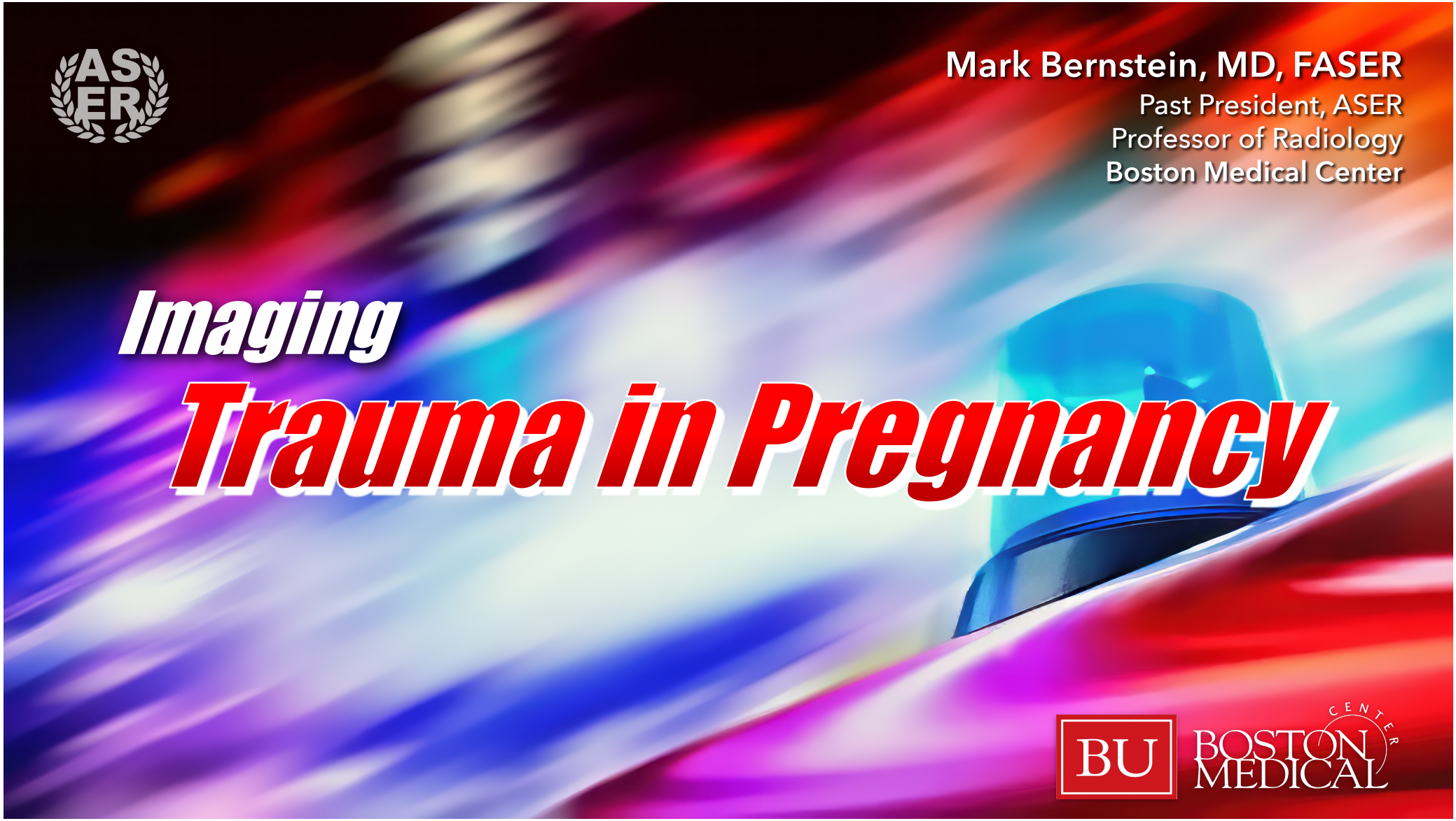

ASER
Mark Bernstein, MD, FASER
Past President, ASER
Professor of Radiology
Boston Medical Center
Imaging
Trauma in Pregnancy
BU
BOSTON MEDICAL CENTER

OUTLINE

Introduction

- Trauma etiologies
- Management & work up

Diagnostic imaging in pregnancy

- Ionizing radiation
- Normal imaging findings
- Maternal & fetal injuries on CT

OVERVIEW

Trauma is the leading cause of non-OB maternal mortality

- **7%** of all pregnancies
- **2%** of level 1 trauma pts have **+** pregnancy test
- serious abdominal injury more likely in pregnant patient *vs* non-pregnant

Fetal death possible with minor maternal injury

- ***no direct*** pelvic trauma needed

ETIOLOGIES

MVC - #1

- 2% of all live births in US exposed in utero to MVC
- result in 1300 fetal losses/year

Falls, especially 3rd T

- altered equilibrium
- fetus lies above bony pelvis
- decreased amniotic fluid

Assault / domestic violence / GSW

TRAUMA & PREGNANCY

Maternal Mortality

- Head trauma
- Hemorrhage

TRAUMA & PREGNANCY

Fetal Mortality

- Maternal Death is #1 cause
- **73%** in penetrating abdominal trauma
- **80%** in cases of maternal shock

TRAUMA & PREGNANCY

When mother survives, major cause of fetal death is *placental abruption*

- complete or incomplete
- Even minor trauma may cause placental separation and fetal death
- Fetal monitoring and assessment of placental integrity are key*

MANAGEMENT & WORKUP

TRAUMA & PREGNANCY

Prehospital Management

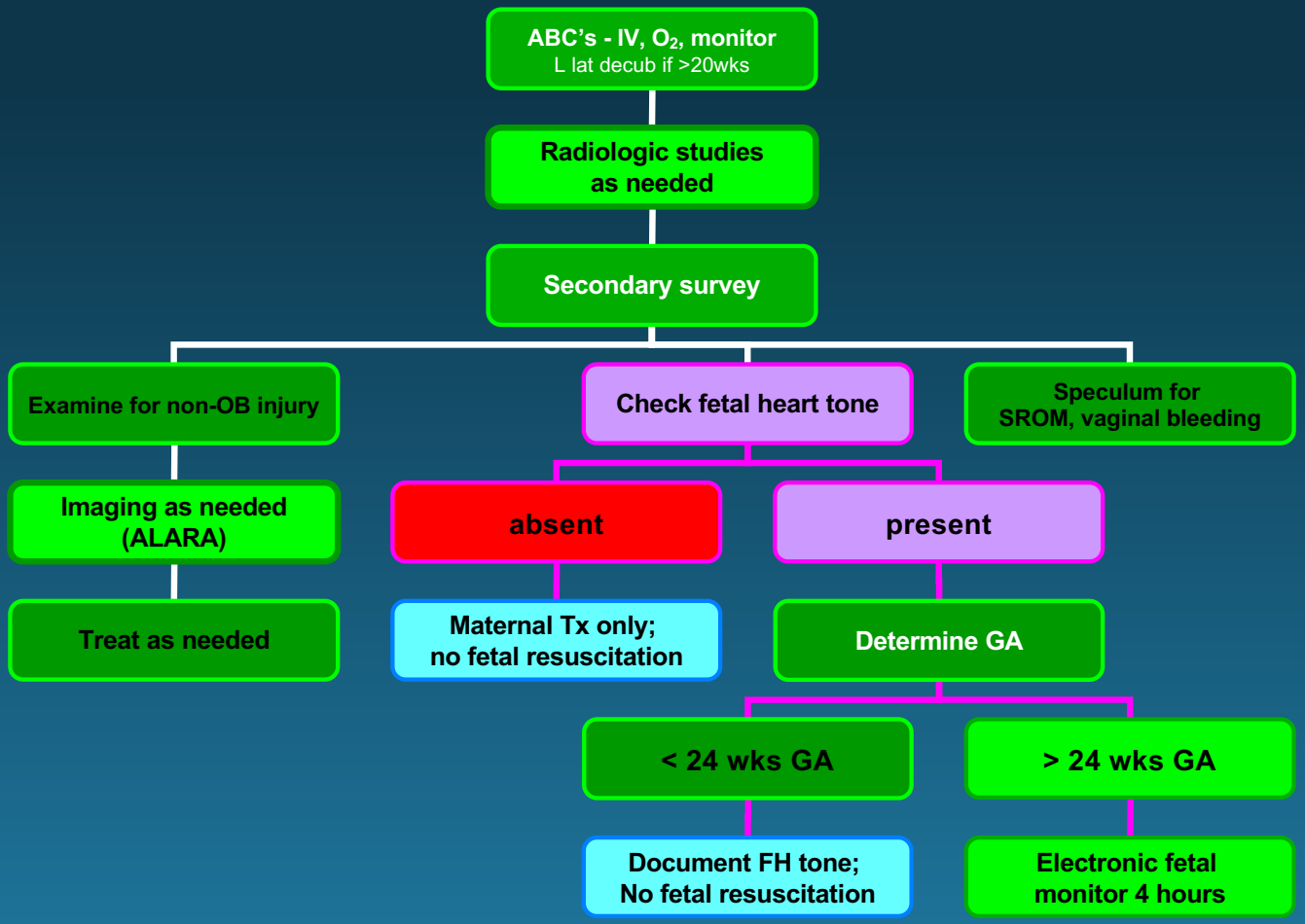
- ABC's
- Lay mother L lateral decubitus
  - allow venous return through IVC (>20 wks GA)
- Regardless of apparent severity, all traumatized pregnant women should be evaluated in a trauma center able to monitor mother & fetus

No fetal survival without maternal survival.

TRAUMA & PREGNANCY

Exception

- 3rd T with poor maternal prognosis for survival may necessitate immediate C-section to save the fetus


ABC's - IV, O_2, monitor
L lat decub if >20wks
Radiologic studies as needed
Secondary survey
Examine for non-OB injury
Check fetal heart tone
Speculum for SROM, vaginal bleeding
Imaging as needed (ALARA)
absent
present
Treat as needed
Maternal Tx only; no fetal resuscitation
Determine GA
< 24 wks GA
> 24 wks GA
Document FH tone; No fetal resuscitation
Electronic fetal monitor 4 hours


Trauma Alert…
32 yo female s/p assault,
pushed down stairs.
Brief LOC.
Now A & O x3
…oh, yeah, she's 20 wks pregnant!

