

# The Fetal RISKS of Ionizing Imaging and MRI (GBCA) Contrast

NASOM, November 14, 2015



**I HAVE NO CONFLICTS**

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# The Fetal RISKS of Ionizing Imaging and MRI (GBCA) Contrast

## Presentation Outline

- Fetal Risk of Ionizing Radiation in Diagnostic Imaging
  - Threshold Risks and the Safe Limit
  - Long Term Risk of Cancer with In Utero Radiation
- MRI Contrast: Fears and Facts

“The INTRIGUE of **ionizing radiation** is that:  
epidemiologic uncertainty, dose variation, miscalculation, and fear  
sway the fetal RISK assessment from  
**irrelevant to REAL”**

# Fetal Radiation In Medical Imaging

## Three Indisputable Facts

FACT 1

### “SAFE” dose for fetal radiation

- Set by NCRP in 1977<sup>1</sup> and EVERYONE still agrees.
- Diagnostic Studies rarely exceed “SAFE” limit
- LARGE safety factor: all defects + timings

**50 mGy = 5 Rad = 50 mSv = Limit of Fetal Safety**

FACT 2

### Threshold/Teratogenic/Tissue Effects

**Do NOT EVER exist BELOW the “Safe” Limit.**

Scarring, cell death, failed migration, spontaneous abortion  
congenital malformation, IUGR, impaired cognition<sup>2</sup>

# Fetal Radiation In Medical Imaging

## Three Indisputable Facts

FACT 3

“The benefits to the mother in diagnosing potentially fatal conditions such as pulmonary embolism, subarachnoid haemorrhage and aortic dissection far outweigh the small, unquantified risk to the fetus”

# RISK below the SAFE Limit

Stochastic Risk = Cancer Risk

**50 mGy = 5 Rad = 50 mSv = Limit of Fetal Safety**

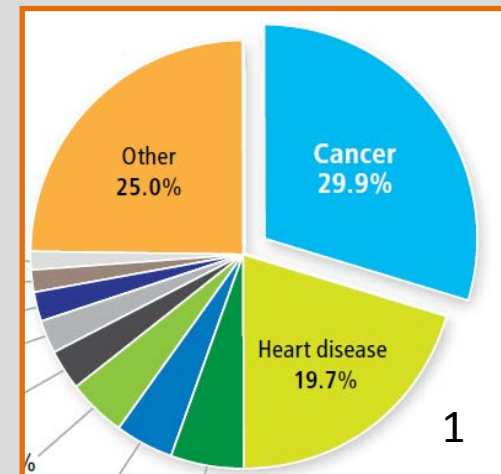
Unlike MRI or US

Radiation tracts through the cell can create ions...

...then a process of **TERRIBLE chance** may follow:

- DNA damage
- Cell Survival and Division
- Acquired cancerous features

- The multi-hit hypothesis of cancer
  - A process of CHANCE and TIME.
  - **Does ionizing diagnostic radiation reduce the time to CANCER?**



