# A Review of Technical Motivations Behind Discontinuing Gonadal Shielding


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# Introduction

- Define gonadal shielding
- Dose reduction of ‘ideal’ shielding
  - Impact of additional filtration in x-ray beam
  - Depth of the gonad
- Factors that reduce effectiveness of ‘ideal’ shields?
  - Scatter radiation
  - Challenges of gonadal shield positioning and negative impact on ‘ideal’ shielding
- Radio-Sensitivity of the gonads?

# What is Gonadal Shielding?

- Placement of a shield, typically Lead equivalent material, on the surface of the patient to directly shadow and protect the male or female gonads from ionizing radiation beneath the shield.
- Practice began in the early 1950s.[1]


1. Magnusson W. A device for the protection of the testicle in roentgen examination of adjacent organs and bones. *Acta Radiol*. 1952; 37(3-4):288-290

# Historical Perspective

- Radiation doses from diagnostic x-ray examinations are ~ 20 - 25[1] times less radiation today: 1951 vs 2020
  - Adult KUB: 1951 ~ 11 – 12 mGy[2]
    2020 ~ 0.5 mGy air Kerma
  - Newborn KUB: 1951 ~ 1.4 mGy[3]
    2020 ~ 0.07 mGy air Kerma

[1]Jeukens C, et.al. Gonadal shielding in pelvic radiography: modern optimized x-ray systems might allow discontinuance. Insights Imaging. 2020:11(1):15.
[2]Handloser JS, Love RA. Radiation Doses from Diagnostic Studies. Radiology 57: 1951, pp. 252-254.
[3]Billings MS, Norman A, Greenfield MA. Gonad Dose During Routine Roentgenography 69: 1957, pp. 37-41.

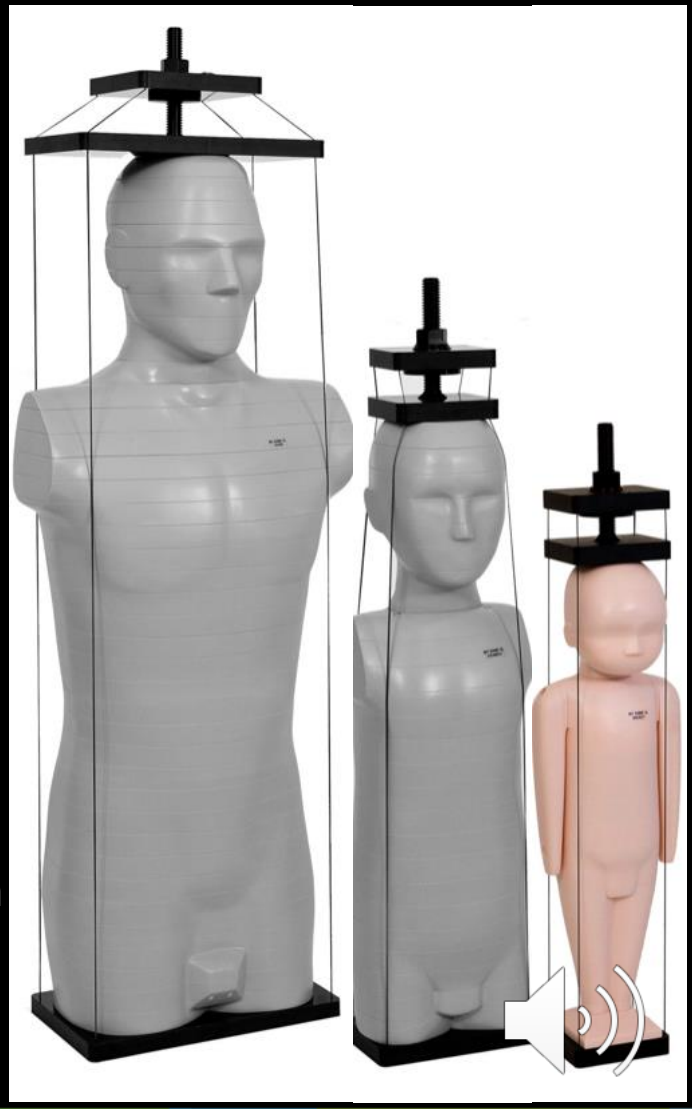
# How Effective are Properly Aligned Gonadal Shields?

