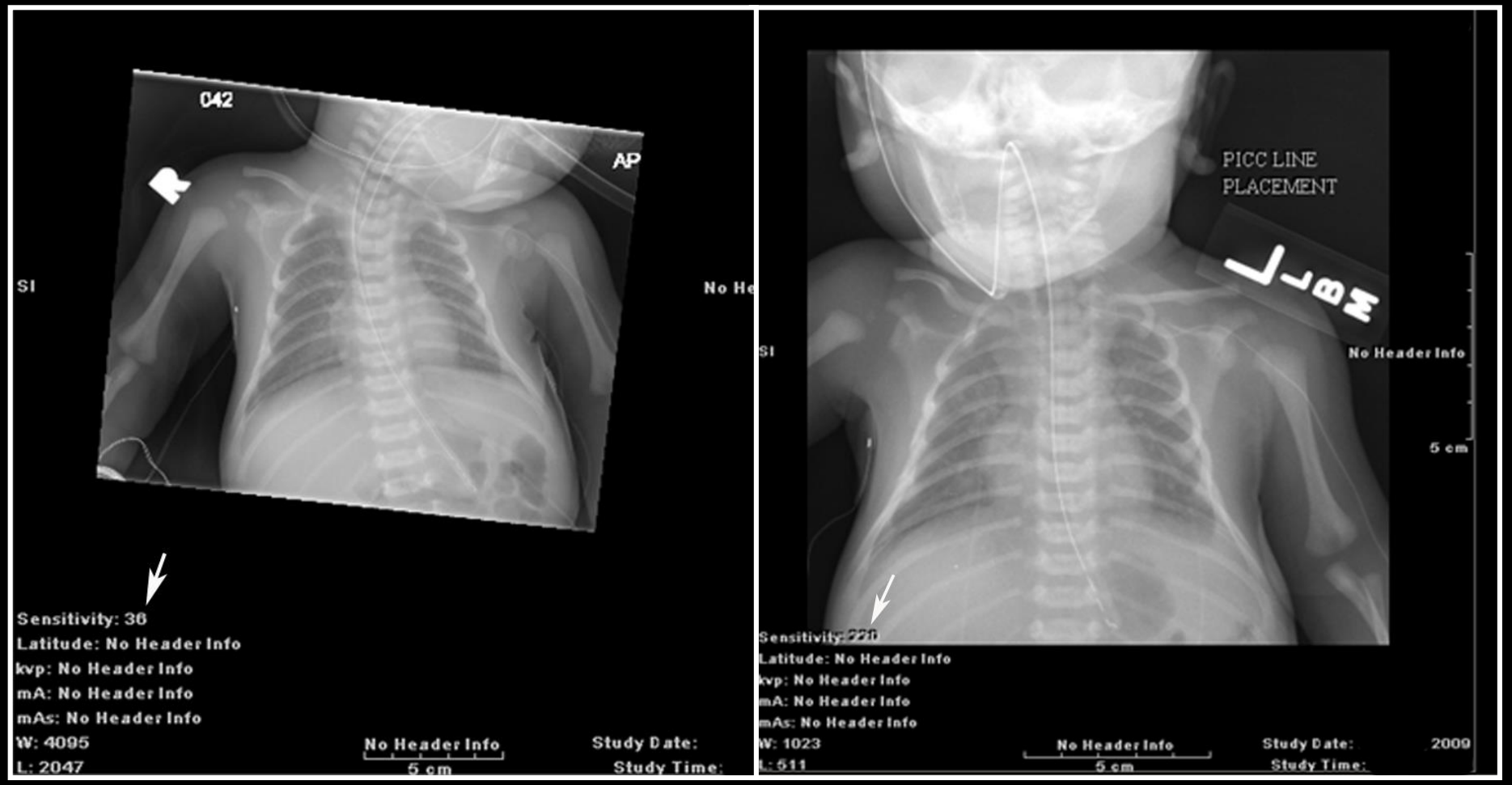
0146-8146/17/$36.00 ■ http://dx.doi.org/10.1016/j.jacr.2017.06.018

Radiologist Perspectives for Radiography

- Consistent
- Adherence to standard performance (# views, collimation, projections, annotation, etc)
- Trust that shielding use in accordance with professional standards
  - Out of site, out of mind
- Image quality
  - No complaints that “too good”
- Radiation dose…?



EI? DI? …So dose metrics in radiography relatively unrecognized; dose in radiography not emphasized



Effectiveness of Gonadal Shields

- **Karami et al (Meta-analysis) Arch Iran Med. 2017;20:113-23**

  Failure to fully cover gonads 52% of the time in males and 85% females

- **Bardo et al Pediatr Radiol 2009;39: 253**
  - **0 - 20% reduction**
  - **Scatter x-rays reach gonads and deliver 80 – 90% of the original dose**
  - ***Varied location of ovaries more than 50% of the time places ovary outside region of primary shielding***