Regardless of GA, good Tx for mother is good Tx for fetus

fetus does not tolerate hypoxemia, hypovolemia

DIAGNOSTIC MODALITIES

WITHOUT IONIZING RADIATION

DIAGNOSTIC MODALITIES
WITHOUT IONIZING RADIATION

Fetal monitoring

- Continuous electronic fetal monitoring is standard of care for a viable fetus
- Fetal distress manifests as abN FHR
- FHR + uterine activity = ***most sensitive technique to Dx abruption***

DIAGNOSTIC MODALITIES
WITHOUT IONIZING RADIATION

Sonography

- ***Fetal***: Safely measures HR, GA, amniotic fluid index, motion
- ***Maternal***: Differentiates *maternal* tachycardia from FHR on Doppler
- ***Misses 50-80% of placental abruptions**

DIAGNOSTIC MODALITIES
WITHOUT IONIZING RADIATION

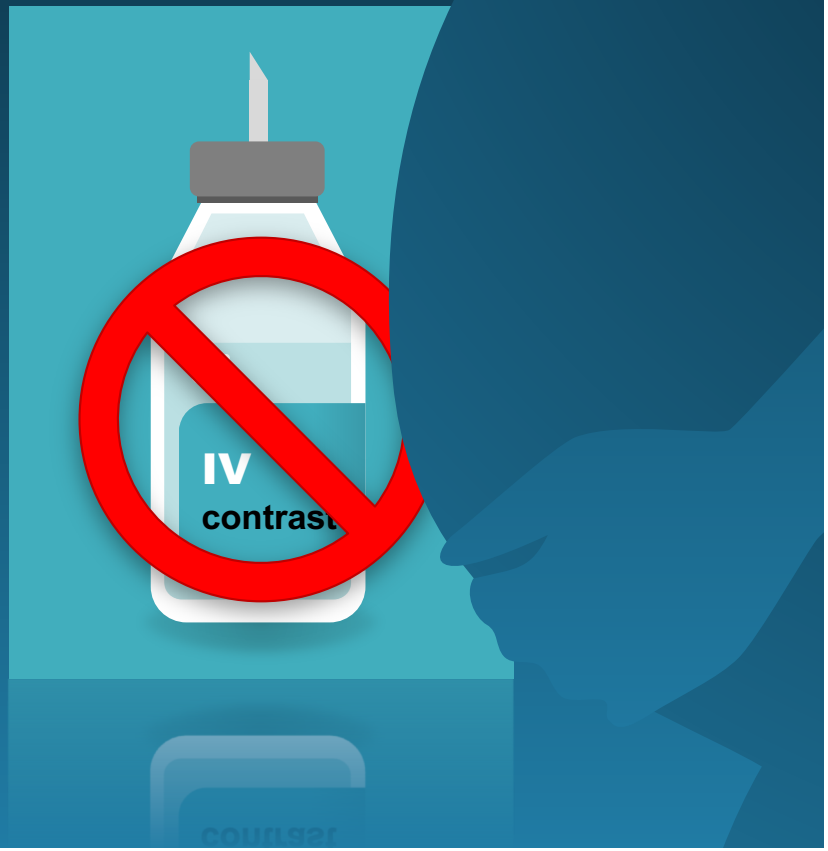
FAST exam

- No radiation
- Portable
- Detects intraperitoneal fluid
- *But* misses injuries without hemoperitoneum

DIAGNOSTIC MODALITIES
WITHOUT IONIZING RADIATION

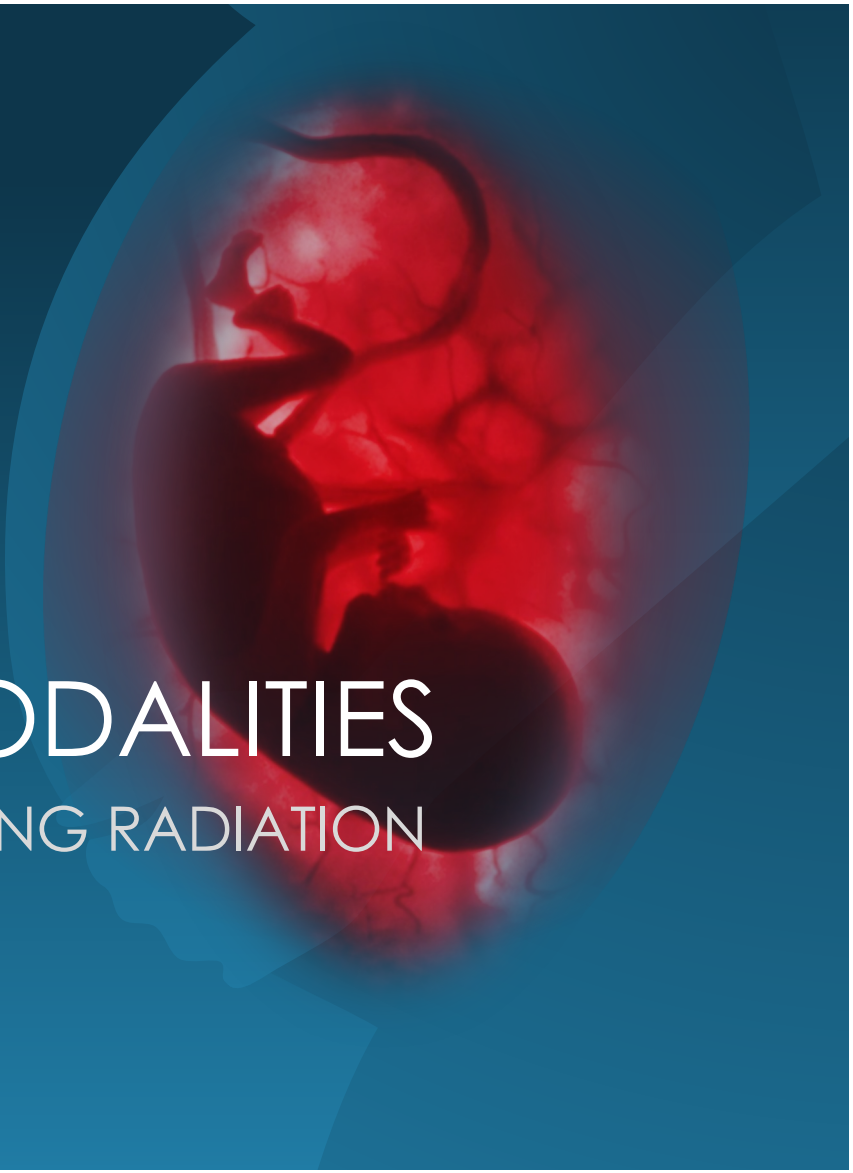
MRI

- Excellent soft tissue contrast
- Safe to use in 2nd & 3rd T
  - **Gadolinium *NOT* recommended**
- 3rd T – fetal motion degrades images
- **Limitations**:
  - time, access, ability to monitor and resuscitate



DIAGNOSTIC MODALITIES

WITH IONIZING RADIATION



IONIZING RADIATION

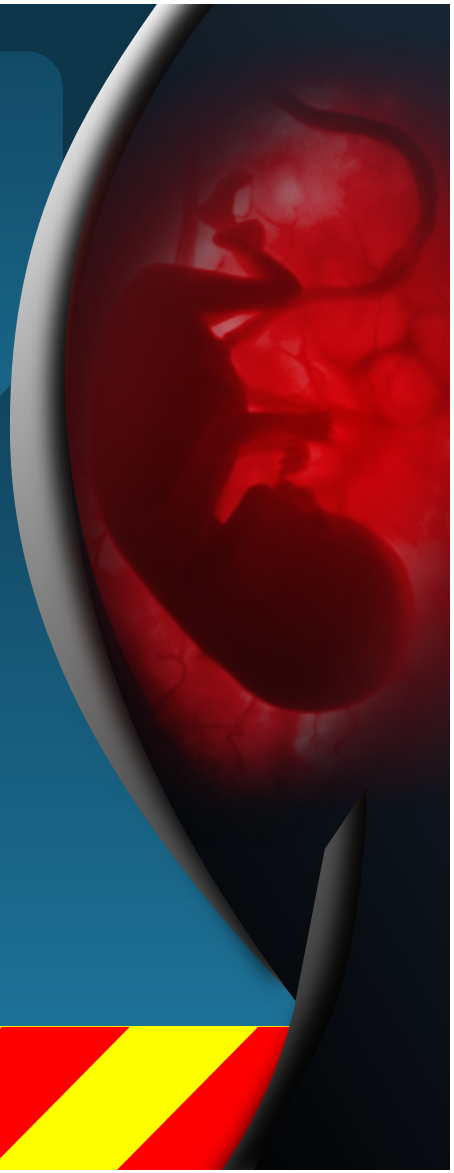
National Council on Radiation Protection:

- *"fetal risk is considered to be negligible at 5 rad or less…"*

American College of OB-GYN:

- *"Exposure to less than 5 rad has not been associated with an increase in fetal anomalies or pregnancy loss."*