# How Effective are Properly Aligned Gonadal Shields?

## Abdominal Doses with Gonadal Shields: Monte Carlo Simulation[1]

- Three ATOM CIRS anthropomorphic Phantoms
  - Contain tissue equivalent major organs

| | AP (cm) | LAT (cm) |
|---|---|---|
| • Adult male | 23 | 32 |
| • 5 yr-old child | 14 | 15 |
| • Newborn | 9 | 10.5 |



1. Somasundaram E, et.al. Achievable dose reductions with gonadal shielding for children and adults during abdominal/pelvic examinations: a monte carlo simulation. Med Phys (in press)

# Properly Aligned Gonadal Shields

## Abdominal Doses with Gonadal Shields: Monte Carlo Simulation[1]

- Three Circular shields equivalent to 0.5 mm Pb

| | Radius | Area |
|---|---|---|
| • Adult male | 4.2 cm | 55 $cm^2$ |
| • 5 yr-old child | 3.6 cm | 40 $cm^2$ |
| • Newborn | 2.5 cm | 20 $cm^2$ |

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# Properly Aligned Gonadal Shields

## Abdominal Doses with Gonadal Shields: Monte Carlo Simulation[1]

- **Clinical X-ray Field Areas**

  - Adult male 1376 $cm^2$
  - 5 yr-old child 459 $cm^2$
  - Newborn 126 $cm^2$

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# Properly Aligned Gonadal Shields

## Abdominal Doses with Gonadal Shields: Monte Carlo Simulation[1]

- **Standard Beam Filtration**

| | kVp | mAs | Patient Air Kerma (mGy) |
|---|---|---|---|
| Adult male | 87 | 10 | 1.6 |
| 5 yr-old child | 79 | 4 | 0.39 |
| Newborn | 77 | 2 | 0.17 |

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# Properly Aligned Gonadal Shields

## Abdominal Doses with Gonadal Shields: Monte Carlo Simulation[1]

- Added Filtration: 0.1 mm Cu + 1 mm Al

| | kVp | mAs | Patient Air Kerma (mGy) |
|---|---|---|---|
| Adult male | 87 | 16 | 1.2 |
| 5 yr-old child | 79 | 6.3 | 0.28 |
| Newborn | 77 | 3.2 | 0.12 |

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# Properly Aligned Gonadal Shields

## Abdominal Doses with Gonadal Shields: Monte Carlo Simulation[1]

- Radiographic Techniques designed to deliver a constant entrance air Kerma to the image receptor for a given phantom

| | Air Kerma (μGy) at Image Receptor | Entrance Air Kerma Reduction with Added Filter |
|---|---|---|
| Adult male | 3 | 29% |
| 5 yr-old child | 4.5 | 29% |
| Newborn infant | 6 | 29% |

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# Properly Aligned Gonadal Shields

## Abdominal Doses with Gonadal Shields: Monte Carlo Simulation[1]

- Standard Filtration WITHOUT Shield

| | Dose (mGy) | | Percent Depth Dose Reduction |
|---|---|---|---|
| | Ovary | Testes | Ovary/Testes |
| Adult male | 0.54 | 1.81 | 30% |
| 5 yr-old child | 0.16 | 0.45 | 36% |
| Newborn infant | 0.09 | 0.16 | 56% |