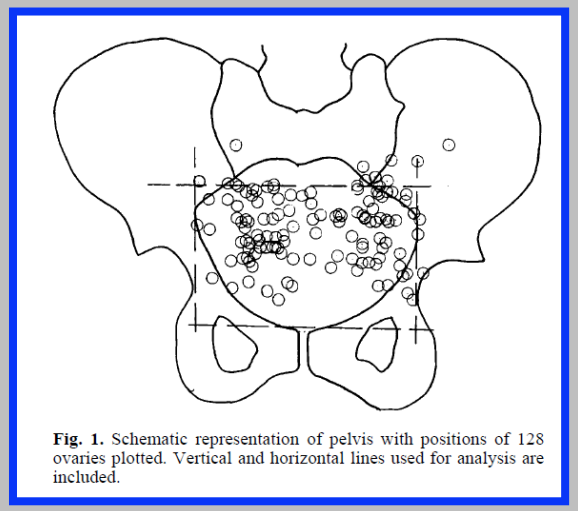
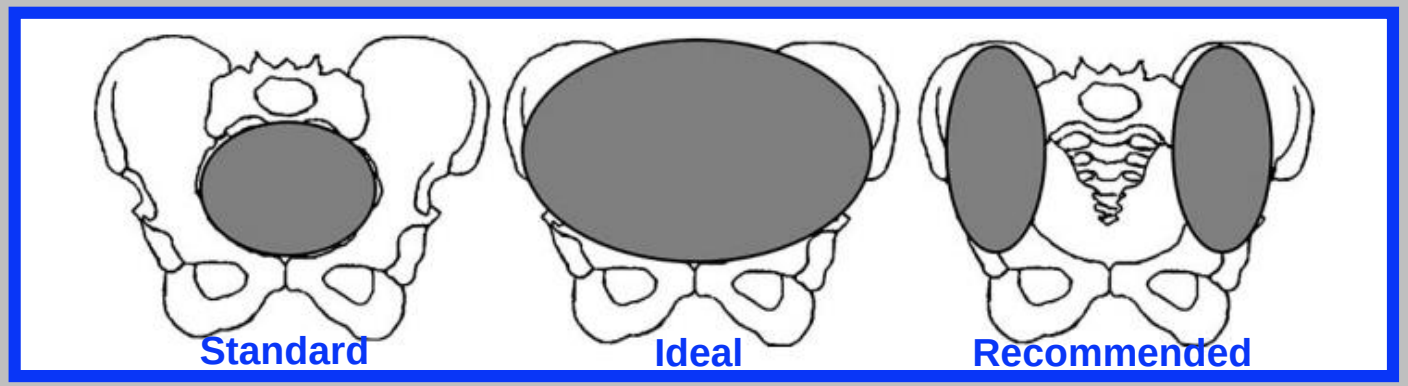


Fig. 1. Schematic representation of pelvis with positions of 128 ovaries plotted. Vertical and horizontal lines used for analysis are included.



Featherstone et al Clinical Oncology (1999)11:393–397

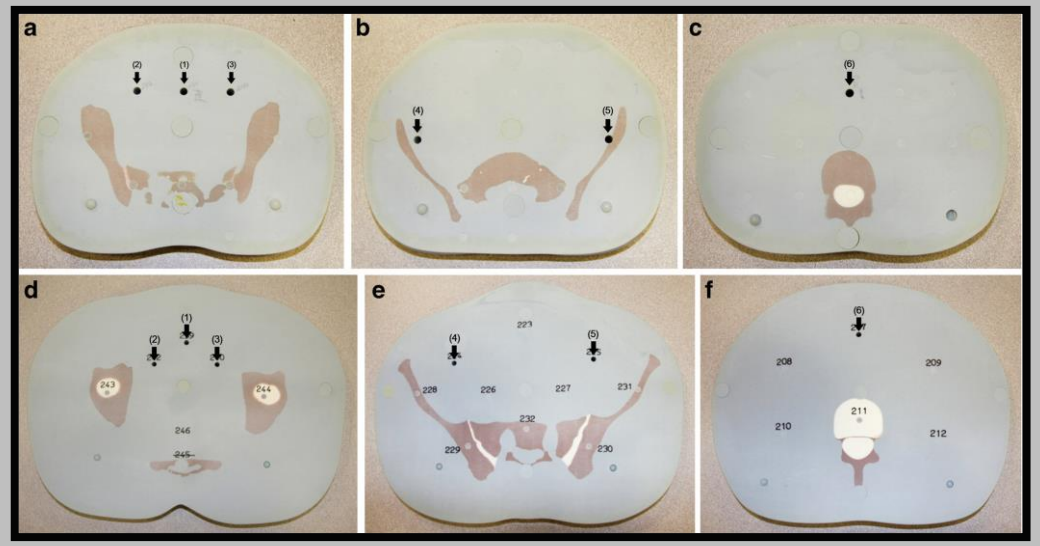
Automatic Exposure Control

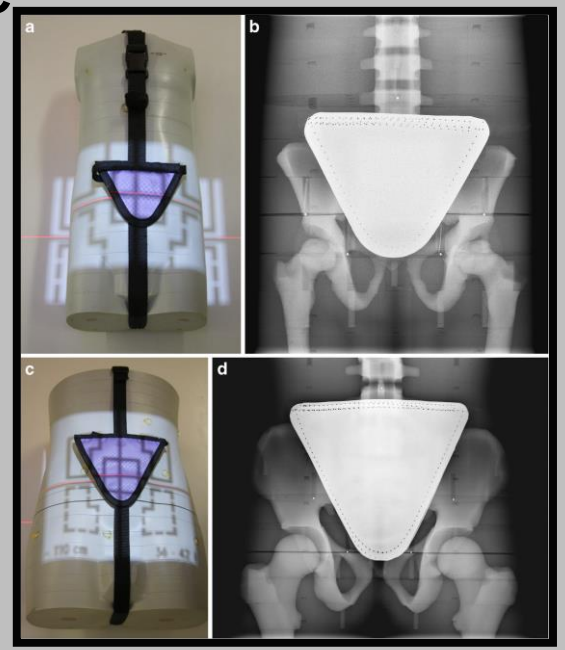
- AEC terminates exposure when target dose received by AEC sensor: valuable and familiar technology
- Not to be used in very small children: use manual/fixed technique

Kaplan et al. Pediatr Radiol (2018) 48:227-34. Anthropomorphic phantoms, shielding, AEC

5 yo

Adult





Automatic Exposure Control

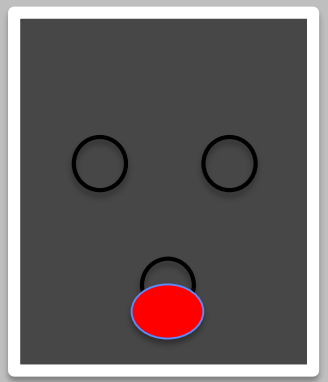
- **Gonadal shield shadowing sensor may elevate patient dose[1]**
  - Increase dependent on degree of shadowing
  - DAP increased 60% (5 yo) and 147% (adult) anthropomorphic phantoms
  - Colon and stomach organ dose increased 21 – 51% and 17 – 100% in 5 yo and adult, with

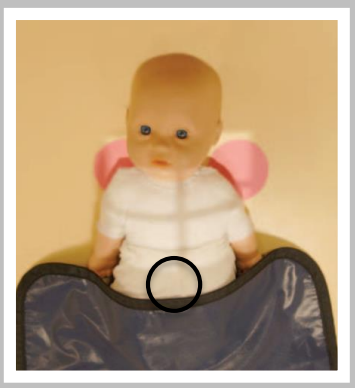
    ICRP weighting factors greater than gonads