Stochastic

# RISK below the SAFE Limit

Stochastic Risk = Cancer Risk

**50 mGy = 5 Rad = 50 mSv = Limit of Fetal Safety**

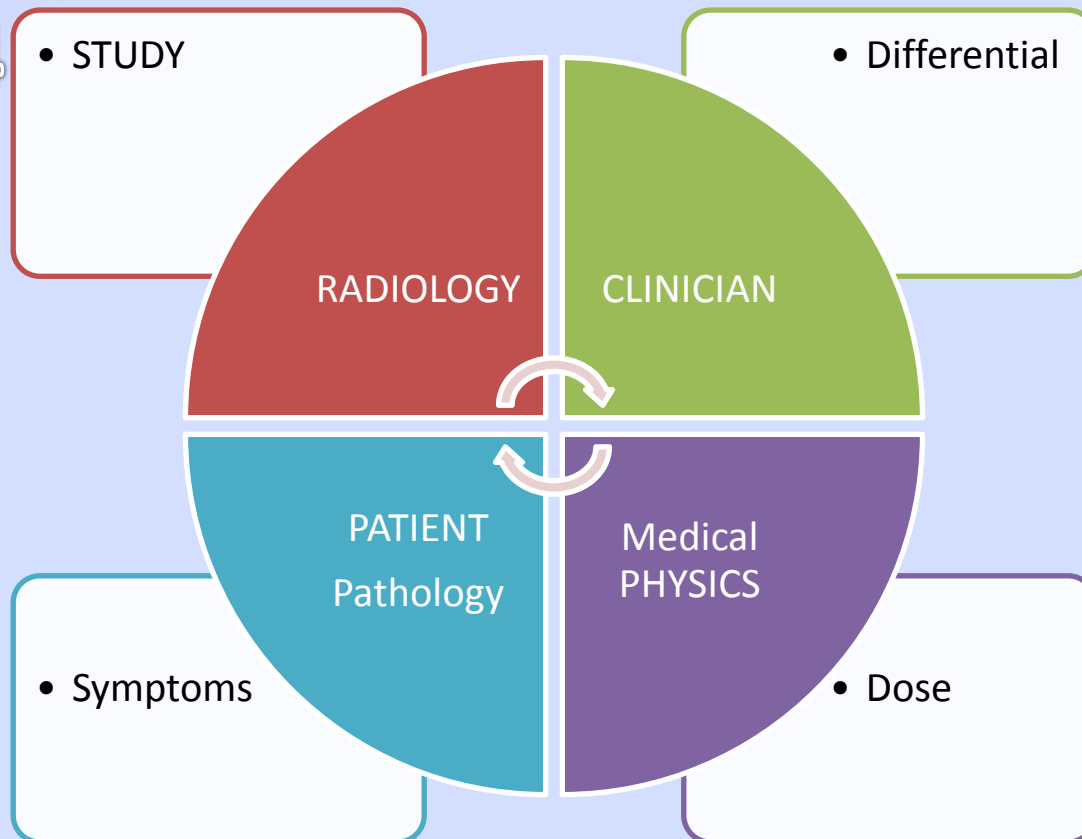
Stochastic

- DOGMA --- ALARA = As low as reasonably achievable
  - ALL radiation can cause HARM
- Linear NO THRESHOLD model
  - Biologic Effects of Ionizing Radiation Study V7
  - United Nations Scientific Committee on the Effects of Atomic Radiation<sup>1</sup>
  - International Commission on Radiologic Protection
  - American College of Radiology
  - +/- NCRP



# DOGMA and The **R** in ALARA: Imaging and Clinical Decision Making

**As Low As **R**easonably Achievable**

**FACT 4**



# What is the Fetal RISK of Cancer from Ionizing Imaging? Guidelines Comparison

Guideline	IntraUterine Exposure Cancer Onset less than 15 years
ACOG 2004 <sup>1</sup>   <small>ACOG cites BEIR5</small>	<b><math>EAR_{Lk}</math>: 1.2% per Gy</b> <b>1 in 10,000 per RAD</b> Incidence leukemia: 1 per 3000 $RR_{Lk}$ : 1.5 to 2 for 1 to 2 rad $EAR_{Lk}$ : 1 in 6000 for 1 to 2 rad
RCR & HPA 2009 <sup>2</sup> +Aust/NZ   <small>Royal college Radiologist Health Protection Agency National Radiologic Protection Board</small>	<b><math>EAR_{CA}</math>: 8% per Gy</b> <b>1 in 1000 per RAD</b> Baseline Cancer Incidence: 1/500 $RR_{CA}$ 2 for 25 mGy  <small>Risk in-utero unlikely greater than early childhood.</small>

**$\Delta$  = an order of magnitude**

EAR: Excess Absolute Risk, Lk Leukemia, CA Cancer



# What is the Fetal RISK of Cancer from Ionizing Imaging?

## Intrauterine RISK = Early Childhood Risk

### Evidence Review and Arguments on RISK

(R. Brent 2014)