5 rad = 50mGy ≈ 50 mSv



IONIZING RADIATION

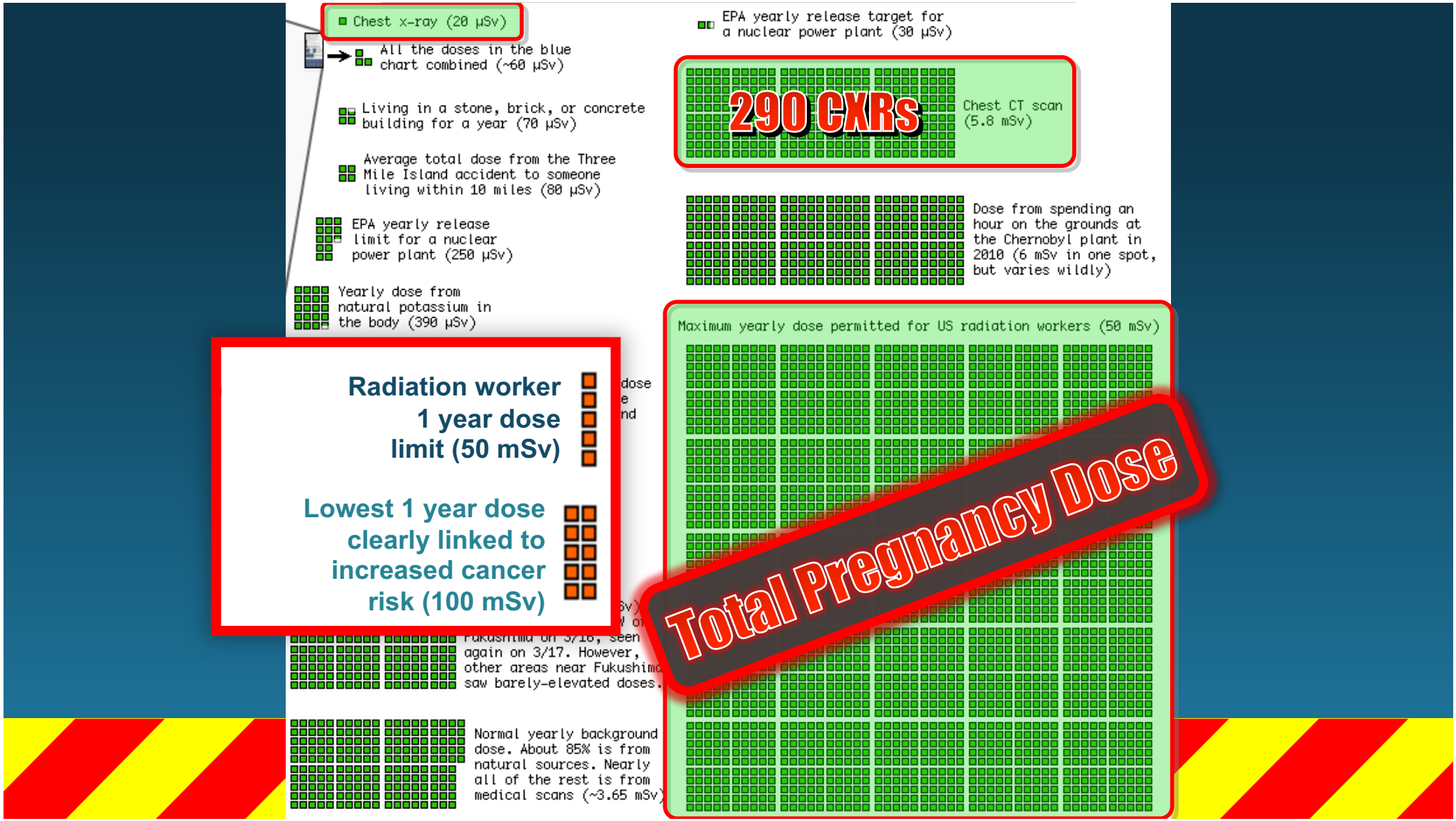
TYPICAL FETAL ABSORBED DOSES

CT	mGy
Head CT	0
Chest CT	0.2
A/P CT	13-25

XR	mGy
CXR - PA	0.002
Abdomen XR	1-3
Pelvic XR	1-3

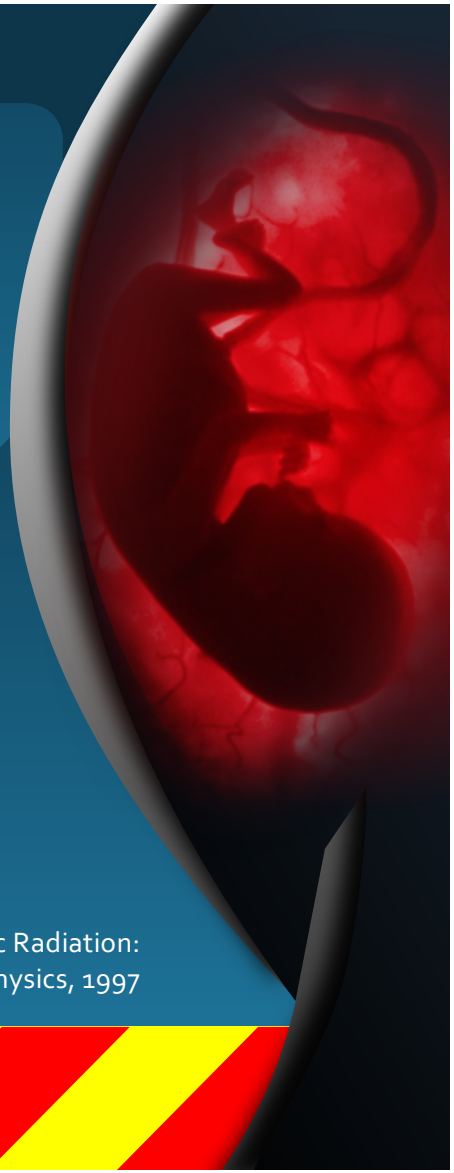
1 mGy ≈ 1 mSv

McCollough et al. *RadioGraphics* 2007; 27:909-918
Wieseler et al., *RadioGraphics* 2010; 30:1215-1233


Chest x-ray (20 μSv)
All the doses in the blue chart combined (~60 μSv)
Living in a stone, brick, or concrete building for a year (70 μSv)
Average total dose from the Three Mile Island accident to someone living within 10 miles (80 μSv)
EPA yearly release limit for a nuclear power plant (250 μSv)
Yearly dose from natural potassium in the body (390 μSv)
EPA yearly release target for a nuclear power plant (30 μSv)
290 CXRs
Chest CT scan (5.8 mSv)
Dose from spending an hour on the grounds at the Chernobyl plant in 2010 (6 mSv in one spot, but varies wildly)
Maximum yearly dose permitted for US radiation workers (50 mSv)
Radiation worker 1 year dose limit (50 mSv)
Lowest 1 year dose clearly linked to increased cancer risk (100 mSv)
Total Pregnancy Dose
again on 3/17. However,
other areas near Fukushima
saw barely-elevated doses.
Normal yearly background dose. About 85% is from natural sources. Nearly all of the rest is from medical scans (~3.65 mSv)

RADIATION EXPOSURE

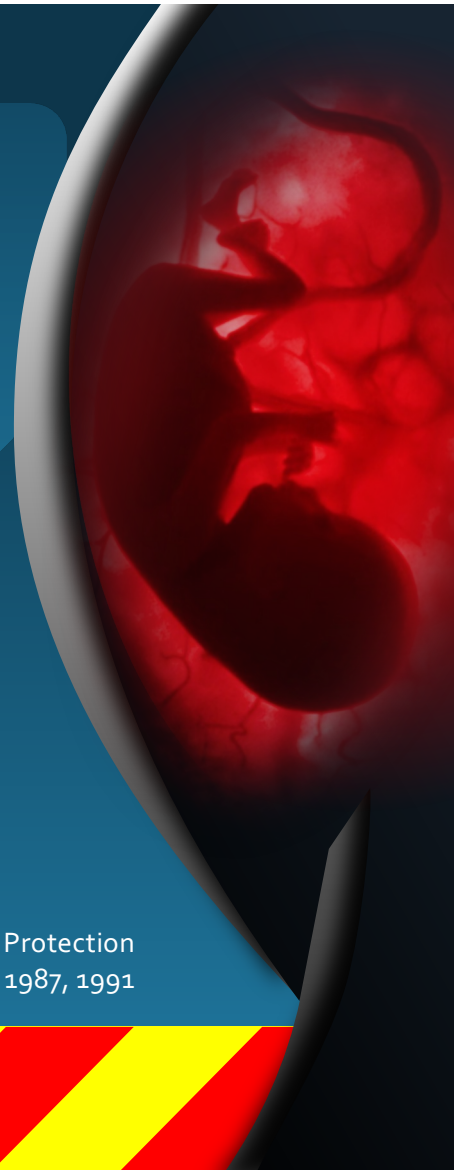
"when a pregnant woman requires an ***emergency*** radiological examination, there should be ***no hesitation*** to do the study"



Exposure of the Pregnant Patient to Diagnostic Radiation:
A guide to medical management. 2nd ed Medical Physics, 1997

RADIATION EXPOSURE

"Sometimes the ***risk*** of irradiating the fetus is ***much less*** than that of not making a ***necessary diagnosis***"

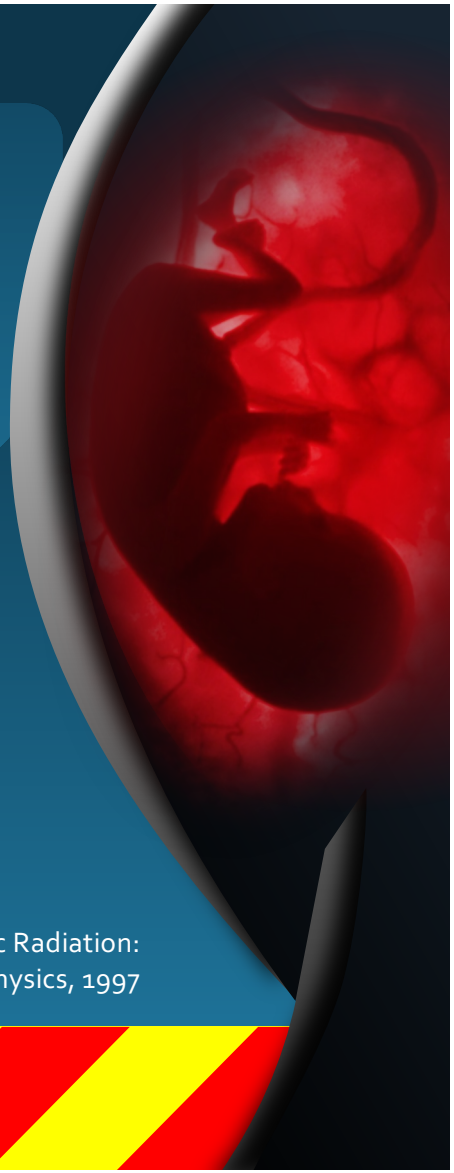


International Congress on Radiological Protection
Oxford, England. 1982, 1987, 1991

RADIATION EXPOSURE

"If the study requires **direct exposure** to the conceptus and there are ***no satisfactory alternatives***, the radiologist should not hesitate to ***complete the procedure properly***"

Exposure of the Pregnant Patient to Diagnostic Radiation:
A guide to medical management. 2nd ed Medical Physics, 1997



POTENTIAL FETAL RADIATION EFFECTS

GA (wks)	STAGE	RISK	SOURCE
0-2	preimplantation	< 1% spontaneous abortion (Dx rad'n)	Stovall et al.
2-8	major organogenesis	Malformations (dose > 100 mGy)	Wagner et al.
2-15	organogenesis & neuronal development	Small head size (seen only in pop'ns)	Otake & Schull
8-15		Mental retardation	Goldman & Wagner
> 15	organogenesis	At best, 0.2-0.8% carcinogenesis (pelvic CT)	Committee on Biological Effects of Ionizing Radiation

CT IV CONTRAST

Class B drug

- ***safe*** in pregnancy based on animal studies
- ***no effect*** on neonatal thyroid function

No human studies / Only animal

- 100x typical human dose has shown no adverse fetal effects:
  - no malformations
  - no cancer risk

DIAGNOSTIC WORKUP

X-rays

- Remote from fetus only deposits scatter
- Can be safely performed at any time
- Avoid unnecessary & duplicate exams (ALARA)

Trauma CT

- Study of choice for rapid, non-invasive assessment
- avoid multiple passes
- IV & O_2 – maximize uterine perfusion

DIAGNOSTIC WORKUP

Angiography

- **Exposures based on:**
  - Amount of fluoroscopic *time*
  - Tissue *thickness (ie. fetal depth)*
- Embolization excellent tool for control of **active hemorrhage, PSA**
- Exposures range 20-100 mGy/min

NORMAL RADIOLOGIC FINDINGS IN PREGNANCY

1st TRIMESTER

CT

- Enlarged, enhancing uterus
- Bulging endometrial lumen

normal 1st trimester (6 wks GA)