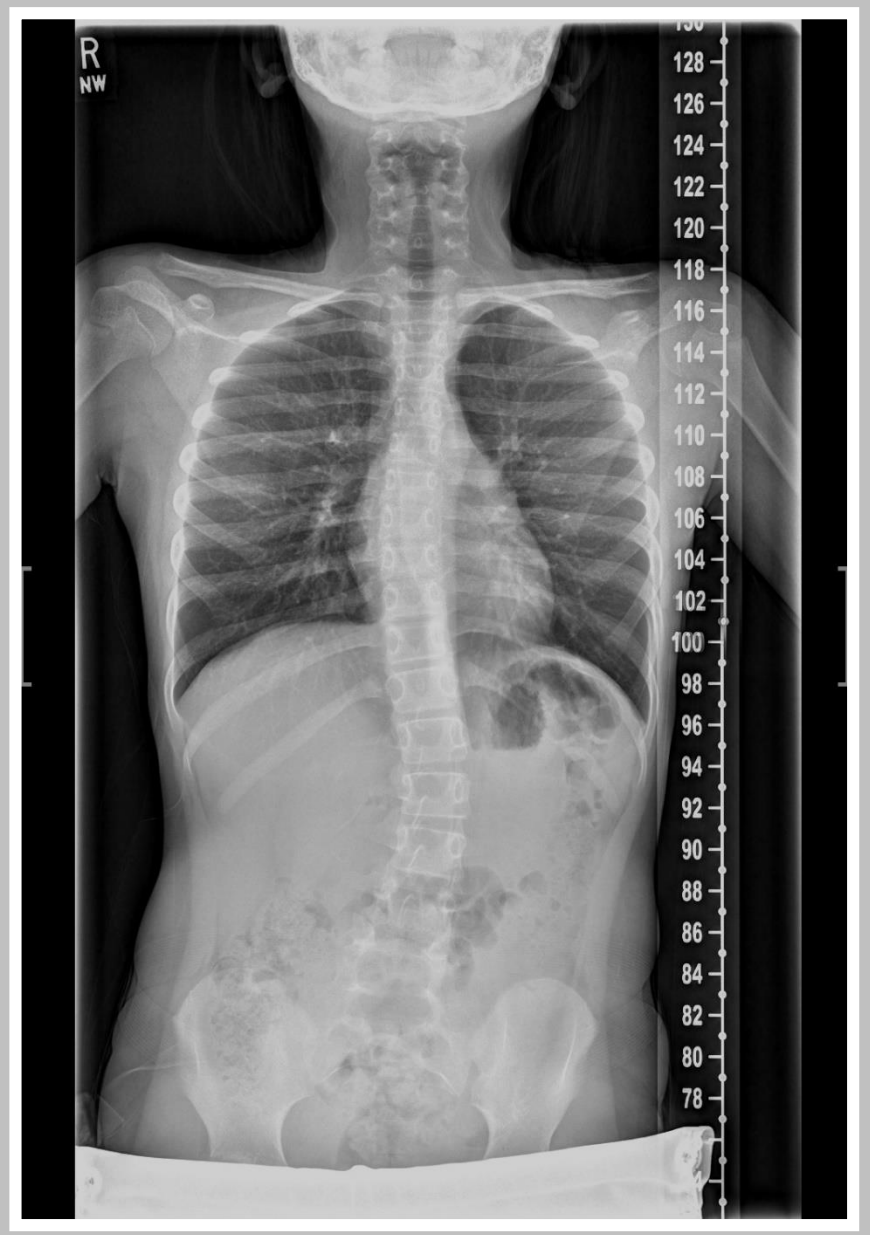
- ***"Guidelines state that a female gonadal shield should not be used in conjunction with AEC,…but use of AEC is so ubiquitous and gonadal shielding so error-prone … that it is likely the two techniques are at times combined."[1]***

[1]Kaplan et al. Pediatr Radiol (2018) 48:227-34

Courtesy Keith Strauss (modified)



