Emergency Radiology in Pregnancy

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July 2003
Patient KB

- 34 year old G3P2002 at 32 and 6/7 weeks p/t ED s/p MVA
- Patient’s car knocked her down and ran over her left leg and side after she reached from outside to turn on AC with car in reverse.
- Pt c/o ankle and neck pain but no abdominal or pelvic pain.
Physical Exam

Upon arrival in the ED:
- VSS
- HEENT: NCAT, EOMi
- CV: RRR, no M/R/G
- Lung: CTAB
- Ab: Gravid, nontender
- GU: Bimanual examination with no evidence of blood, 1 cm and long.
- Ext: Swelling and bruising of L lateral leg and ankle, scrapes along L side of body
Fetal Monitoring

- Tocometer: contractions q 3 min, mild.
- Fetal monitor:
  - HR 130s
  - Moderate variability
  - Positive accelerations
  - No decelerations
Labs/Radiology

- Originally only significant for Hct 32
- What radiology will you order?
- Hct 32 $\rightarrow$ 29 $\rightarrow$ 27 over first 11 hours in ED with no other remarkable labs
- Now what radiology will you order?
- What are you concerned about regarding the imaging of a pregnant patient vs a non-pregnant patient?
Radiation Basics

- **Absorbed dose:**
  - Measured in rads (old units)
  - New units – gray (Gy)
  - 100 rad = 1 Gy

- **Factors affecting estimated dose:**
  - Number and type of projections
  - Exposure time
  - Distance
  - X-ray output

Radiation Effects on Prenatal Development

1) Intrauterine fetal death

2) Teratogenesis

3) Carcinogenesis
# Radiation Effects on Prenatal Development

<table>
<thead>
<tr>
<th>Gestational Stage</th>
<th>Days after Conception</th>
<th>Fetal Dose (rad)</th>
<th>Observed Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preimplantation</td>
<td>0-2 weeks</td>
<td>5-10</td>
<td>Intrauterine fetal death</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Animal data: survive undamaged or abort</td>
</tr>
<tr>
<td>Organogenesis</td>
<td>2-8 weeks</td>
<td>20-25</td>
<td>Teratogenesis</td>
</tr>
<tr>
<td></td>
<td>2-15 weeks</td>
<td>20-25</td>
<td>Animal and NBS data: growth retardation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NBS data: small head size</td>
</tr>
<tr>
<td>Rapid CNS Development</td>
<td>8-15 weeks</td>
<td>&gt;10</td>
<td>Teratogenesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small head size, seizures, decline in IQ 25 points/100 rad</td>
</tr>
<tr>
<td>Anytime (most susceptible 3-8 weeks)</td>
<td>As low as 1 rad</td>
<td></td>
<td>Carcinogenesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 leukemia case/2000 persons /rad</td>
</tr>
</tbody>
</table>

NBS = National bomb survivor from Hiroshima and Nagasaki
Adapted from Parry PA et al, 1999; Kruskal, JB 2001; Brent RL, 1986; Mettler and Upton r, 1995; CDC, 2002; Neufeld, 2002; Goldman and Wagner, 1996.
Data Summary

- Radiation exposure <5 rad has *not* been associated with increase risk of intrauterine fetal death or teratogenesis.
- 5 rads is a guideline not an absolute number
- Increased cancer risk is controversial
## Estimated Doses to Uterus from Plain Films

<table>
<thead>
<tr>
<th>Examination</th>
<th>Absorbed Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rad</td>
</tr>
<tr>
<td><strong>Plain films</strong></td>
<td></td>
</tr>
<tr>
<td>C-spine/Extremities</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>CXR</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Upper GI</td>
<td>0.1</td>
</tr>
<tr>
<td>Cholecystography</td>
<td>0.1</td>
</tr>
<tr>
<td>Pelvic</td>
<td>0.2</td>
</tr>
<tr>
<td>KUB</td>
<td>0.25</td>
</tr>
<tr>
<td>Hip and Femur</td>
<td>0.3</td>
</tr>
<tr>
<td>Lumber spine</td>
<td>0.4</td>
</tr>
<tr>
<td>Retrograde pyelography</td>
<td>0.6</td>
</tr>
<tr>
<td>Barium enema</td>
<td>1.0</td>
</tr>
<tr>
<td>Hysterosalpingography</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Adapted from Parry et al, 1999.
# Estimated Doses to Uterus from CT