Due to shielding of overlying soft tissue. Effect less for small patient

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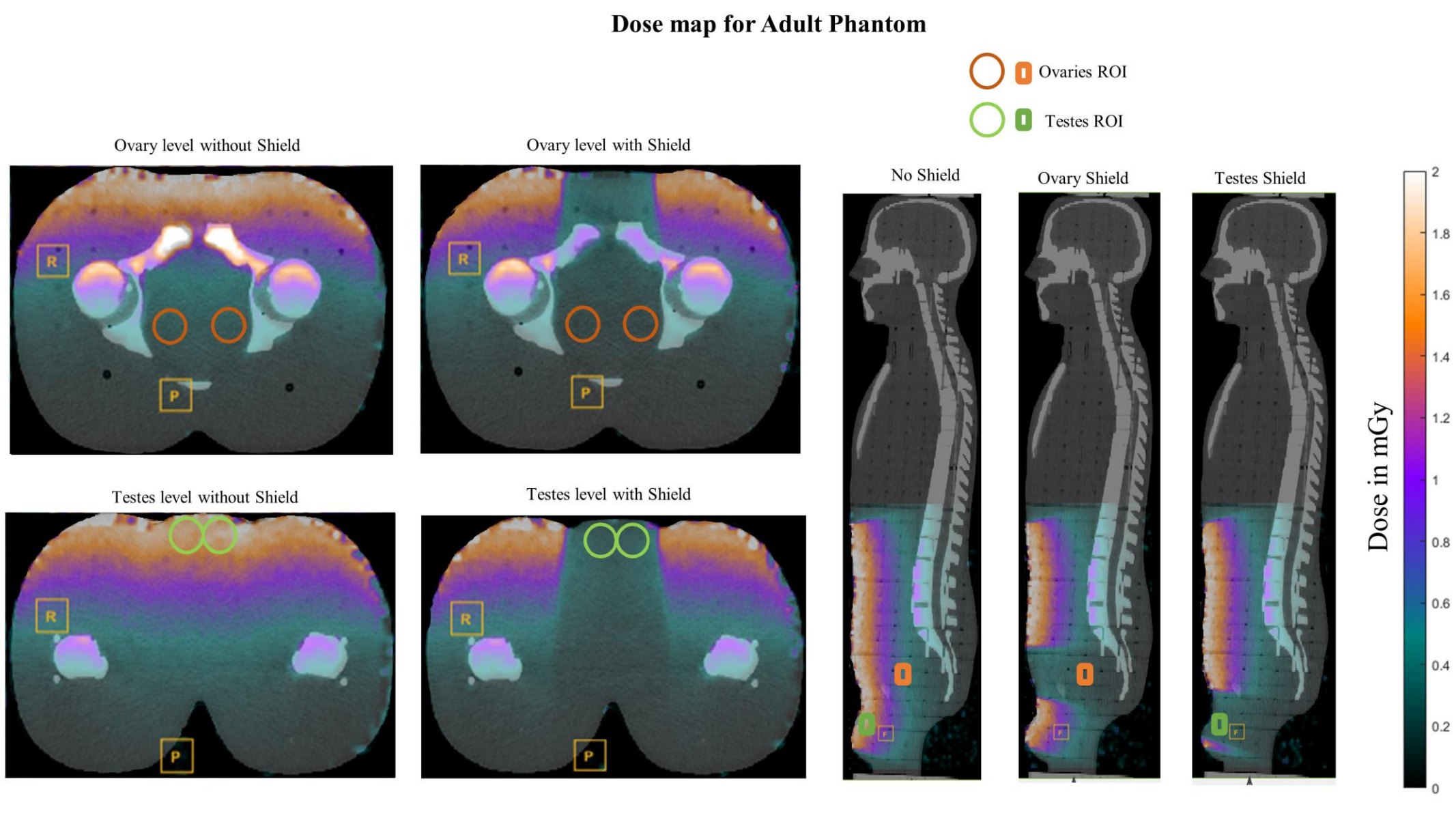
# Properly Aligned Adult Gonadal Shields



# Properly Aligned Gonadal Shields

## Abdominal Doses with Gonadal Shields: Monte Carlo Simulation[1]

- Standard Filtration with Shield

| | Dose (mGy) | | Shielded Percent Reduction | |
|---|---|---|---|---|
| | Ovary | Testes | Ovary | Testes |
| Adult male | 0.23 | 0.28 | 57% | 85% |
| 5 yr-old child | 0.06 | 0.04 | 63% | 91% |
| Newborn infant | 0.02 | 0.02 | 78% | 88% |