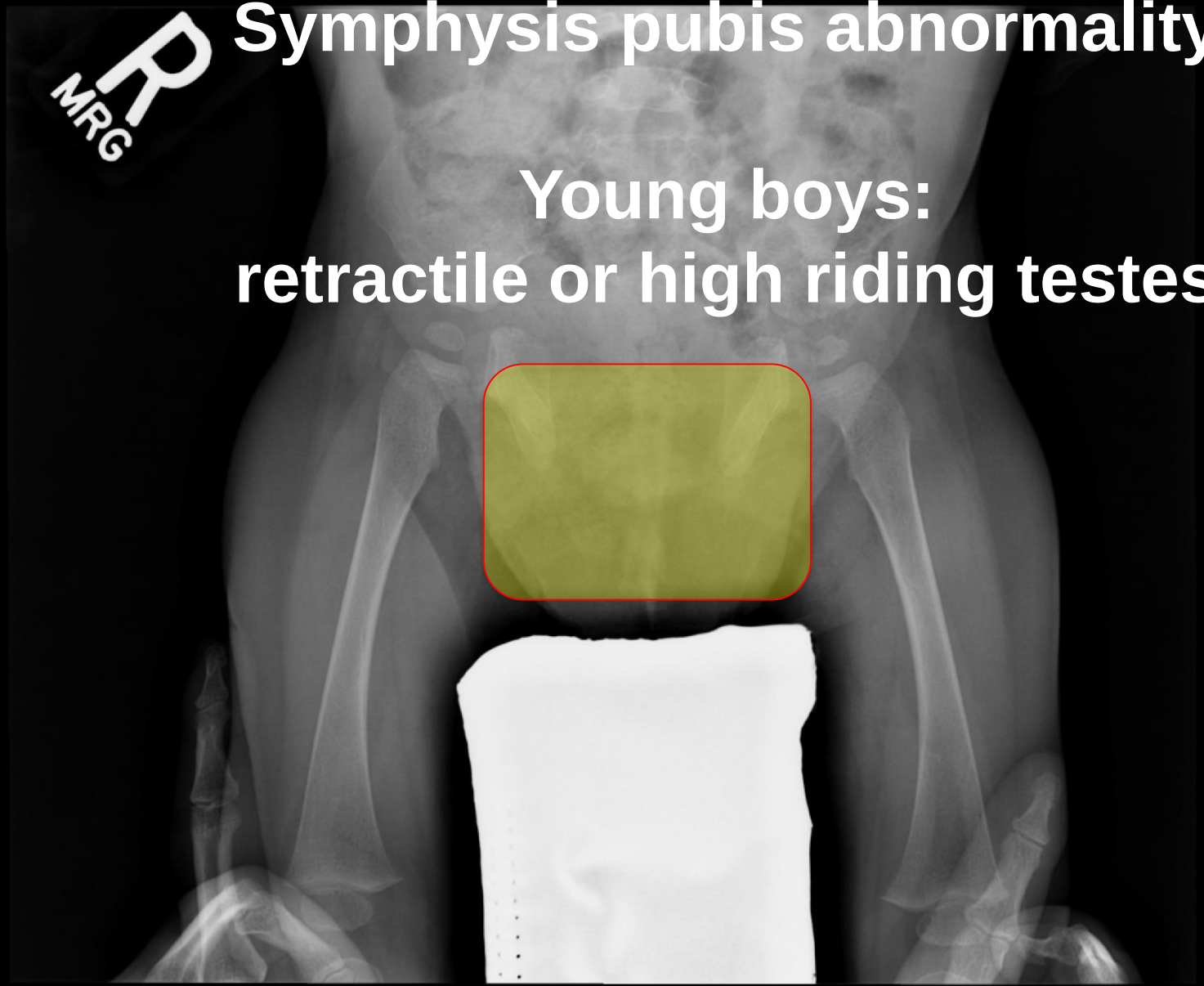




Remember: not prohibition for gonadal shielding rather a *prescription* when use is warranted. *So shielding can be used.*

And there are issues with overall shielding in this scoliosis evaluation

Symphysis pubis abnormality

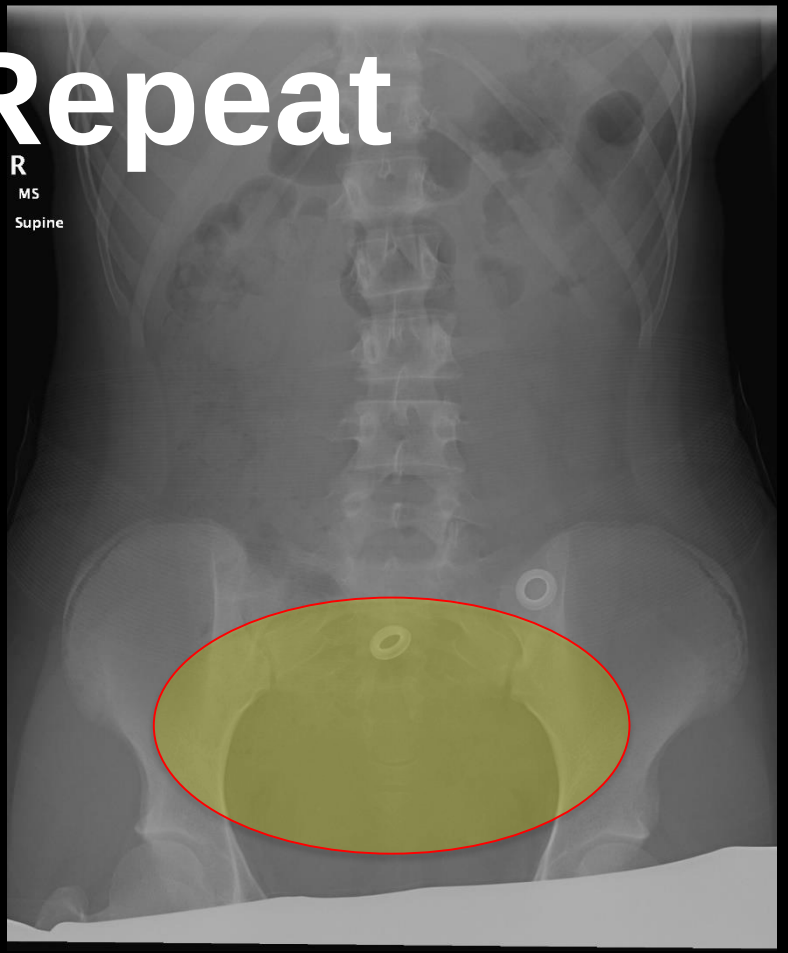


Young boys:
retractile or high riding testes

13 yo female: abdominal pain.