2nd TRIMESTER

CT

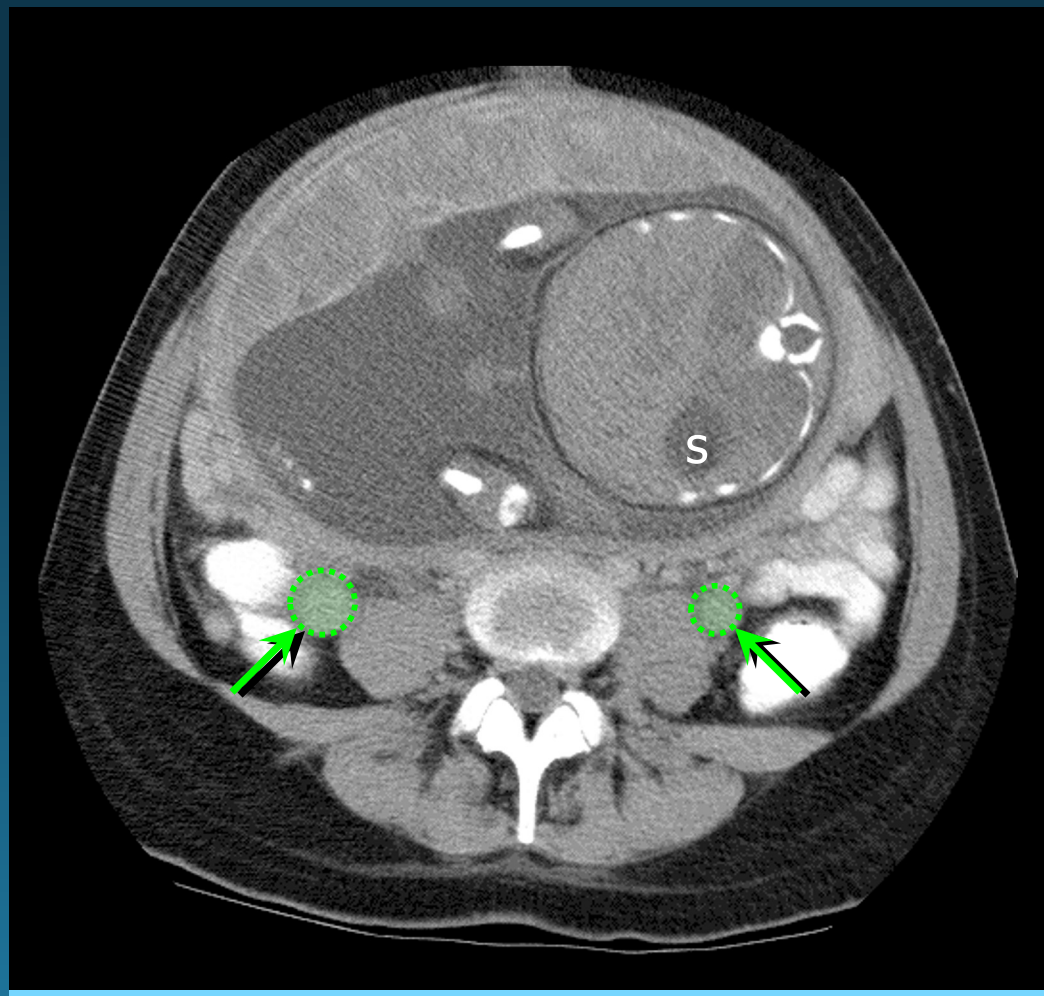
- Placental areas of low density with surrounding high-density rings (cotyledons)
- Fetal parts evident
- amniotic fluid remains low density throughout gestation

normal 2nd trimester (16 wks GA)

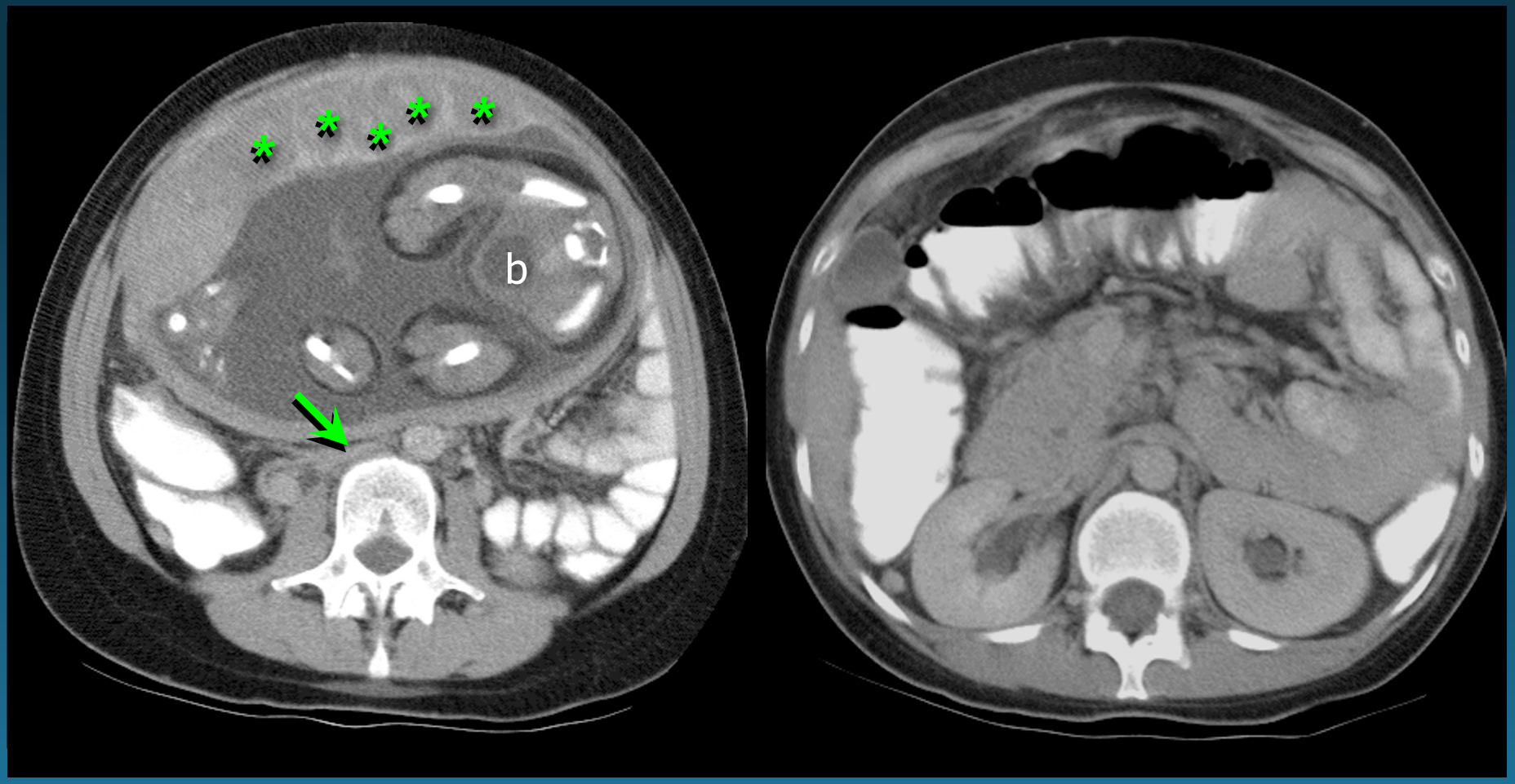
3rd TRIMESTER

CT

- Fetal skeleton easily seen
- Ovarian veins enlarged
- Enlarged uterus:
  - IVC compressed
  - bowel displaced laterally
  - hydronephrosis of pregnancy
- no fetal enhancement



normal 3rd trimester (32 wks GA)



normal 3rd trimester (32 wks GA)

MATERNAL & FETAL INJURIES

MATERNAL INJURIES

Greater incidence of:

- **liver and spleen lacerations**
    - Compressed between rib cage and enlarged uterus
- **bladder injury**
    - upward displacement from protective bony pelvis
- **pelvic *bleeding***
    - increased uterine blood flow and venous engorgement

MATERNAL INJURIES

Can lose **30%** of blood volume before showing signs of shock due to normal hypervolemia of pregnancy

Fetal shock *can* occur in the setting of a normotensive mother

- ***NO uterine autoregulation***

MATERNAL SHOCK

➔ fetal death rate approaches 80%

Fetal survival depends on adequate uterine perfusion

- **no uterine autoregulation**
- perfusion related directly to maternal BP
- maternal shock → uterine vasoconstriction

PLACENTAL ABRUPTION

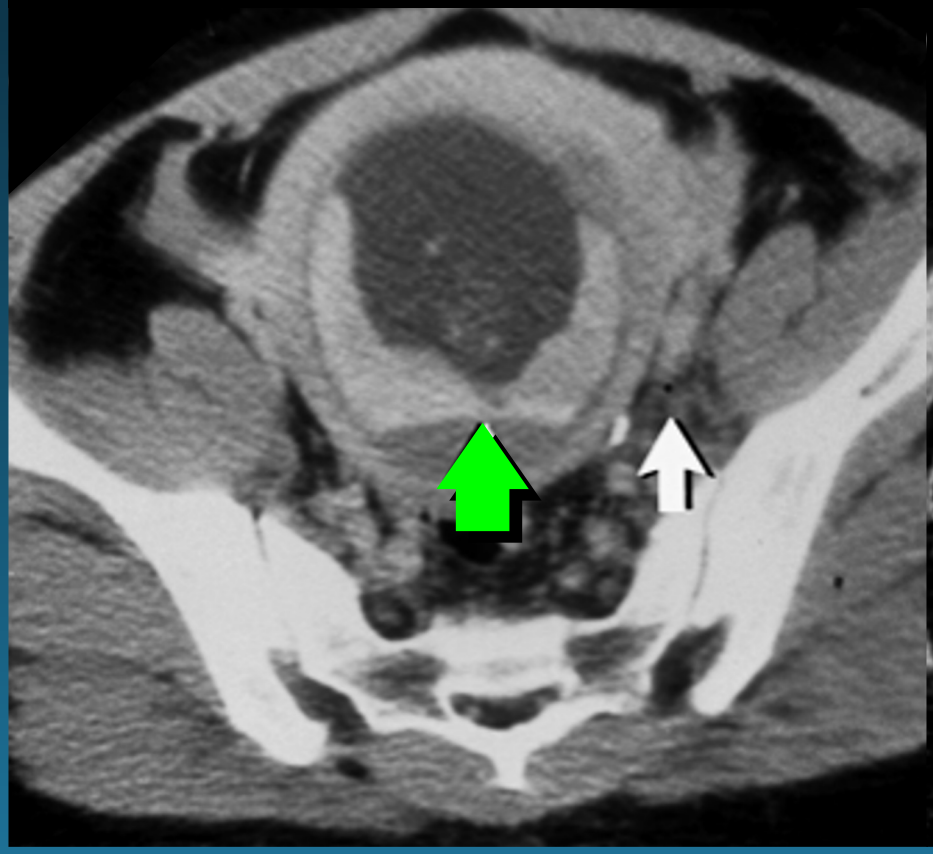
- Shearing forces between flexible uterine muscle and rigid placenta