**Why is effectiveness of shielding greater for the Testes as opposed to the Ovaries?**

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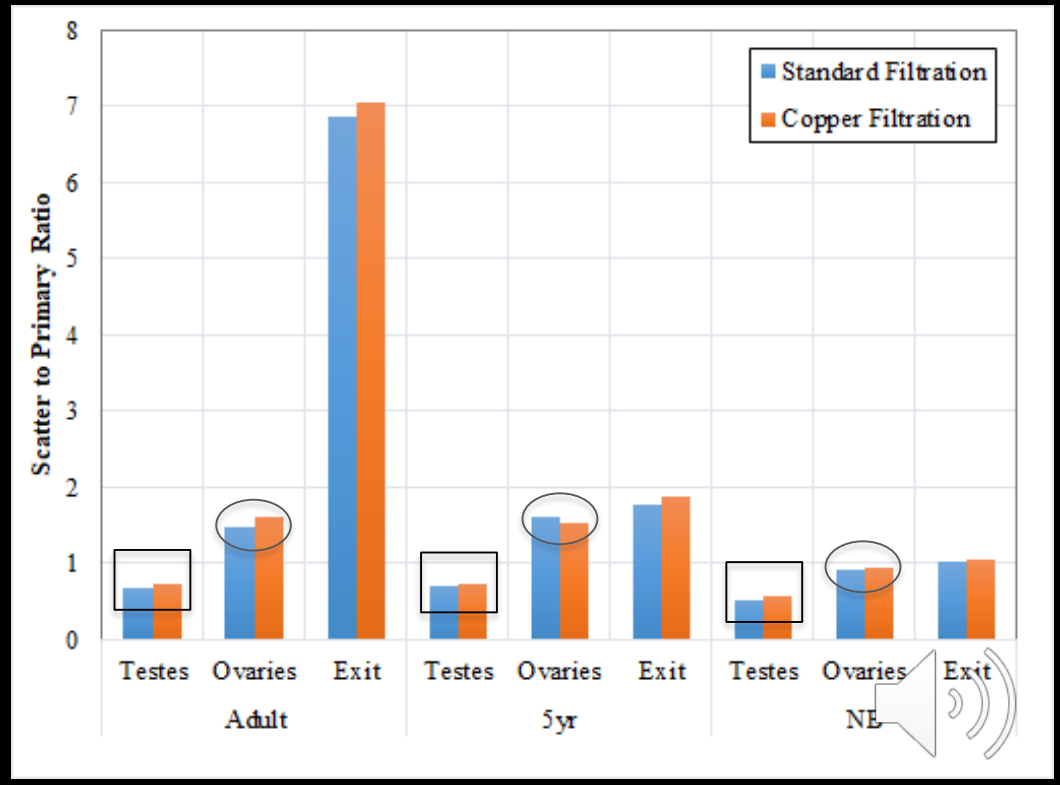
# Properly Aligned Gonadal Shields

- Why is effectiveness of shielding always greater for the **Testes** as opposed to the **Ovaries?**
  - As x-rays penetrate to greater depth, scatter radiation builds up as the primary x-rays scatter and are removed from the x-ray beam
    - **Scatter/Primary** increases with Depth
    - **Phantoms**: S/P = 1 - 1.5 for Ovaries[1]
      S/P = 0.6 for Testes[1]

Dose to **unshielded** Testes substantially due to **primary** while dose to Ovaries substantially due to **scatter**.