Moved…

Repeat

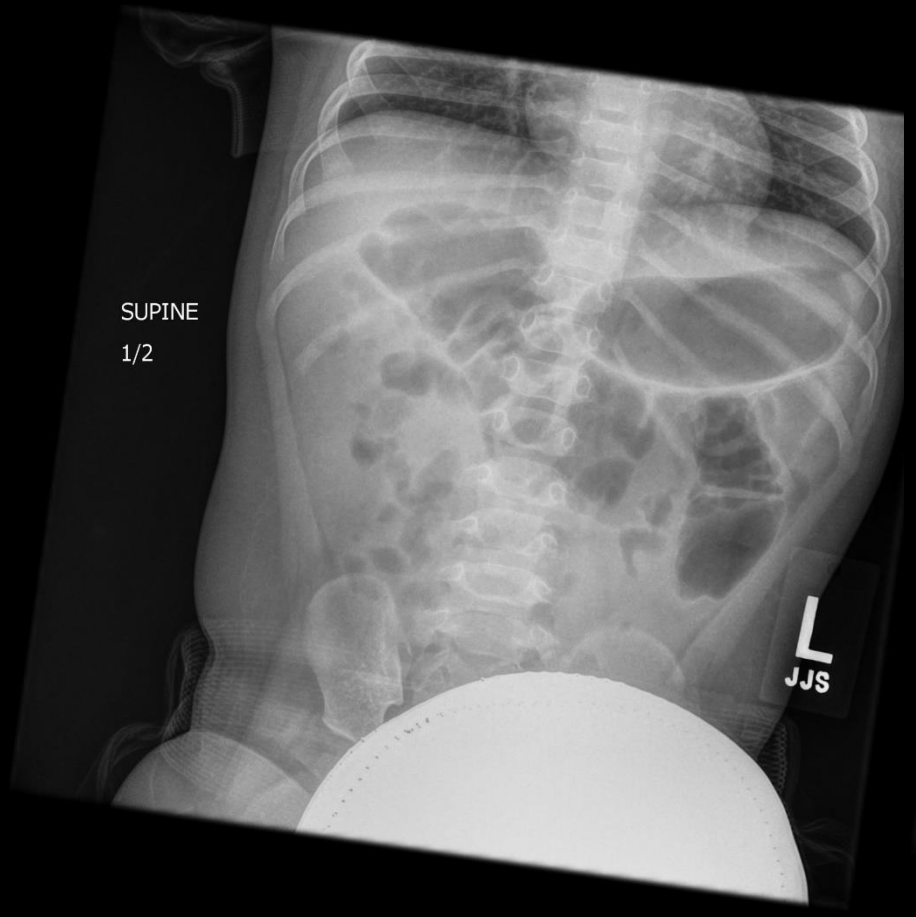


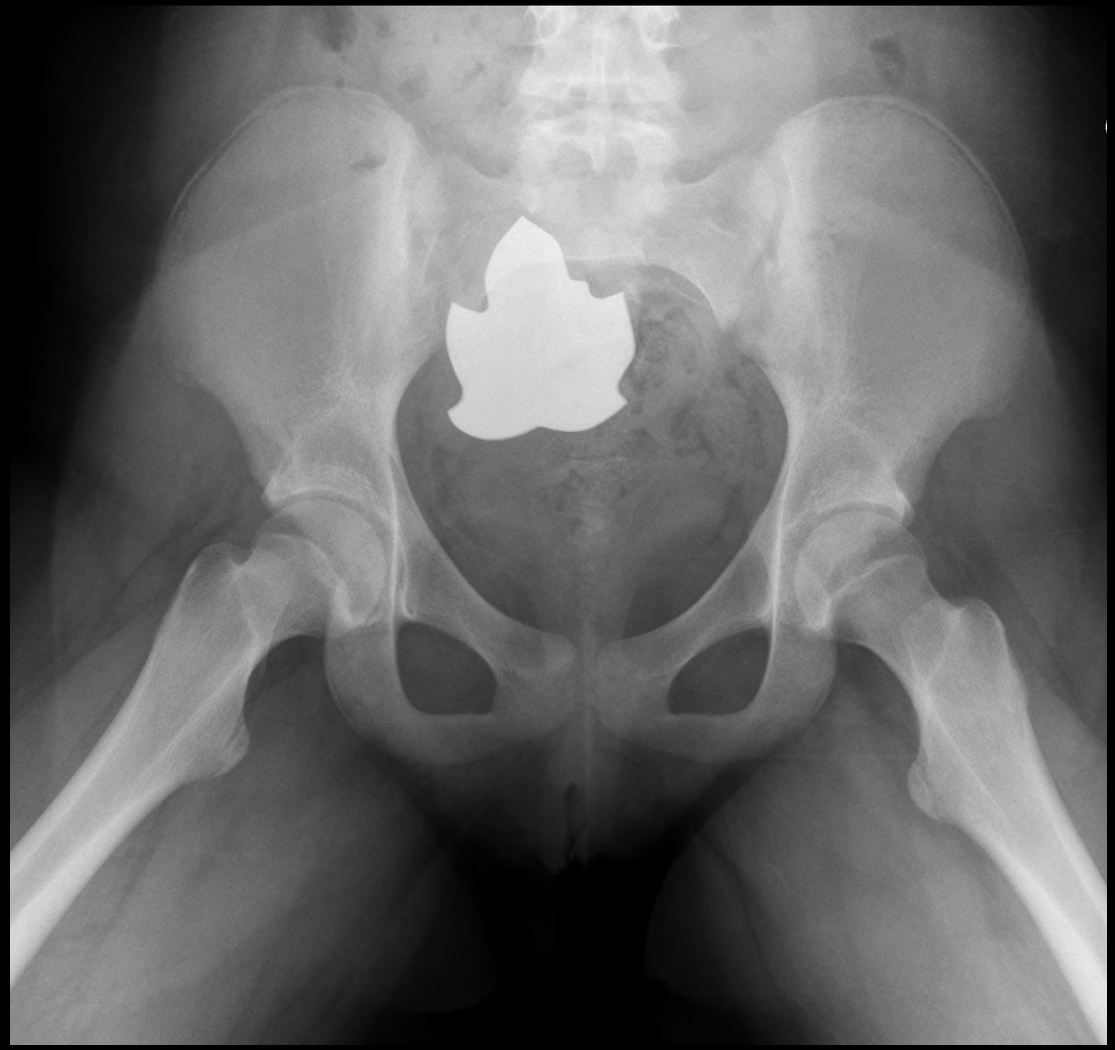
Gonads shielded?