<table>
<thead>
<tr>
<th>Examination</th>
<th>Absorbed Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$Rad$</td>
</tr>
<tr>
<td>CT</td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>0</td>
</tr>
<tr>
<td>Chest</td>
<td>0.016</td>
</tr>
<tr>
<td>Abdomen</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Adapted from Parry et al, 1999.
Radiological Modalities
Readily Available in Most EDs

US

Plain Films

CT
US

- **Strengths:**
  - Uses sound waves, no risk to fetus
  - Status of fetus, placenta, uterus
  - Abdominal organs
  - Intraperitoneal free fluid/hemorrhage (se 88%, sp 99%, accuracy 97%) (F.A.S.T. exam)

- **Weaknesses:**
  - Accuracy for bowel and biliary tree lesions
  - Can be difficult in obese patients
  - Operator dependent

Plain Film

Strengths:
- Low radiation exposure in films usually obtained in ED (C-spine, CXR, KUB, pelvis)
- Can limit exposure by proper shielding
- Fast
- Usually available

Weaknesses:
- Radiation exposure
- Composite shadowgram
- Only 4 shades of gray
- Organ outlines only appreciated when differing radiologic densities next to each other

Lieberman et al, 2003
CT

- **Strengths:**
  - Identify organ specific damage
  - Fast

- **Weaknesses:**
  - Highest radiation exposure
  - Contrast load - hit to kidneys
  - Metal artifact

Lieberman et al, 2003
Recommendations for Physicians

- NEVER forgo necessary diagnostic procedure because of concern of fetal radiation exposure
- Maternal health is most important factor in fetal health
- Use US and MRI instead of ionizing radiation modalities when possible

Chang, 2001; Desjardins, 2003; Goldman and Wagner, 1996; Kruskal, 2001; Mirvis and Young, 1992; Neufeld, 2002; Personal communication with Dr. John F. Copeland, July 17, 2003.
Recommendations for Physicians

To decrease radiation exposure:
- Collimation to expose only area of interest
- Avoid grids and magnification near uterus
- Use lead aprons to protect abdomen and pelvis
- CT
  - Wide pitch (move pt through scanner at faster rate)
  - Thickest slices possible (10mm vs 5mm or 1mm)

Chang, 2001; Desjardins, 2003; Goldman and Wagner, 1996; Kruskal, 2001; Mirvis and Young, 1992; Neufeld, 2002; Personal communication with Dr. John F. Copeland, July 17, 2003.
Recommendations for Patients

- Radiation risks are *far* below background population risks of:
  - miscarriage (15-35%)
  - congenital anomalies (3-4%)
  - genetic disease (10%)
  - growth restriction (4-10%)

Brent, 1986; Kruskal, 2001; Mettler and Upton, 1995
Recommendations for Patients

- Decision to terminate pregnancy should be based on careful estimation of:
  - Absorbed fetal dose
  - Gestational stage at time of exposure
  - Individual situation of family

Brent, 1986; Kruskal, 2001; Mettler and Upton, 1995
Beyond Radiation: Other Concerns

- Anatomic changes in pregnancy
- Contrast
Anatomy of Pregnancy

Liver
Kidney
Intestines
Stomach
Fetus
Uterus
Rectum
Bladder

6th Month
9th Month

Courtesy of AMA http://www.ama-assn.org/
Anatomy of Pregnancy

- Breast engorgement
- Diaphragm elevation
- Abdominal viscera moved superior and posterior
- Bladder moved inferior and anterior
- Physiologic dilation of ureters and mild hydrenephrosis
- Compression of IVC by uterus when supine (mainly 3rd trimester)
Contrast

- No published increased incidence of fetal thyroid disease with iodinated contrast exposure
- Trend to use non-iodinated contrast in general

Emergent Abd/ Pelvic Imaging in Pregnancy: Potential Etiologies

<table>
<thead>
<tr>
<th>OB/GYN</th>
<th>ABDOMINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ectopic pregnancy</td>
<td>Acute abdomen – perforation/ rupture of any abdominal viscus; most often due to trauma</td>
</tr>
<tr>
<td>Preterm labor</td>
<td>Appendicitis</td>
</tr>
<tr>
<td>Placental abruption</td>
<td>Cholecystitis</td>
</tr>
<tr>
<td>Uterine dehiscence</td>
<td>Diverticulitis</td>
</tr>
<tr>
<td>Uterine rupture</td>
<td>Nephrolithiasis</td>
</tr>
<tr>
<td>Incompetent cervix</td>
<td>Pyelonephritis</td>
</tr>
<tr>
<td>Placenta accreta</td>
<td>Bowel Obstruction</td>
</tr>
<tr>
<td>Ovarian hyperstimulation syndrome</td>
<td></td>
</tr>
<tr>
<td>Ovarian torsion</td>
<td></td>
</tr>
</tbody>
</table>
Back to Patient KB