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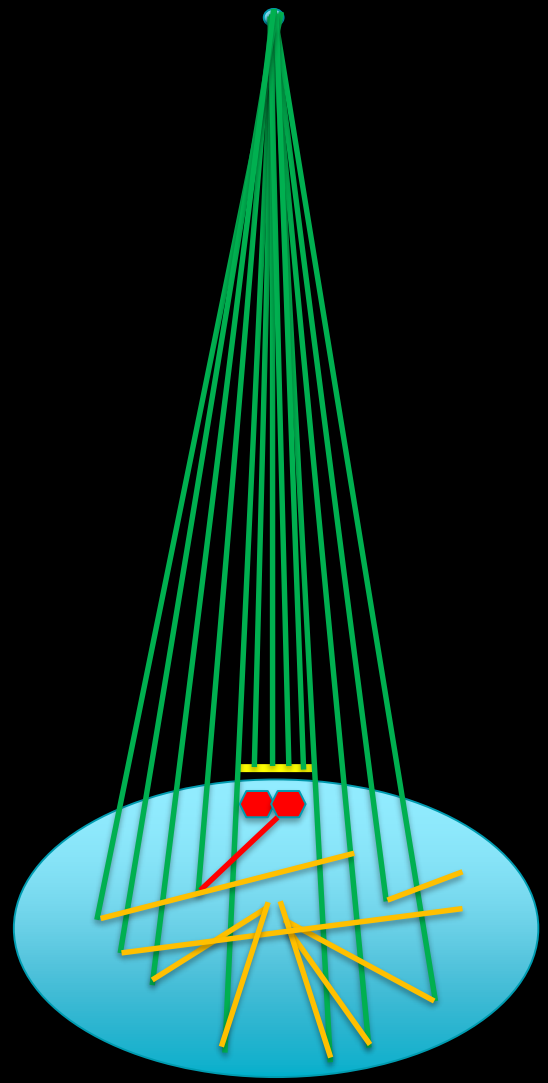
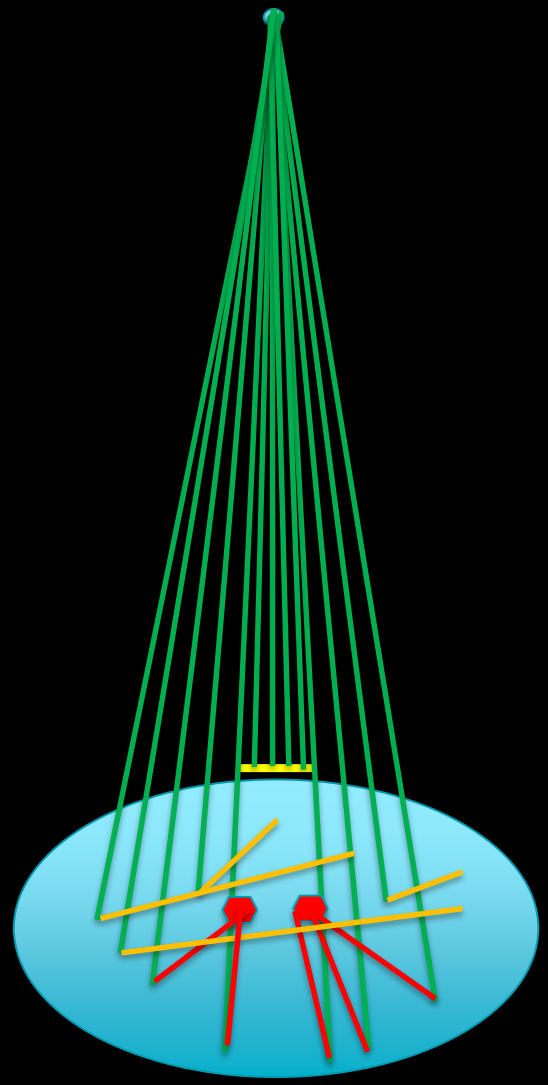
# Properly Aligned Gonadal Shields

- **Male**
  - Testes near surface and close together
  - Shield stops substantially all primary x-rays hitting it,
  - but none of scatter x-rays from outside the shielded area
  - One scattered x-ray of all drawn delivers dose to one of testes.
- **Testes tucked within protected region below the shield protects from all primary and most of scattered x-rays.**



# Properly Aligned Gonadal Shields

- **Female**
  - Ovaries near at mid depth and not necessarily on the midline.
  - Shield stops substantially all primary x-rays hitting it,
  - but none of scatter x-rays from outside the shielded area
  - Five scattered x-rays of all drawn deliver dose to the ovaries.
- **Ovaries are not effectively protected from increased levels of scattered x-rays at mid depth within the patient.**



# Alignment Affects Gonadal Shield Effectiveness

- Prior discussion is about ‘ideal’ performance of gonadal shields which is seldom **clinically** achieved . . .