PLACENTAL ABRUPTION

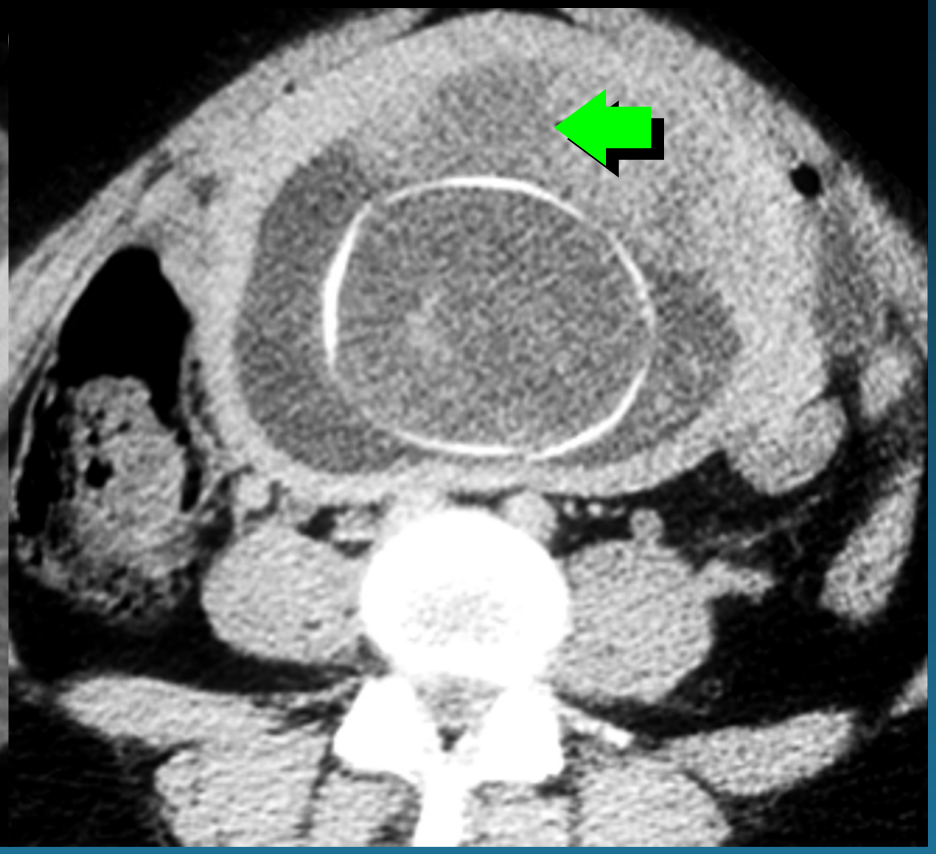
70% fetal mortality rate

- **Can be *clinically silent***
- **Ultrasound *will not* visualize all cases**
  - *May be seen on Trauma CT*
- **>50% abruption → fetal demise**