- Initial Radiology:
  - C-Spine series
  - L ankle AP, mortise, lateral

- Total radiation dose to uterus = negligible
Patient KB

After Hct drop:

- **CT of Abdomen and Pelvis with non-iodinated contrast**
  - One pass
  - No CT without contrast was performed

- **Total radiation dose to uterus = 1.8 rad**

Calculations performed by Dr. Haejin Kang, physicist, BIDMC (assuming 120 kVp, 0.8 rot/sec, pitch 1.5, 240 mA, which is a standard abdomen technique)
Patient KB Abd and Pelvic CT: Scout Film

Abdominal viscera pushed superior

Bladder pushed inferior

Fetus with head down

PACS, BIDMC
Patient KB Abd and Pelvic CT

- Mild hydronephrosis
- Colon pushed anterior and posterior/lateral
- Contrast-enhancing placenta in superior uterus
- Small bowel pushed posterior

PACS, BIDMC
Patient KB Abd and Pelvic CT

- Fetal vertebra
- Rib
- Arm
- Bowel posterior

PACS, BIDMC
Can you determine the fetus’ sex?

Definitely a boy!
Trauma in Pregnancy:

- Placental injury
- (black arrows)
- Free fluid in abdomen (white arrow heads)

Fetal skull fracture (black arrow)

Mirvis SE, 1992
Ectopic Pregnancy:
Transabdominal US

Patient 3
Ectopic Pregnancy: Transvaginal US
Placental Abruption: Transabdominal US

Placenta

Uterine Myometrium

Hemorrhage

Courtesy of Dr. Tejas Mehta
Uterine Dehiscence: Transvaginal US

Normal uterine wall thickness

Anterior dehiscence

Patient 5
Small Bowel Obstruction: 
CT

Air-fluid level
in small bowel

Courtesy of Dr. Tejas Mehta
Small Bowel Obstruction: CT

Patient with SBO is pregnant!

Courtesy of Dr. Tejas Mehta
Appendicitis: 
US

Transverse

Increased size: 
1.14cm

PACS, BIDMC
Appendicitis: US

Sagittal

Likely fluid in appendix

PACS, BIDMC
Appendicitis: CT

Cecum (c)

Appendix:
• Enlarged
• Does not fill with contrast (white arrow)

Fetus

Courtesy of Dr. Tejas Mehta
Appendicitis: MRI

Appendix
Wave of Future: MRI

- **Strengths:**
  - No radiation
  - Soft tissues

- **Weaknesses:**
  - No data on safety re fetus
  - NRPB recommends to avoid in 1st trimester
  - Time
  - Expense
  - Availability
  - Contraindications

NRPB = National Radiological Protection Board
Personal communication with Dr. John F. Copeland, July 17, 2003.
Wave of Future: Planar CT

- **Strengths:**
  - Theoretically will decrease radiation
  - All strengths of current CTs

- **Weaknesses:**
  - Still radiation
  - Availability
  - Expense

NRPB = National Radiological Protection Board
Personal communication with Dr. John F. Copeland, July 17, 2003.
Take Home

- NEVER forgo necessary diagnostic procedure due to concerns of fetal radiation exposure
- Maternal health is most important factor in fetal health
- Be cognizant of radiation associated with each test and 5 rad guideline – radiation doses can add up fast!
Take Home

- Talk with radiologist/tech about strategies to diminish exposure
- Counsel patients appropriately.
  - Radiation risks are *far* below background population risks of miscarriage, congenital anomalies, genetic disease, and growth restriction.
  - Cancer data is controversial.
Acknowledgements

Thank you:

- Gillian Lieberman, MD
- Pamela Lepkowski
- Erik Stien, MD
- John Copeland, PhD
- Haejin Kang, Ph.D.
- Tejas Mehta, MD
- Deborah Levine, MD
- Nicole Nelson, MD
- Christopher Taylor, MD
- Bernadette Kennedy
References

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Mirvis SE and Young JWR, Eds. “Abdominal and Pelvic Trauma.” In Imaging in Trauma and Critical Care Baltimore: Williams and Wilkins, 1992.