- **Why?**

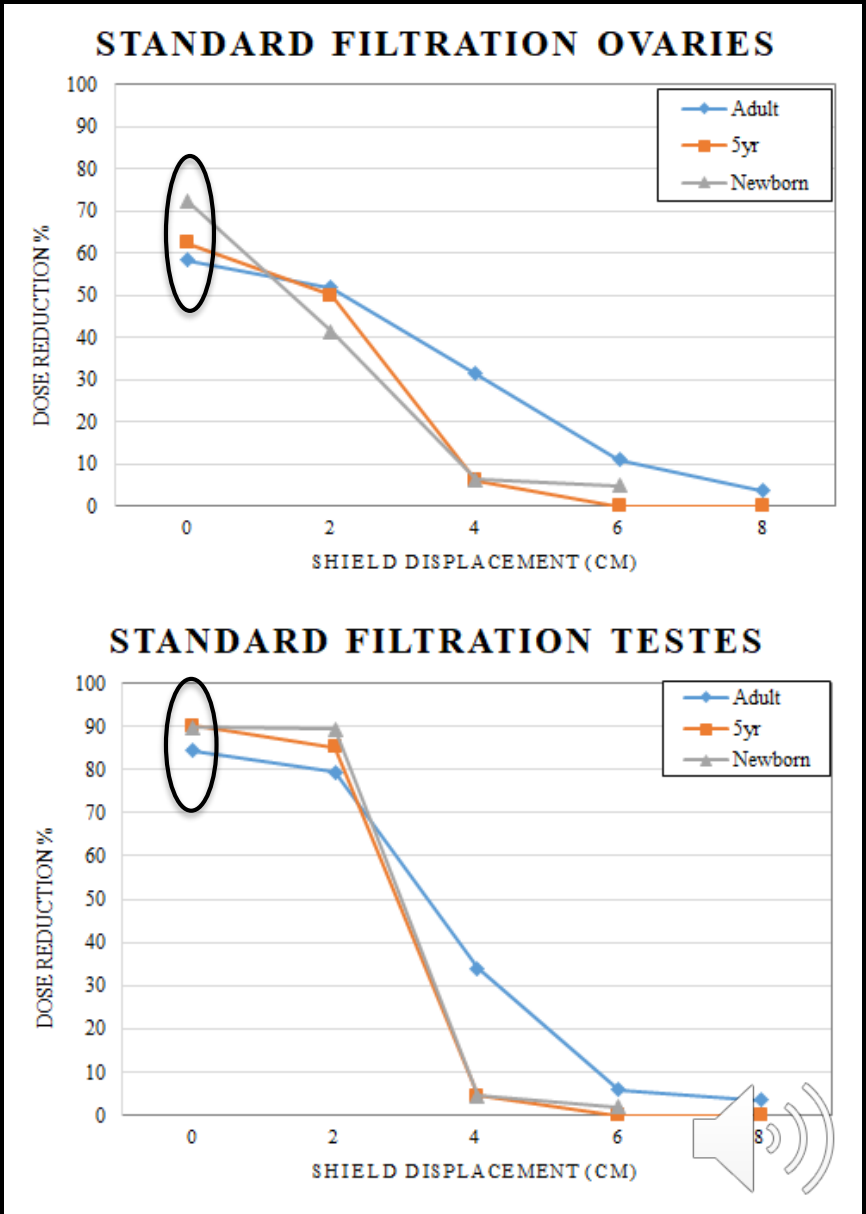
# Alignment Affects Gonadal Shield Effectiveness

- Technologists use protocoled surface landmarks on the patient's body to position gonadal shields,
  - But, the actual location of the gonads varies greatly from patient to patient.
  - Technologist is asked to perform a very difficult task.
- Gonads not fully covered **52%** and **85%** of the time for males and females respectively.[1]

[1]Karami V, Zabihzadeh M, Shams M, et.al. Gonadal shielding during pelvic radiography: a systematic review and meta-analysis. Arcg Urab Ned, 2017;20(2): 113 – 123

# Alignment Affects Gonadal Shield Effectiveness[1]

- **Ideal Shielding:**
  - 58% - 72% reduction for females
  - 85 – 90% reduction for males