1. Case-control studies subsequent to OSCC
2. Japanese survivor studies
3. All Cohort studies<sup>1</sup>

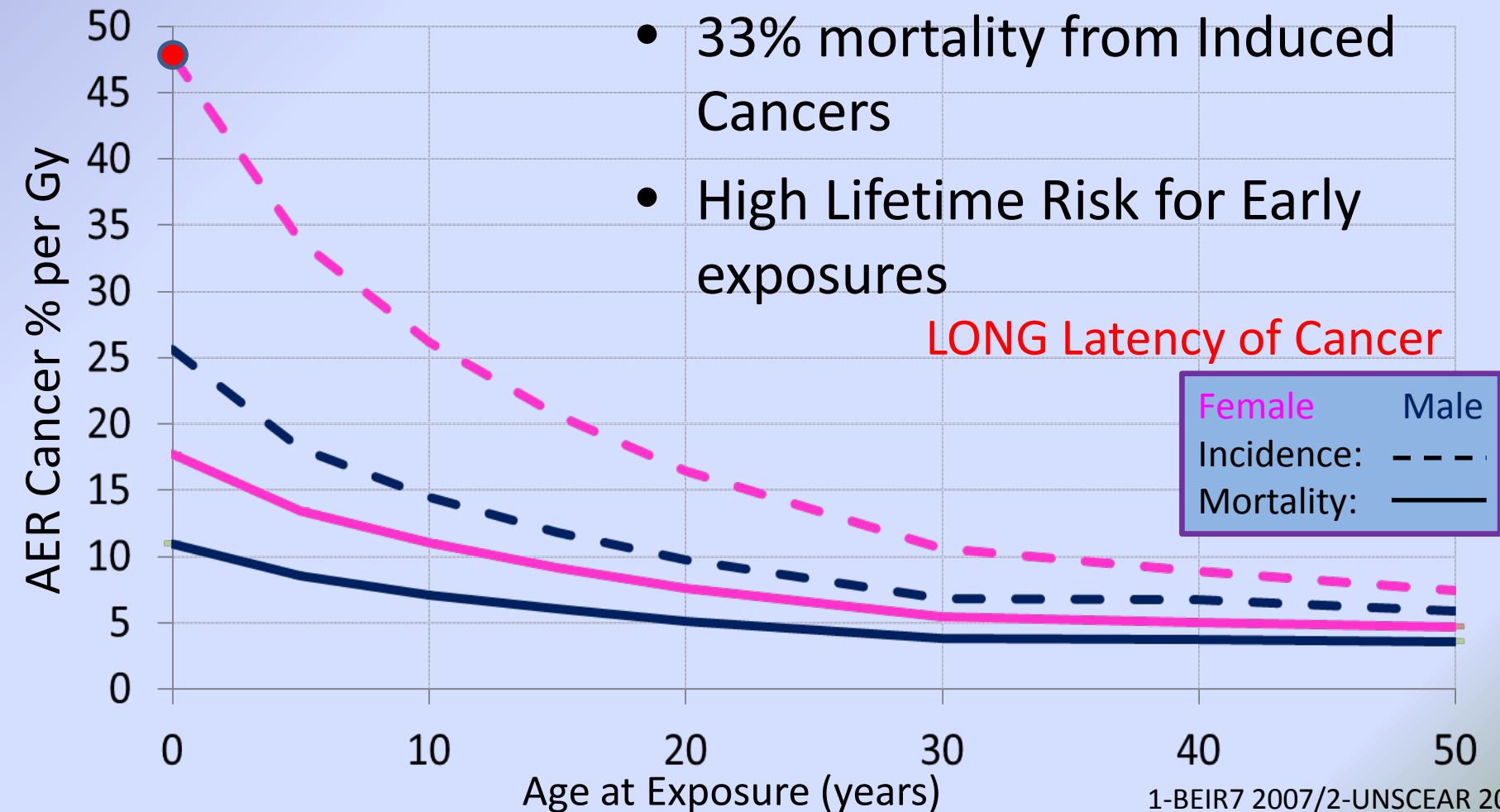
In-utero RISK unlikely greater than early childhood exposure<sup>1,2</sup>