placental separation

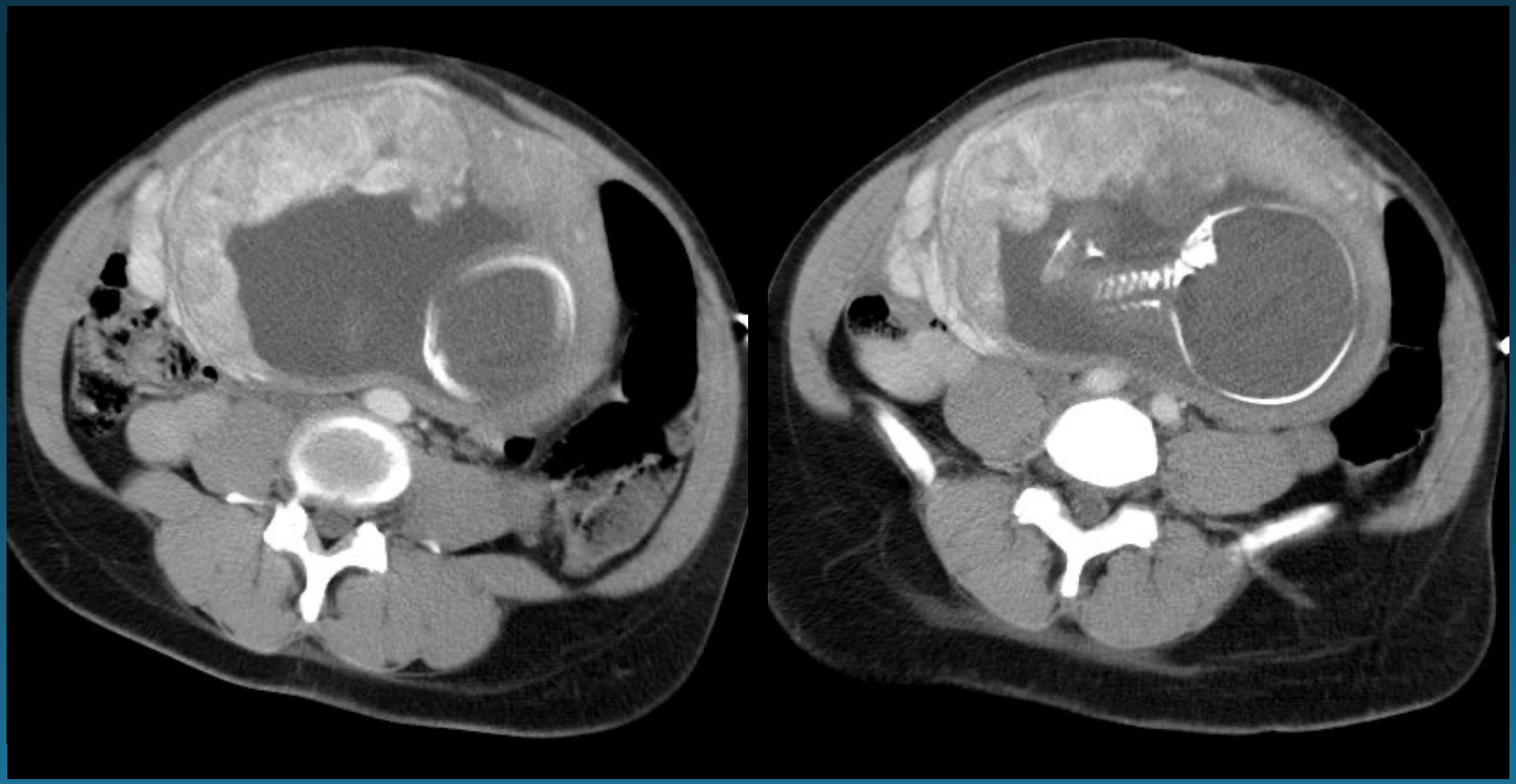


placental perfusion defects

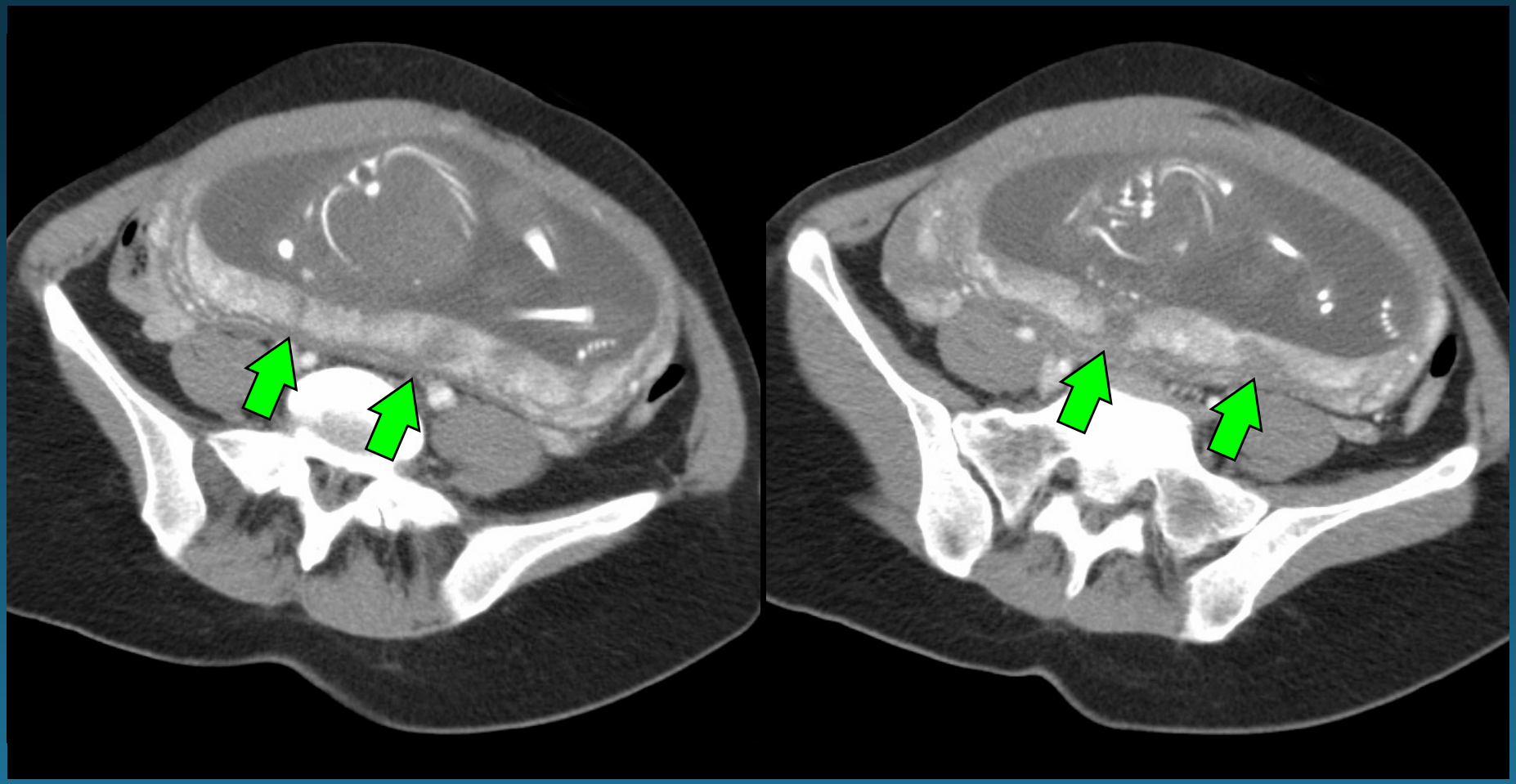


placental injuries

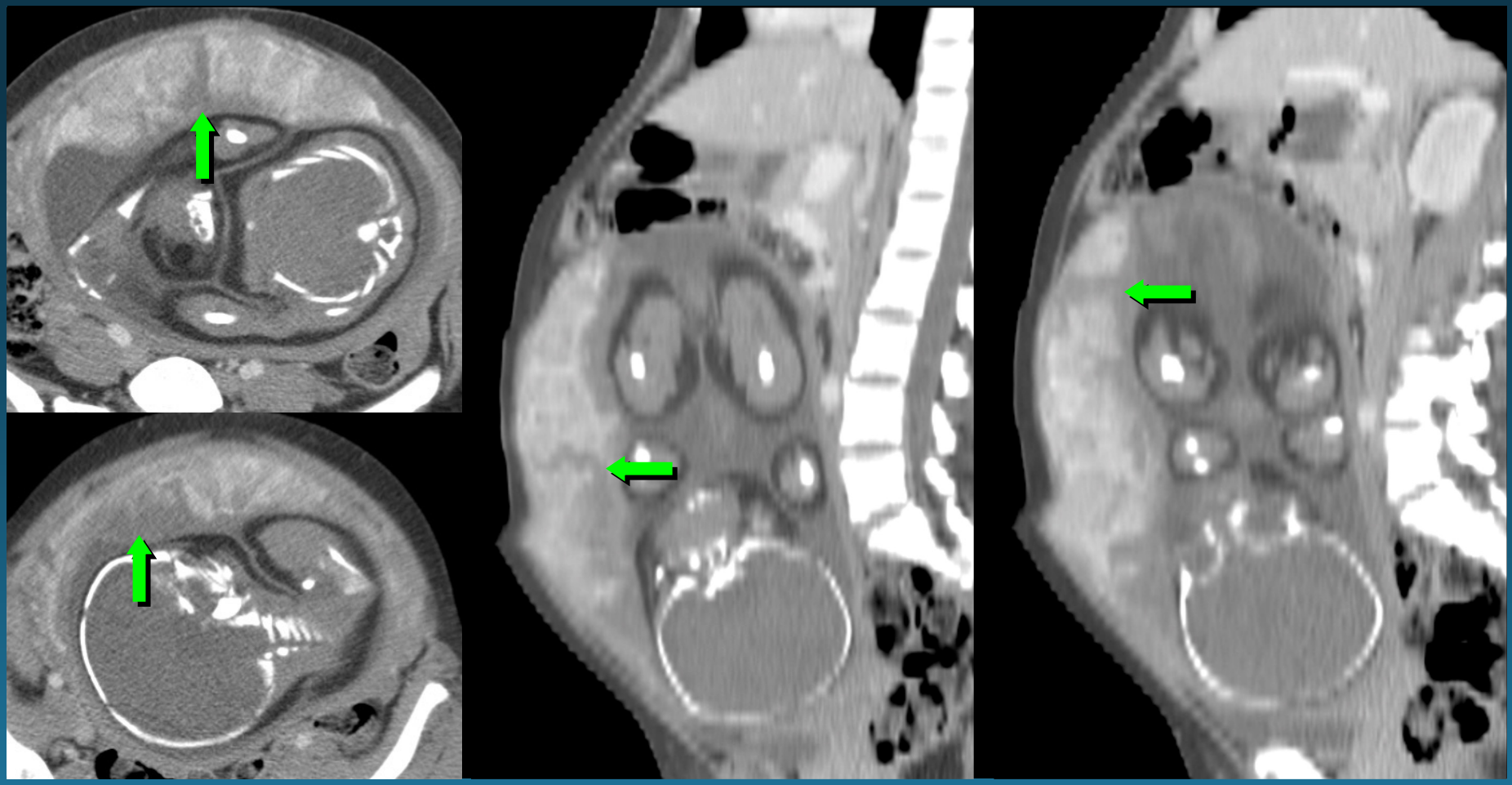
Radiographics 1999; 19:S243-255



normal placental perfusion

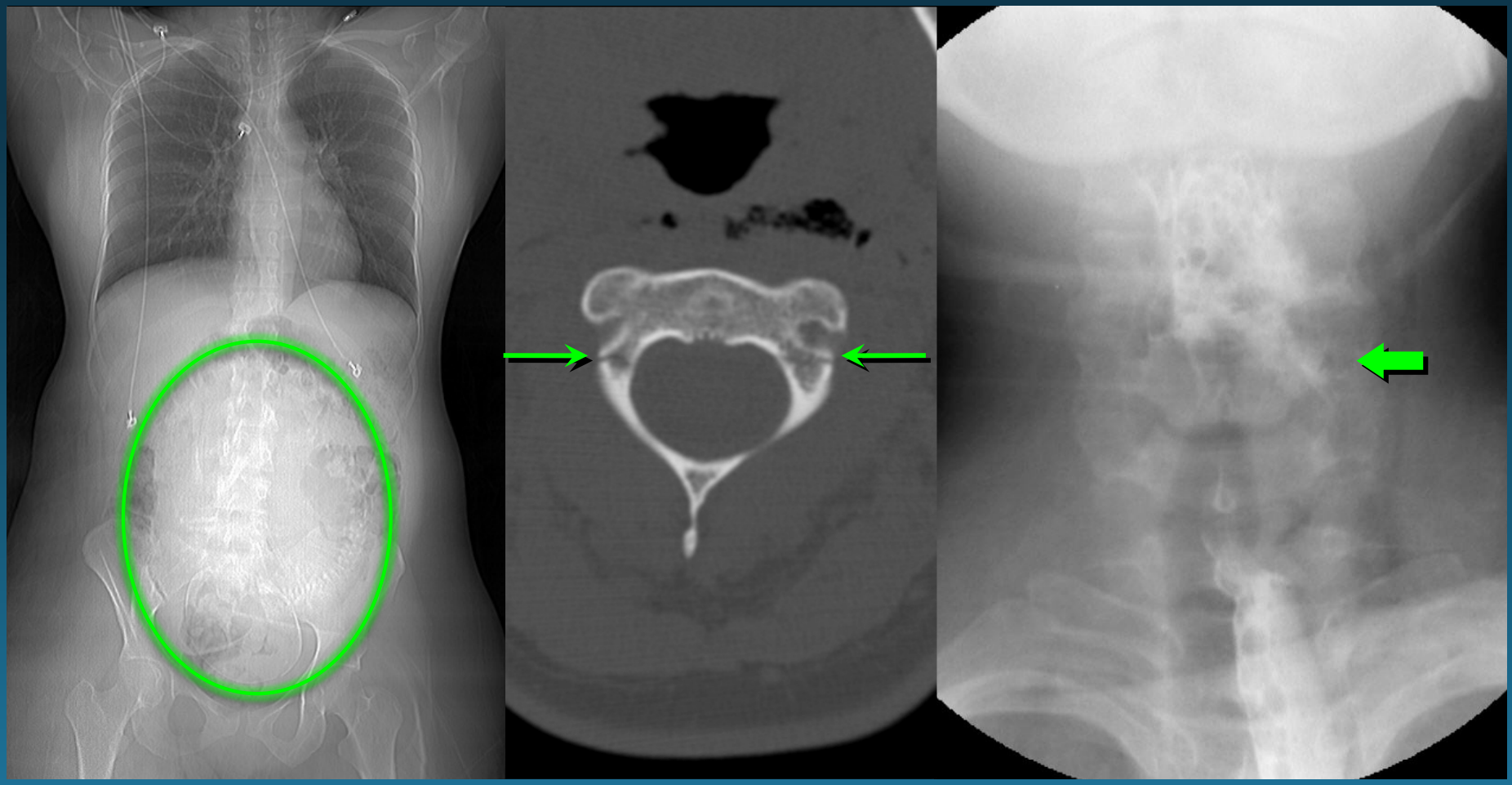


patchy placental perfusion / lacerations

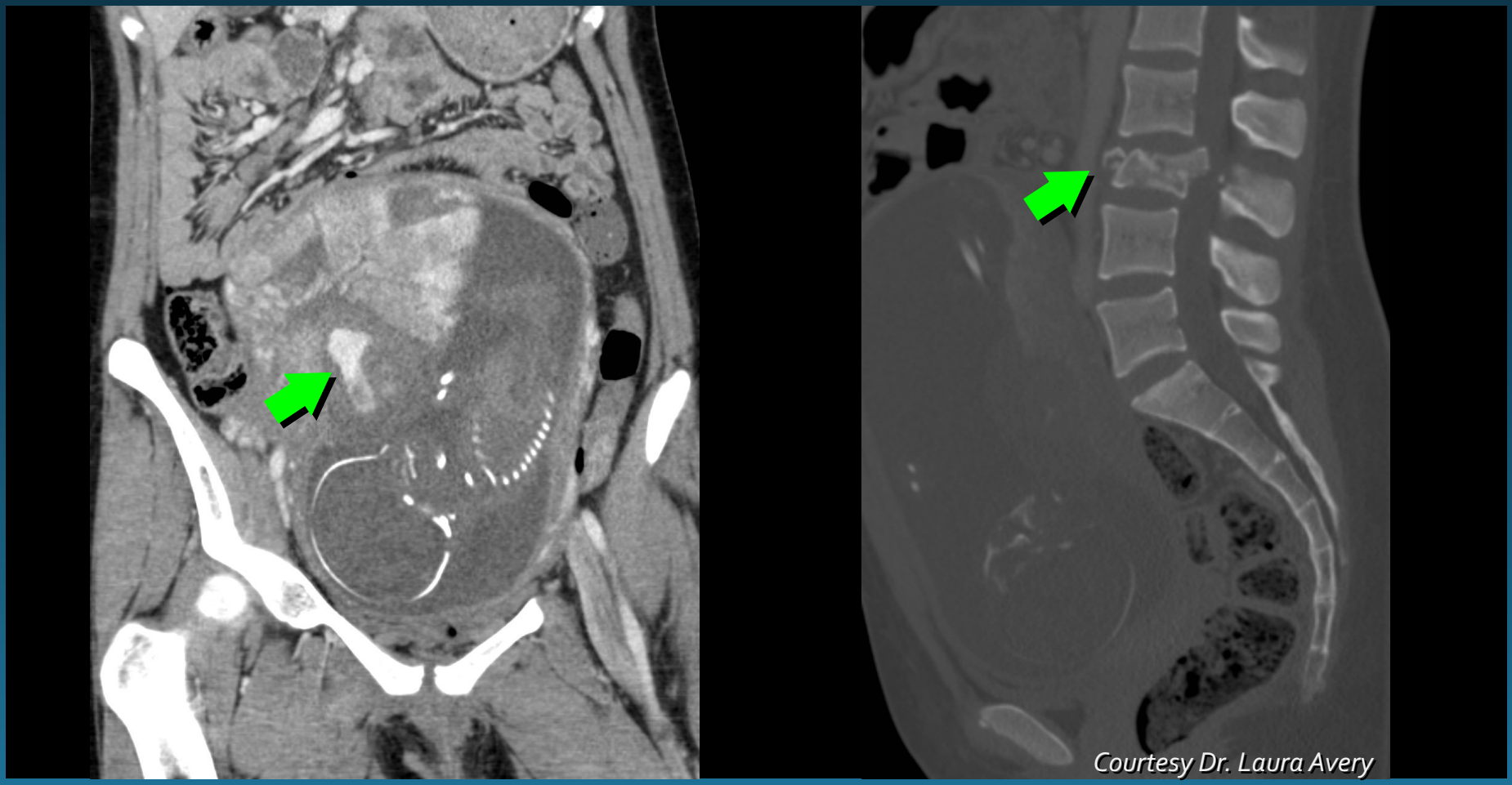