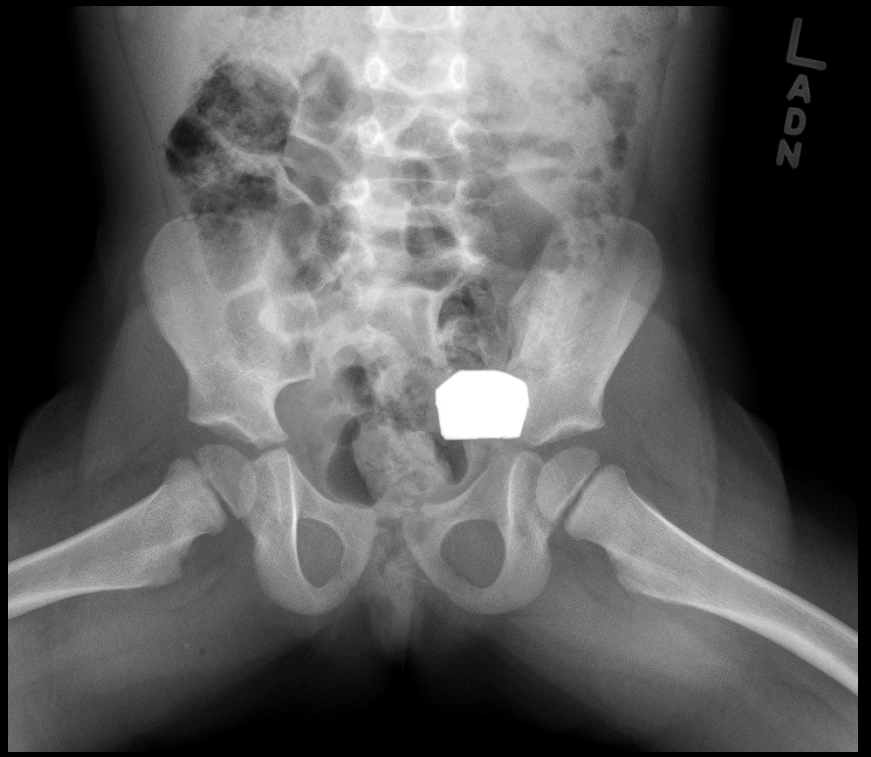
Repeated left femur true lateral

Upright upper and lower “KUB”

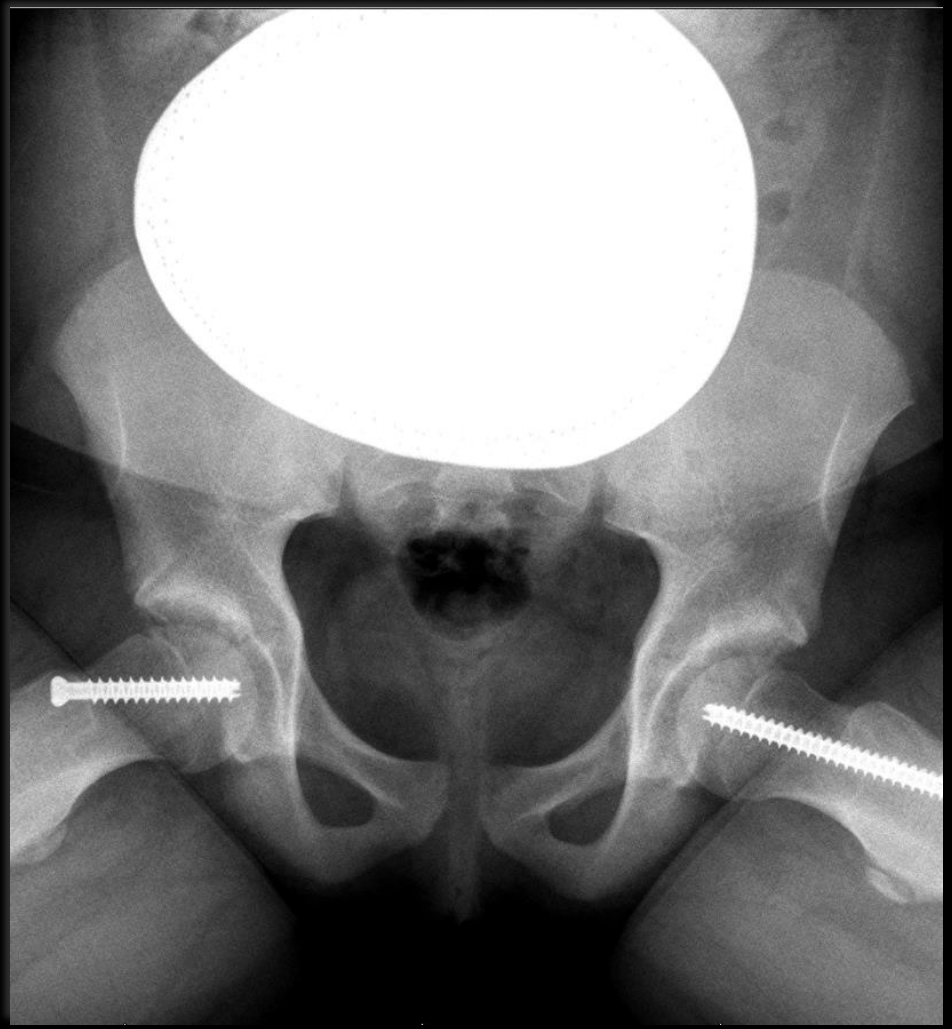
Supine upper and lower “KUB”