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- **Ideal Shielding:**
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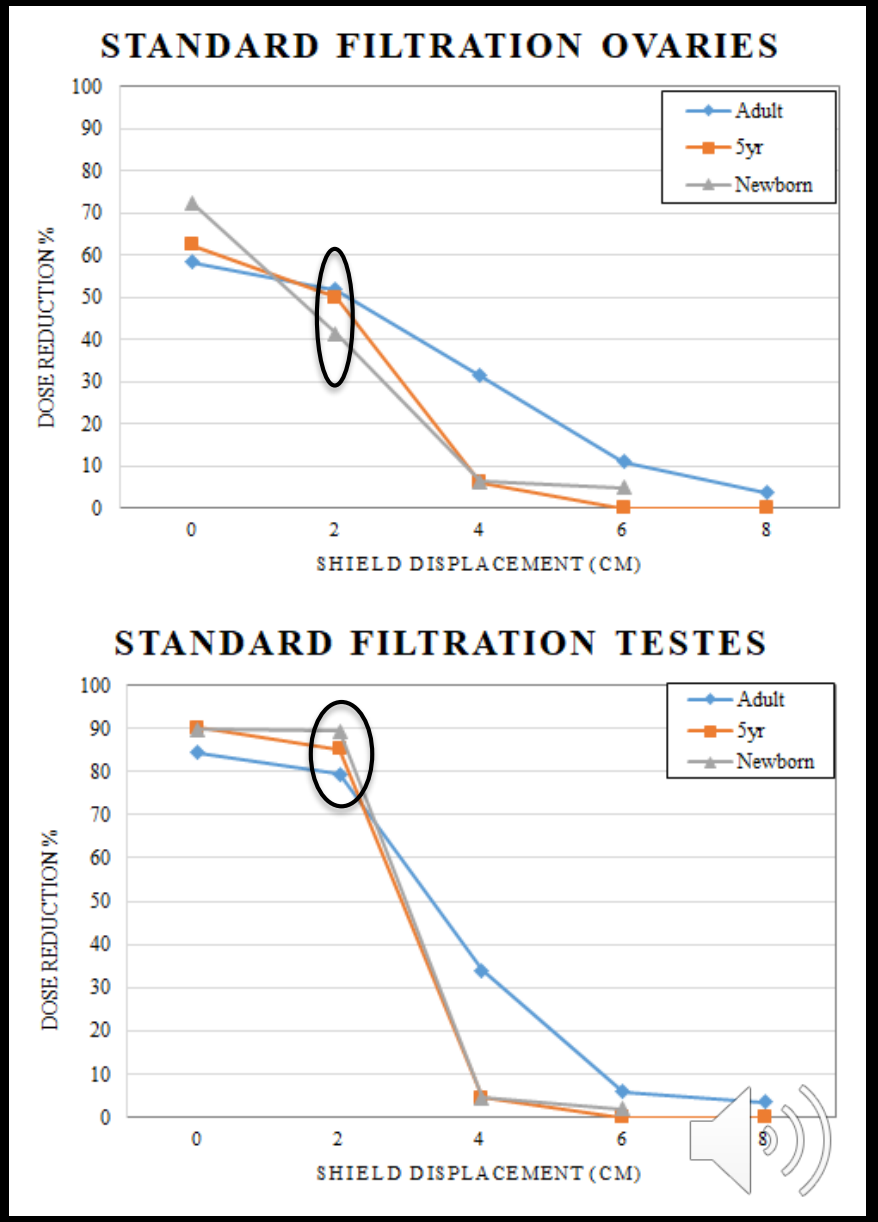
  - 85 – 90% reduction for males
- **Misaligned Shielding:**
  - **2 cm**: small effect for males, 10 – 40% loss of effectiveness for females[1]