placental defects – delivered 4 hrs later

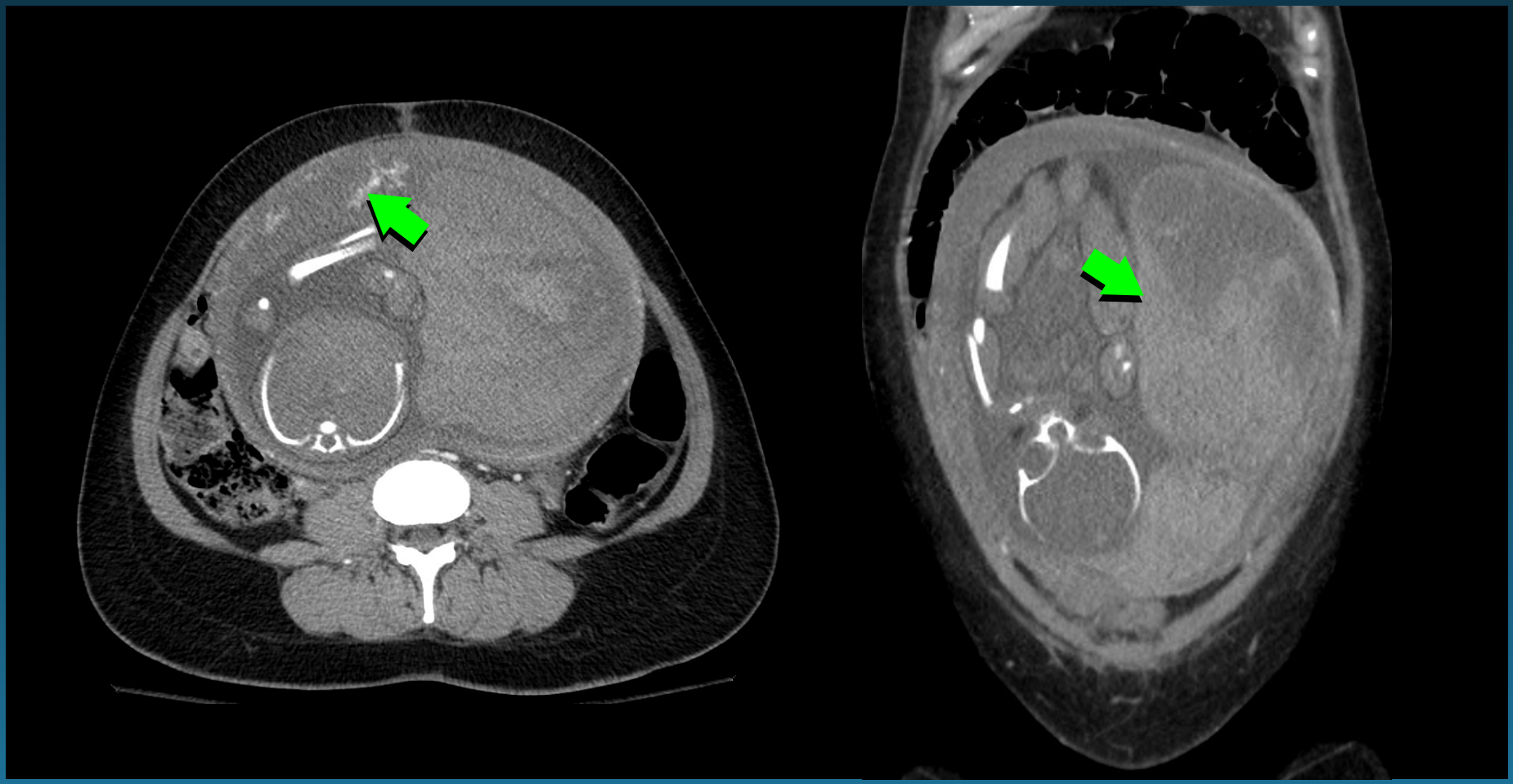

FDNY
FDNY



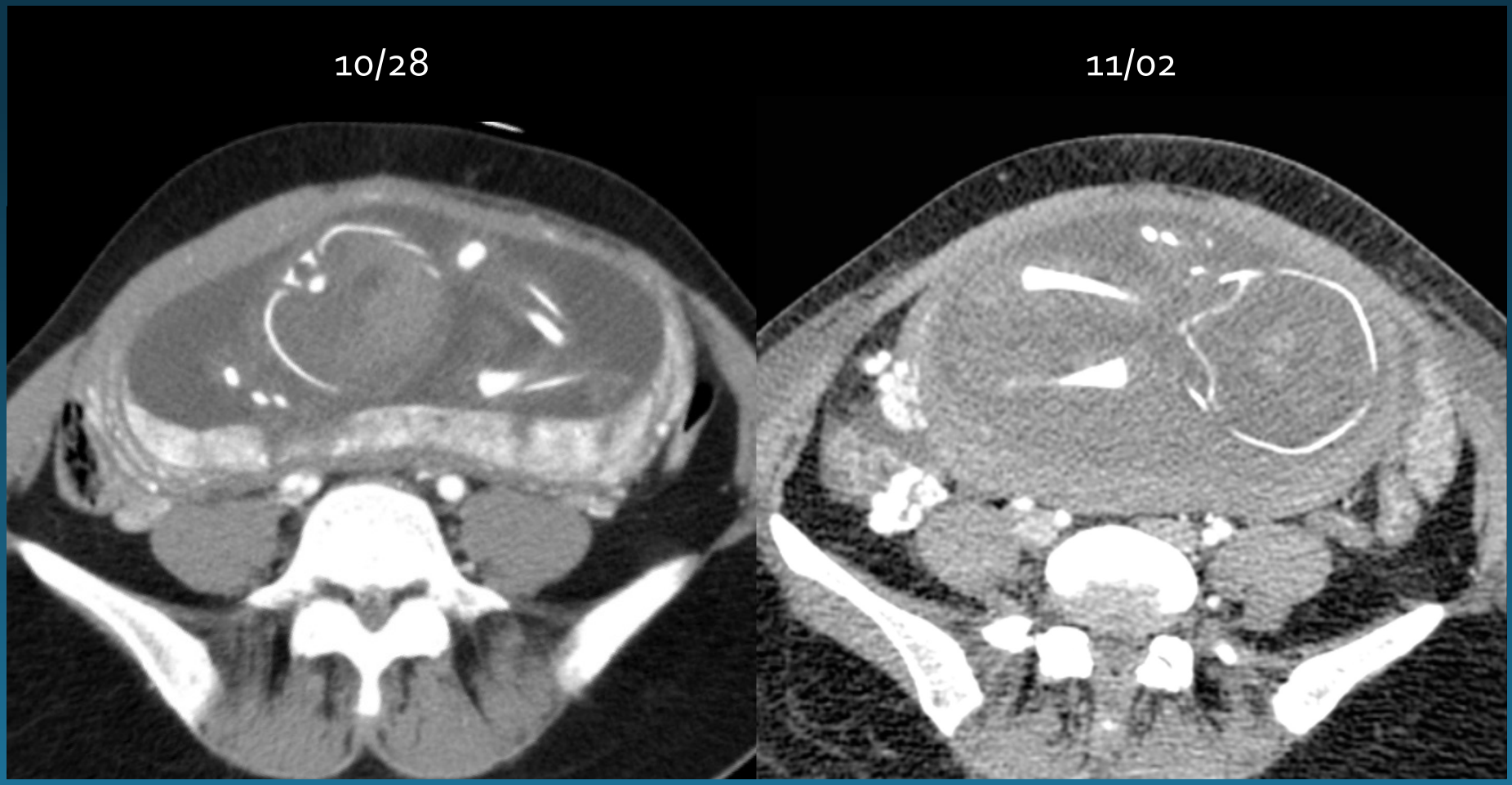
no placental perfusion – still born (22 wks GA)



placental hematoma active extravasation & L3 burst fx (24 wks)



placental infarction, bleed (28 wks)



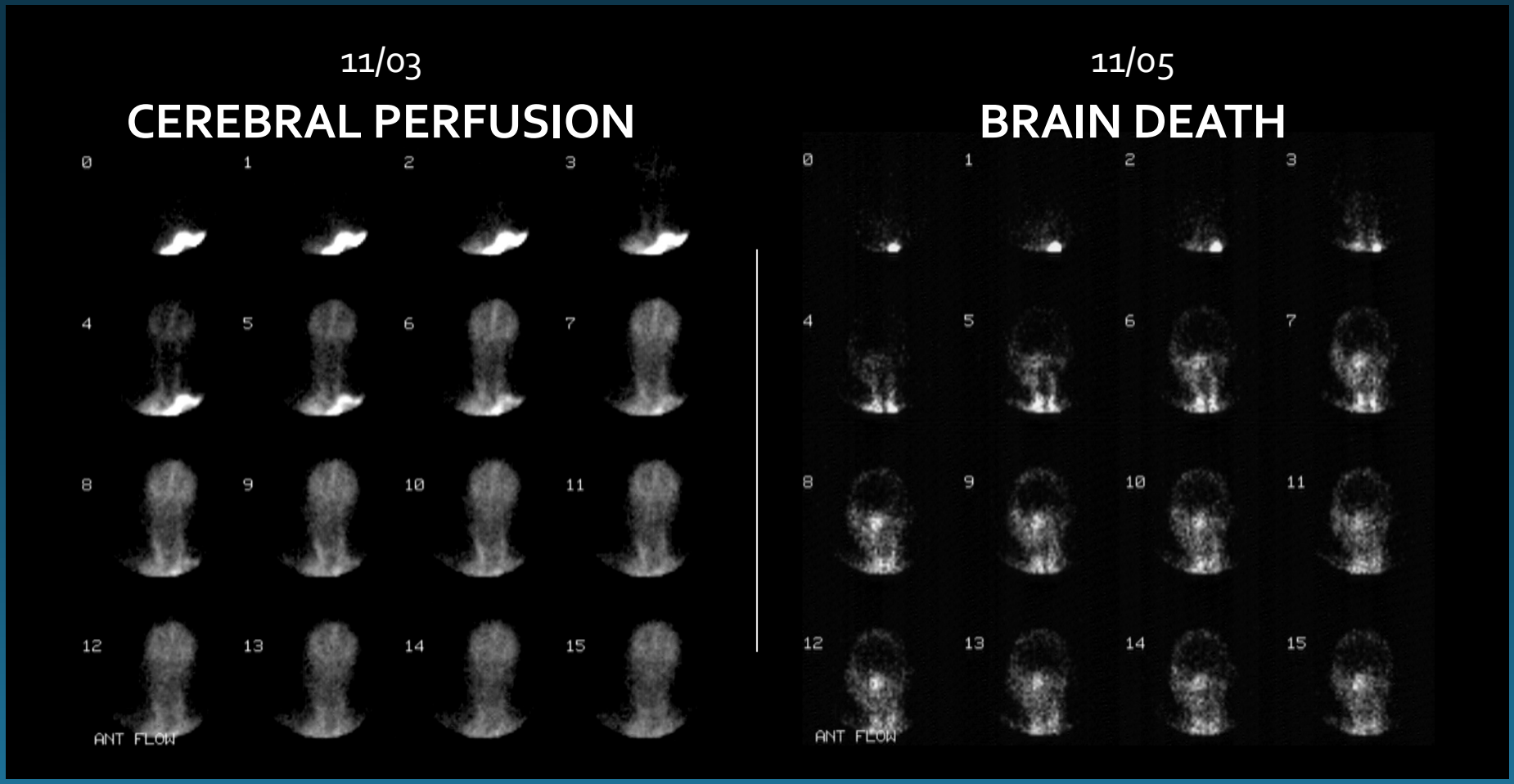
34 yo ped struck – placental lac & infarct (22 wks GA)