Courtesy Summer Kaplan, MD CHOP



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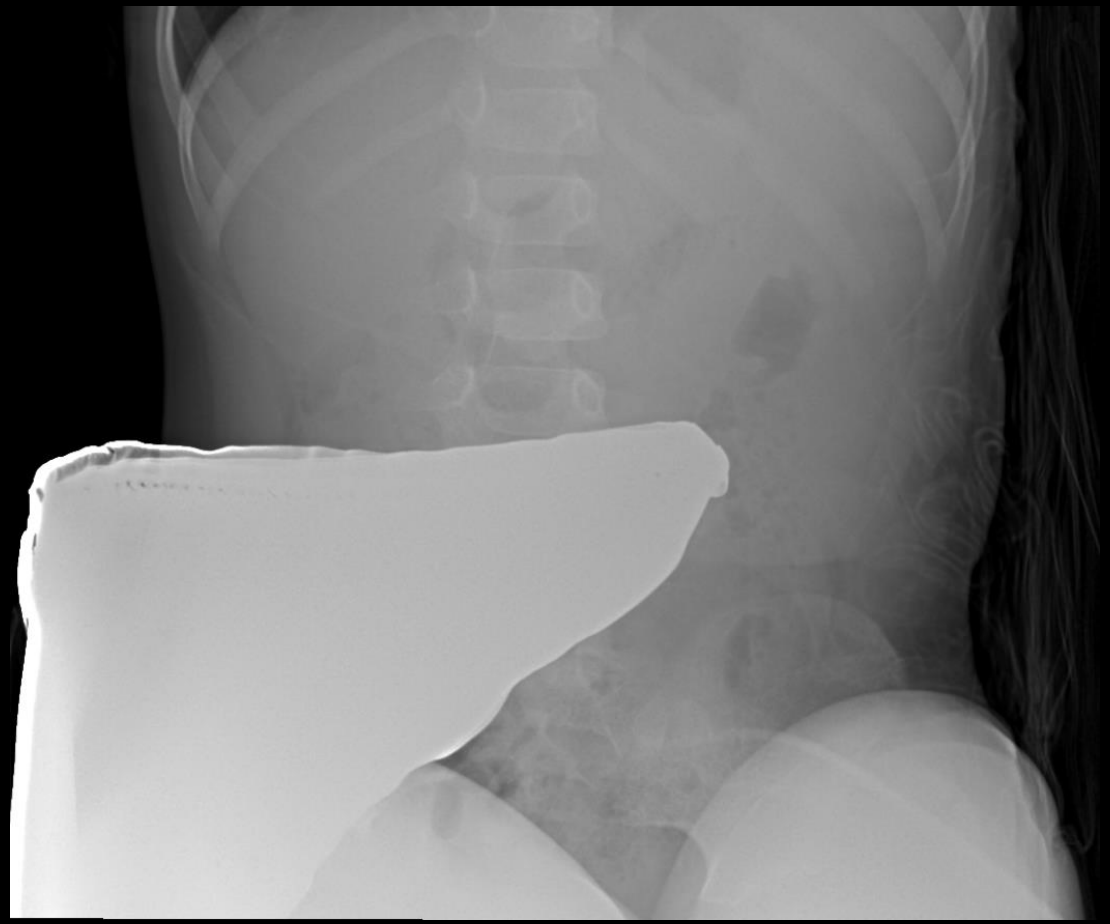
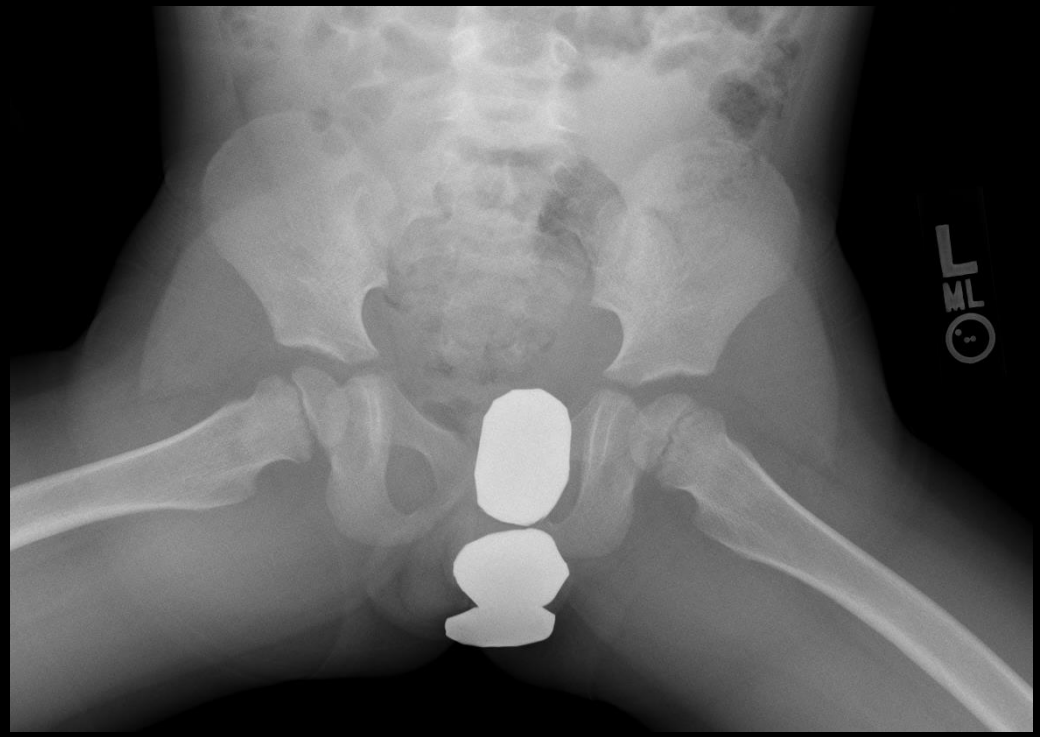
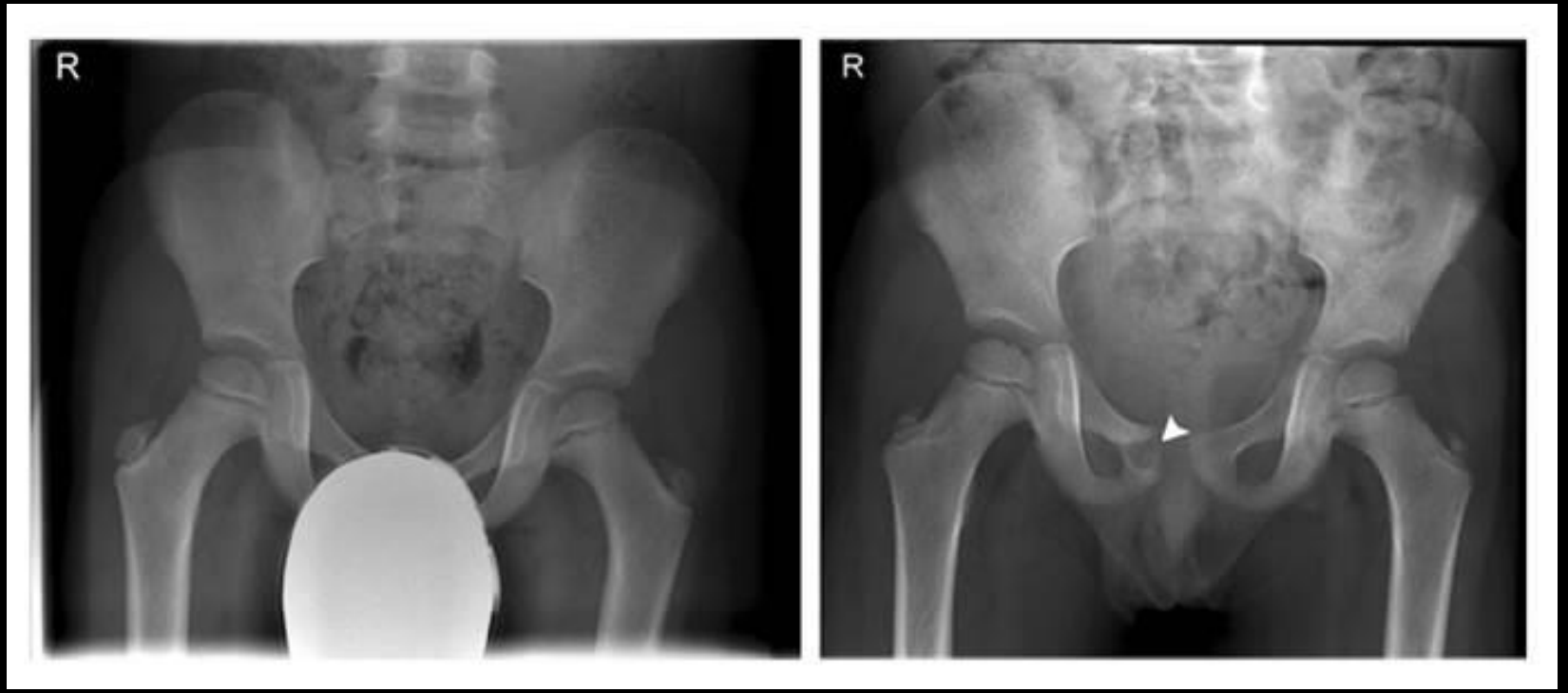