# Pediatric Radiation Exposure and Lifetime Cancer Risk

## BEIR7 Lifetime Attributable Risk

- Strong Effect of Age at exposure
- 33% mortality from Induced Cancers
- High Lifetime Risk for Early exposures

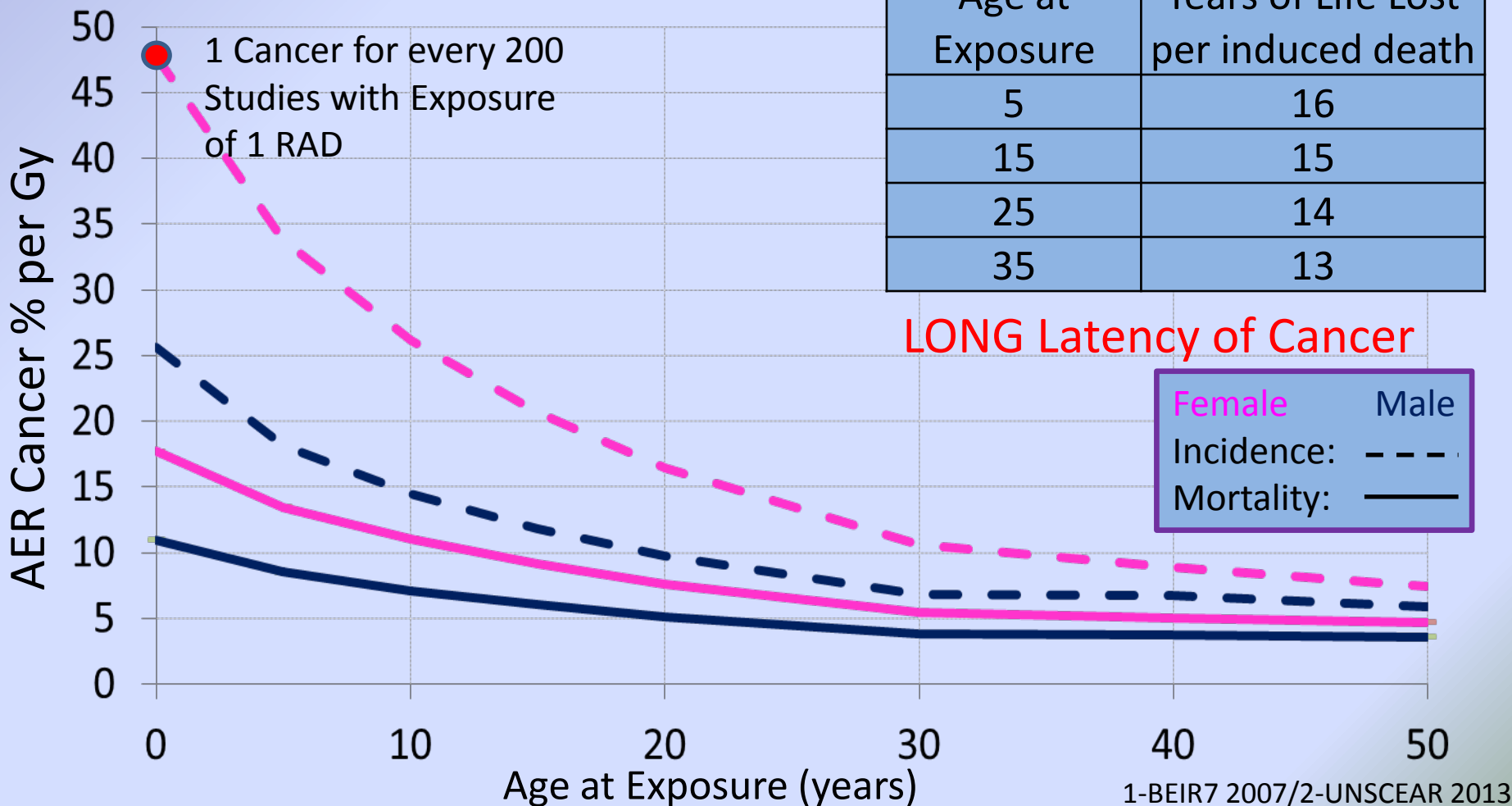
LONG Latency of Cancer



# Pediatric Radiation Exposure and Lifetime Cancer Risk

## BEIR7 Lifetime Attributable Risk

UNSCEAR <sup>2</sup>	
Age at Exposure	Years of Life Lost per induced death
5	16
15	15
25	14
35	13



# What is the Fetal RISK of Cancer from Ionizing Imaging? BEIR7 (Life Years Lost) supports UK Estimate

EAR 1.2% per Gy



**26** LYL per 100 per Gy

EAR 8% per Gy



**170** LYL per 100 per Gy



**BEIR7** Lifetime RISK of CANCER Estimate  
for exposure at “0” years  
**180** LYL per 100 per Gy

# Intrauterine Exposure

Short Latency Pediatric Cancer at less than 15 years



Excess Absolute Risk of Cancer 8% per Gy

1 Cancer is caused per 1000 Studies at 1 RAD  
(10 mGy) of fetal radiation exposure

Pediatric Radiation Exposure and Lifetime Cancer Risk

**BEIR7** Lifetime Attributable Risk

# Diagnostic Imaging

## Fetal Radiation Dose and Cancer RISK

IMAGE	RADS	Y x SAFE	EAR Pediatric CA 8% per Gy
Myocardial SPECT Tc <sup>99m</sup> 6	1 to 5	1	1 in 200 to 1 in 1000
CT Abdomen+Lumbar Spine 1,6	3.5		
Barium Enema 1,2,3,5	1 to 3		
Renal IVP 1,3,5	0.6 to 1		
CT Abdomen <sup>2,5</sup> and CT Pelvis 1,2,5,6	0.25 to 2		