11/03

CEREBRAL PERFUSION

11/05

BRAIN DEATH



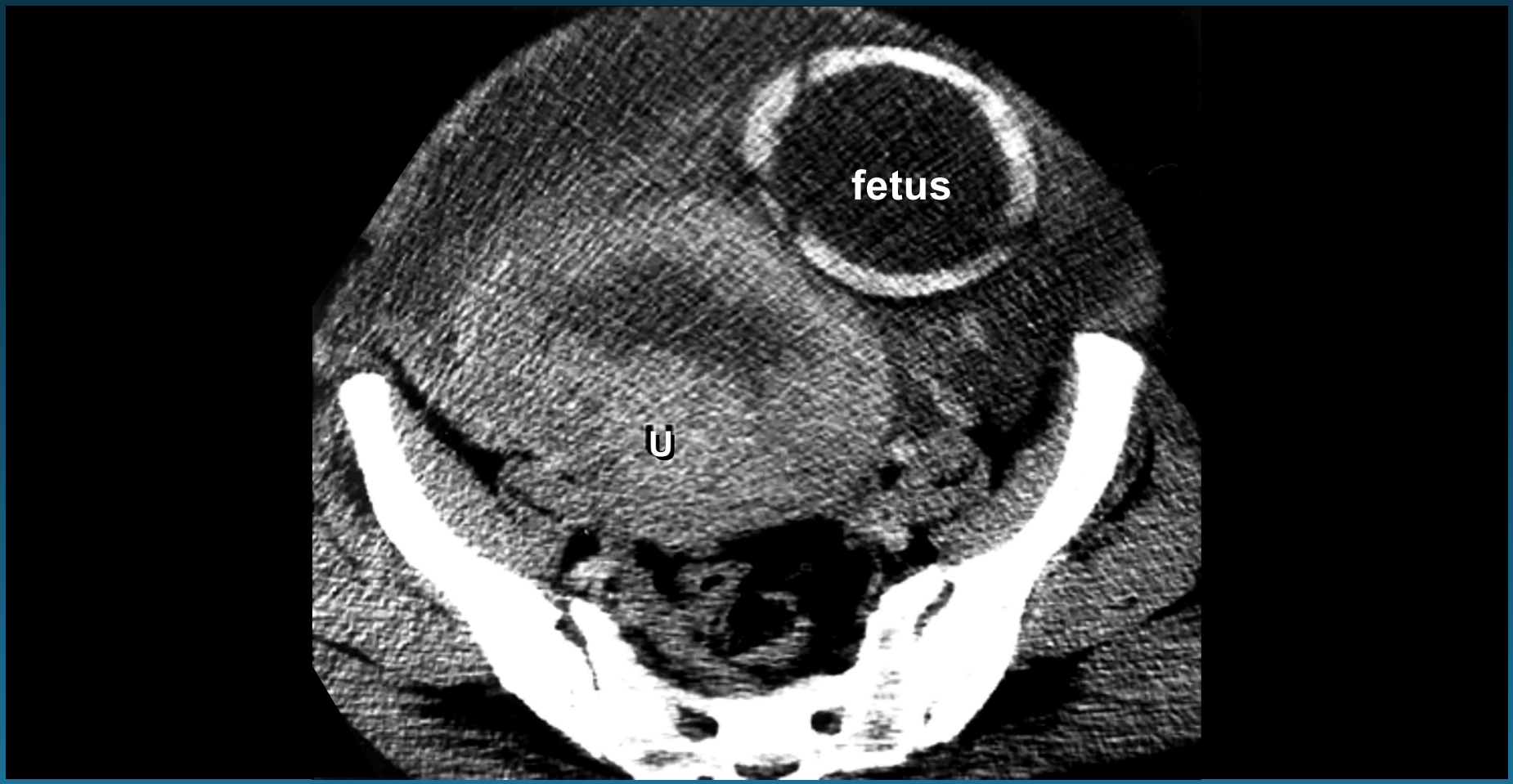
34 yo ped struck – placental lac & infarct (22 wks GA)

UTERINE RUPTURE!

0.6% all pregnant major trauma patients

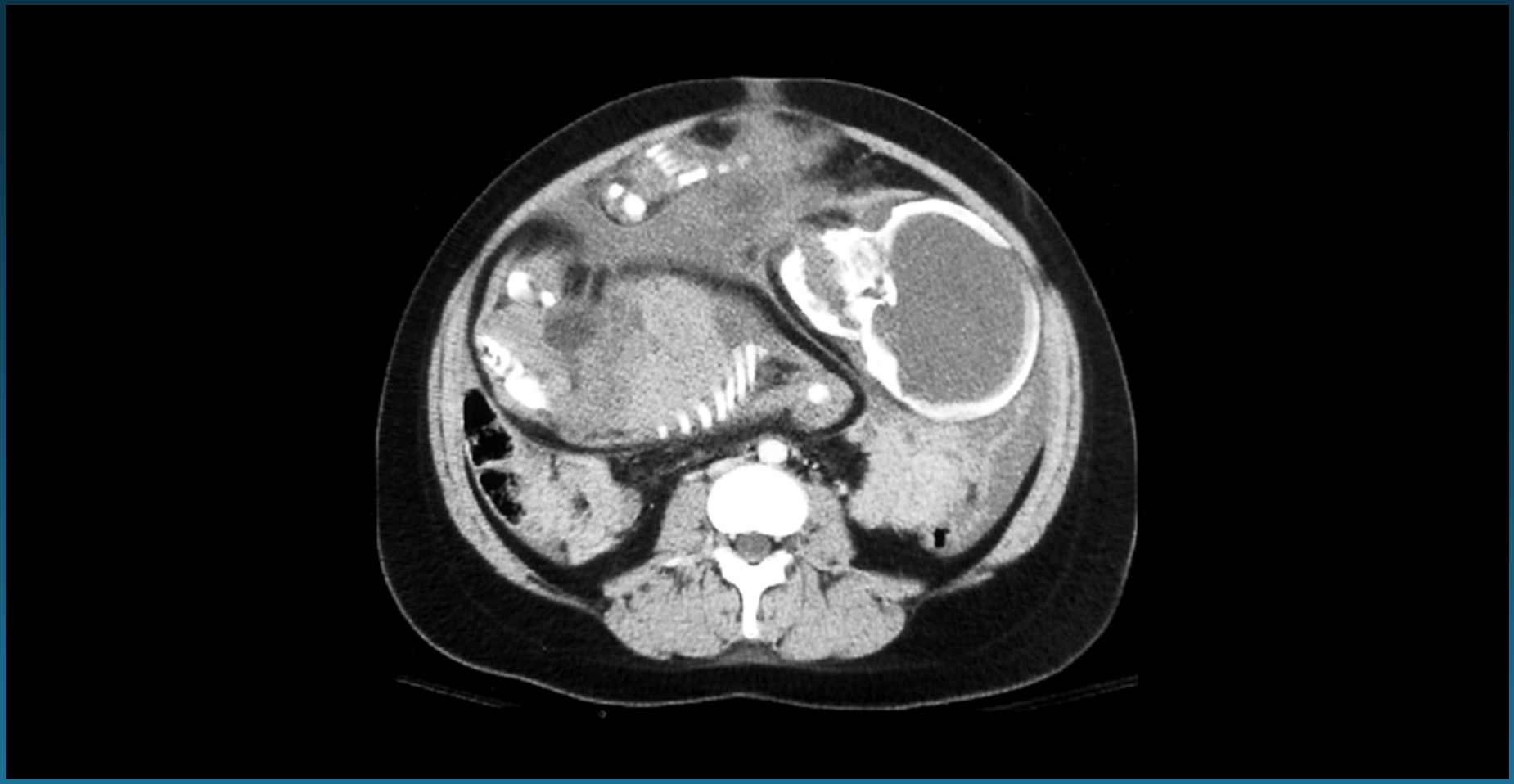
More common with prior C-section

- **100% fetal mortality**
- **46% maternal mortality**
- 79% hysterectomy rate in survivors



uterine rupture – MVC, pelvic fxs (36 wks GA)

Radiographics 1999; 19:S243-255



uterine rupture

Journal of Trauma 2001; 51:1192

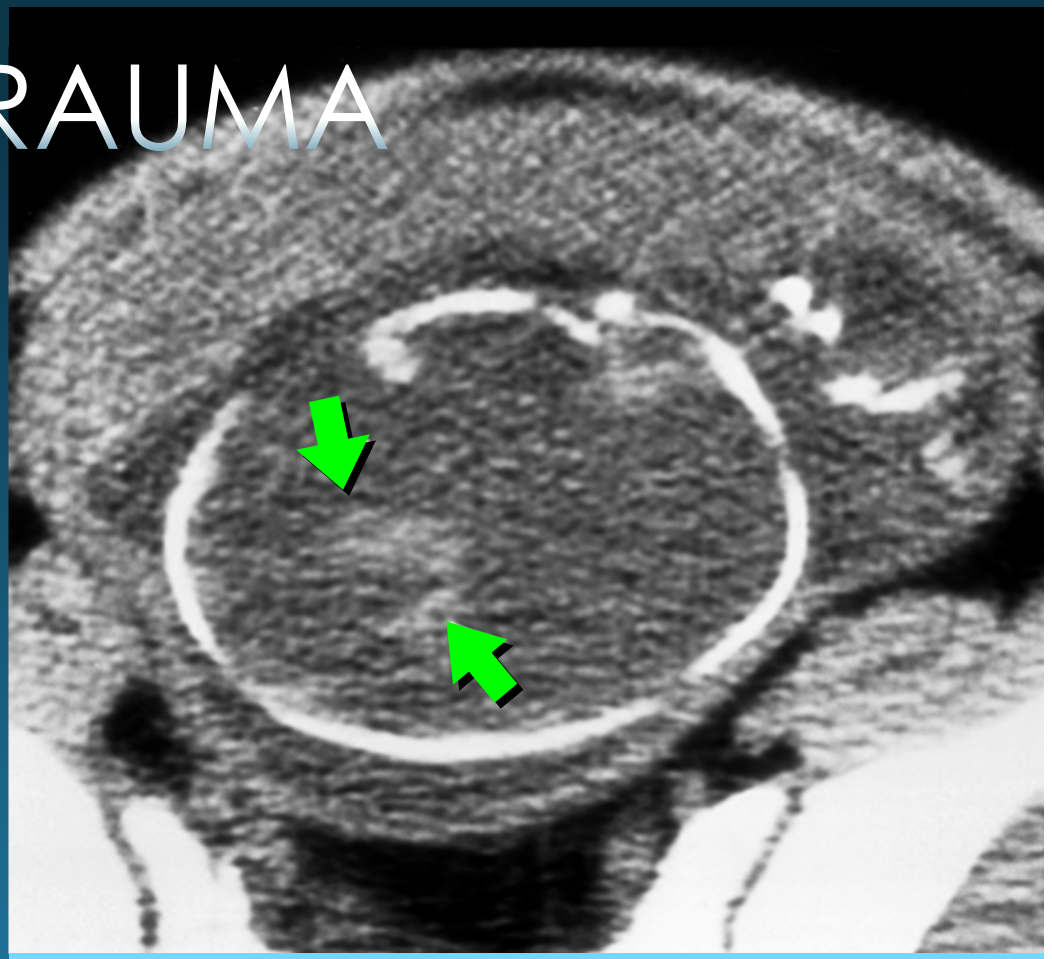
DIRECT FETAL TRAUMA

Blunt Trauma

- Skull fracture and intracranial bleed most common

GSW to uterus

- fetal mortality 70%
- maternal mortality 8%
- uterus protective to mother



fetal skull fracture, intracranial hemorrhage

Radiographics 1999; 19:1349

MAIN POINTS

There can be ***no fetal survival without maternal survival***.

Placental abruption on CT

Goal **<50 mSv** entire pregnancy


AMBULANCES ONLY
EMERGENCY
THANK YOU!
BU
BOSTON MEDICAL CENTER