Courtesy Summer Kaplan, MD CHOP

Frantzen et al. Insights Imaging; 2012: 3:23-32



Osteomyelitis

Difficulties in the Clinical Environment

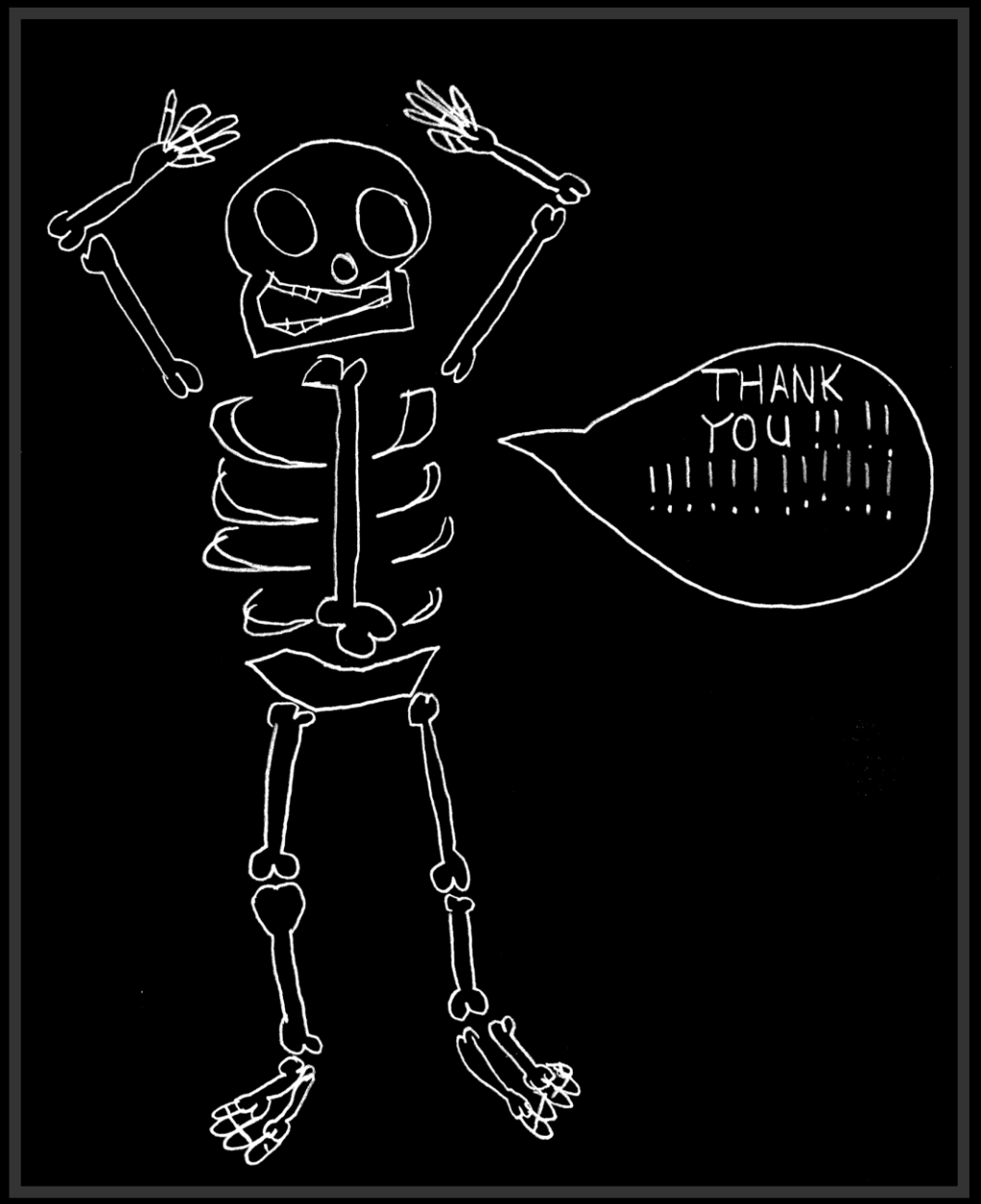
- Expectations and traditions
- Easy to be judgmental: *avoid blame*
- Radiologists are relatively disconnected
- When is diagnostic potential compromised?
- Who decides?
- Current regs and guidelines are not always in synchrony with practice
- Differing professional practice with shielding (eg shielding during dental radiography)

Summary

- **Radiography deserves more investment in dose and quality assessment**
- **Radiologists at minimum *must support* change in practice of routine shielding**
- **Expertise of technologists and medical physicists is essential**
- **Communication/deployment of practice change must be mindful**
- **And…**

Don’t forget the (other) basics…

The “chabdomextremity” film


THANK YOU!!!!!!!!!!!!!!!!