Bone Scan Tc <sup>99m</sup> 6	0.1 to 1	10	1 in 1000 to 1 in 10,000
Lumbar or Lumbosacral Xray 3,5	0.5		
Upper GI series 2,3	0.25 to 0.7		
Hip or Abdomen Xray 1,2,3,5	0.1 to 0.25		
Lung Ventilation Scan 2,3,6	0.01 to 0.015	100	1 in 10,000 to 1 in 100,000
Lung Perfusion Scan 2,3,4,6	0.01 to 0.06		
CT Pulmonary Angiography 3,4,5,6	0.01 to 0.05		
CT Brain <sup>2,6</sup> Or Brain Angiography <sup>1</sup>	0.001-0.01		
CXR <sup>1,2,3,6</sup>	0.00005 to 0.001	1000	EXTREME LOW RISK

# Diagnostic Imaging

## Associated Fetal Radiation and RISK

IMAGE	RADS	Y x SAFE	CONTEXT
Myocardial SPECT Tc <sup>99m</sup> 6	1 to 5	1	Near the "safe" limit ALARA STOP THINK Collaborate
CT Abdomen+Lumbar Spine 1,6	3.5		
Barium Enema 1,2,3,5	1 to 3		
Renal IVP 1,3,5	0.6 to 1		
CT Abdomen <sup>2,5</sup> and CT Pelvis 1,2,5,6	0.25 to 2		
Bone Scan Tc <sup>99m</sup> 6	0.1 to 1	10	0.3R Annual cosmic radiation to flight attendant <sup>2</sup> 0.5R Occupational fetal Limit <sup>2</sup>
Lumbar or Lumbosacral Xray 3,5	0.5		
Upper GI series 2,3	0.25 to 0.7		
Hip or Abdomen Xray 1,2,3,5	0.1 to 0.25		
Lung Ventilation Scan 2,3,6	0.01 to 0.015	100	0.06 R Fetal environmental radiation per year <sup>2</sup> NOT significant fetal risk <sup>4</sup>
Lung Perfusion Scan 2,3,4,6	0.01 to 0.06		
CT Pulmonary Angiography 3,4,5,6	0.01 to 0.05		
CT Brain <sup>2,6</sup> Or Brain Angiography <sup>1</sup>	0.001-0.01		
CXR <sup>1,2,3,6</sup>	0.00005 to 0.001	1000	EXTREME LOW RISK