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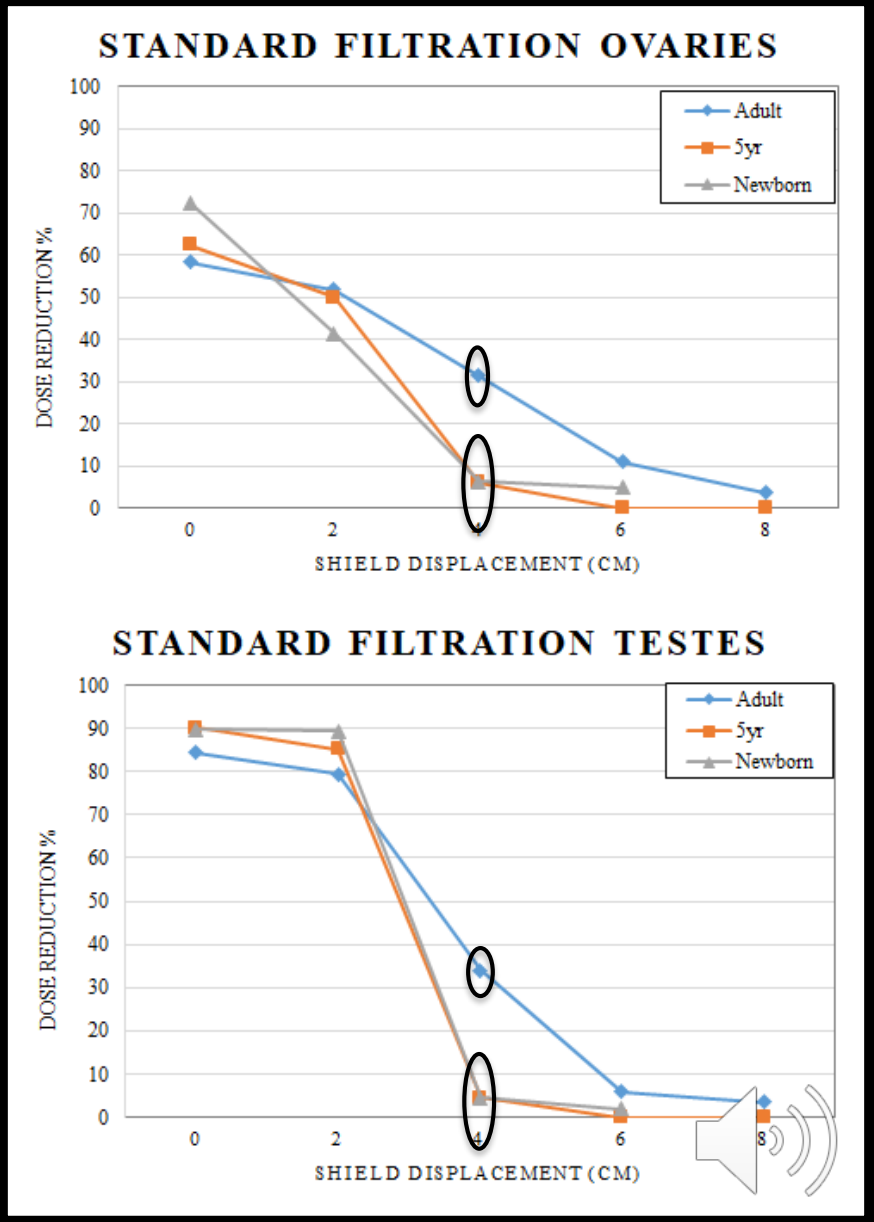
- **Ideal Shielding:**
  - 58% - 72% reduction for females
  - 85 – 90% reduction for males
- **Misaligned Shielding:**
  - **2 cm**: small effect for males, 10 – 40% loss of effectiveness for females
  - **4 cm**: substantially reduced effectiveness for children; **area of shields smaller**
    - Some remaining effect for adults.[1]

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# Reconsidering the Value of Gonadal Shielding

- Believed reduced radiosensitivity of gonads
  - ICRP 103:
    - Gonadal tissue weighting factor reduced: 0.2 to 0.08
    - Colon, stomach, liver, and bone marrow same at 0.12.
  - Why are we shielding a less sensitive organ at the expense of more sensitive organs?

# Reconsidering the Value of Gonadal Shielding

"**Changing a 'tradition' is not easy. . .**
Patients expect . . . the best care possible.

. . . care givers need to . . . help patients understand that their imaging experience should evolve to allow continued deliverance of the best care possible."[1]

[1]Strauss KJ, Gingold EL, Frush DP. Reconsidering the value of gonadal shielding during abdominal/pelvic radiography. J Am Coll Radiol. 2017 Dec; 14(12) pp 1635-6.

# Thank you


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