# SWITCH Gears: Lets talk about MRI Contrast (GBCA)





# 2015 the BIG Guidelines

## A Tone of Extreme Caution

Administer with caution in pregnancy. Only use if usage is critical and potential benefits justify the potential unknown fetal risk<sup>1</sup>  
**American College of Radiology 2015**

When there is a very strong indication for enhanced MR, the smallest possible dose of one of the most stable GDBA contrast agents may be given to the pregnant female<sup>2</sup> **ESUR**





# GBCA in PREGNANCY

## 1988: MRI Contrast Introduced



In 1988 there were good reasons to be CONCERNED about Gadolinium Based Contrast Agents (GBCA) in pregnancy

1. Aversion to injecting toxic heavy metals
2. The AFT (Amniotic Fluid Trap)
3. Nephrogenic Systemic Fibrosis



# 2015

## Fear of the Hypothetical



In 2015:

- No adverse fetal effects of GBCA in pregnancy<sup>1</sup>
- New Macrocyclic agents with much improved safety<sup>2</sup>
- Macaques data for rapid clearance from “AFT”<sup>3</sup>
- No cases of NSF with GFR > 60 mL/minute<sup>4</sup>





# 2015

## Ask yourself these questions



- If a 6 year old developed an incurable fibrotic skin condition, would it get investigated and published?
- Who is the voice of the clinician?
  - WHY is ACOG not providing clinical balance?
- When do YOU stop fearing the hypothetical?

**RISK..RISK..RISK..RISK..RISK**

# GBCA in Pregnancy

## Next Steps

- DON'T
  - CANCEL an indicated contrast studies based on the misperception of a factual RISK of GBCA in pregnancy
  - Cause Maternal STRESS over hypothetical worries.
- DO
  - Discuss the benefit of GBCA with radiology.
  - Always CHECK maternal creatinine
  - Expect a slow reduction in GBCA FEAR (ESUR)

# Key Resources

## Protection of Pregnant Patients during Diagnostic Medical Exposures to Ionising Radiation

Advice from the Health Protection Agency, The Royal College of Radiologists and the College of Radiographers



Seminars in Fetal & Neonatal Medicine 19 (2014) 203–213

Contents lists available at [ScienceDirect](#)



## Seminars in Fetal & Neonatal Medicine

journal homepage: [www.elsevier.com/locate/siny](http://www.elsevier.com/locate/siny)

Review

## Carcinogenic risks of prenatal ionizing radiation

Robert L. Brent\*

Thomas Jefferson University, Alfred I. duPont Hospital for Children, Room 308, A/R Building, PO Box 269, Wilmington, DE 19899, USA

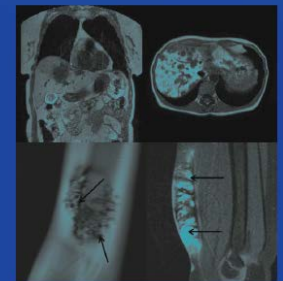
Medical Radiology  
Diagnostic Imaging  
M.F. Reiser  
H. Hricak  
M. Knauth

Henrik S. Thomsen  
Judith A. W. Webb  
*Editors*

# Contrast Media

Safety Issues and ESUR Guidelines

*Third Edition*



Springer

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