Chapter 43
The Pregnant Trauma Patient

Jason L. Sperry and Matthew T. Heller

Clinical Problem

Twentynine-year-old female at 22 weeks gestation was involved in a motor vehicle collision. She had an altered mental status with GCS 7. She was intubated at the scene. En route she developed hypotension (SBP <90 mmHg) and heart rate increased to 125 bpm. Fluid resuscitation was initiated and her hemodynamics improved.

The more active lifestyle, the increased number of women in the work force, and the higher exposure to domestic violence and abuse in our society today, place pregnant women at significant risk for traumatic injury throughout gestation. The most common mechanism is motor vehicle collision, which is usually responsible for over half of all trauma events during pregnancy. The remainder is divided almost equally among falls and interpersonal violence, or assault. The incidence of trauma increases as women approach the later stages of gestation, primarily the late 2nd and 3rd trimesters. A majority of these pregnant trauma patients are minimally injured. This is due, in part, because women are more likely to present to the hospital after a potentially injurious event because they are pregnant, rather than because they are injured. Despite this, it has been shown that even with minor maternal injuries, there is increased risk of poor fetal outcome in the acute setting and throughout the remaining pregnancy.

J.L. Sperry, MD, MPH (✉)
Department of Surgery, University of Pittsburgh Medical Center,
200 Lothrop Street, Suite F1268, Pittsburgh, PA 15213, USA
e-mail: sperryjl@upmc.edu

M.T. Heller, MD
Division of Abdominal Imaging, Department of Radiology,
University of Pittsburgh Medical Center, 200 Lothrop Street, 3950 PUH S. Tower,
Pittsburgh, PA 15213, USA
e-mail: hellermt@upmc.edu

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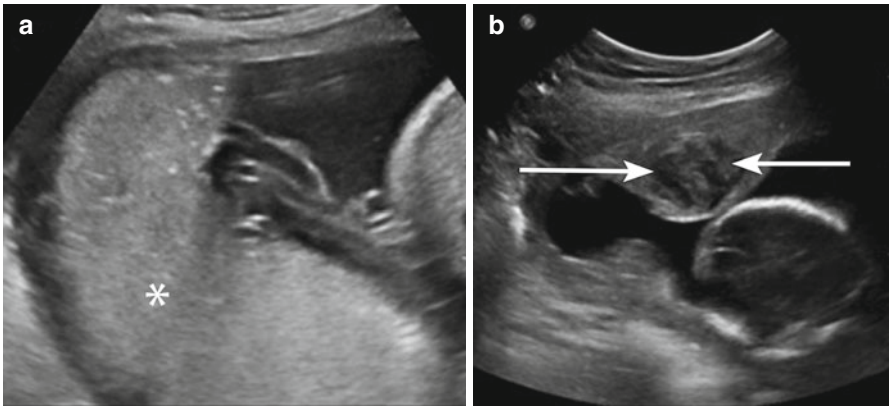

Fig. 43.1 (**a**) Transverse image from a pelvic ultrasound (US) shows a normal-appearing placenta (*asterisk*). (**b**) In a different patient, the US shows a focal hemorrhage (*arrows*) within the placenta due to focal abruption

Fetal Monitoring

All pregnant women with a potentially viable fetus (i.e. able to survive in an extrauterine environment), defined by a gestational age of 24 weeks or greater, should undergo continuous cardiotocographic monitoring (CTM). This consists of measuring simultaneous fetal heart rate and uterine contractions of the mother. CTM remains the most widely used modality for evaluation of the fetus, and is considered the "gold standard" for fetal assessment following injury. Multiple studies have shown that fetal morbidity and mortality can occur even in women without apparent injury. The objective of the monitoring period is to identify premature labor, placental abruption, and fetal distress for which an urgent intervention is needed. Less than 5 % of fetal deaths following maternal injury are due to direct injury to the fetus while up to 70 % are due to placental abruption. In addition to physical examination, ultrasound (US) (Fig. 43.1a, b) is important for evaluating the fetus and uterus for potential complications. CTM may identify fetal distress from placental abruption before changes in physical examination are evident.

Women with no apparent significant injury, without concerning physical examination findings such as vaginal bleeding or uterine tenderness, who have a normal 6 h CTM tracing without evidence of contractions or abnormal fetal heart rate variability, can be safely discharged from the hospital. An extended period of CTM for 24 h is required If:

- any monitoring abnormality is identified during the initial monitoring
- the mother requires admission for management of her injuries
- the mother requires general anesthesia
- the mother is clinically considered to be at high risk for fetal complications based on history or mechanism of injury.

Also, direct trauma to the uterus can cause release of decidual lysosomes and arachidonic acid metabolites that can result in uterine contractions and can induce premature labor and pre-term delivery.

Trauma Management in Pregnancy

Despite two individuals being at risk, the first and primary goal in treating a pregnant trauma victim is maternal stabilization. Achieving maternal wellbeing offers the best chance for preventing fetal morbidity and mortality. Simple measures like preventing hypotension through compression of the vena cava by placing pregnant patients greater than 20 weeks gestation in the left lateral decubitus position throughout resuscitation will help decrease potential fetal problems.

Early obstetric consultation should be obtained while initial resuscitation and assessment are occurring. A full obstetric history should be included along with the usual history and physical examination. An estimation of gestational age derived from the history and by accessing fundal height is an important factor in the decision regarding early delivery if needed. In addition to the trauma physical examination, a pelvic examination is required to rule out factors associated with fetal or placental injury, such as vaginal bleeding, ruptured membranes, or a bulging perineum.

Screening

Assault or interpersonal violence effects up to 20 % of all pregnant women sometime during gestation, though perhaps as few as 4–10 % of cases present for medical care. Such violence is commonly associated not with just a single event, but rather multiple episodes are the norm (Fig. 43.2). Violence occurs across all races and

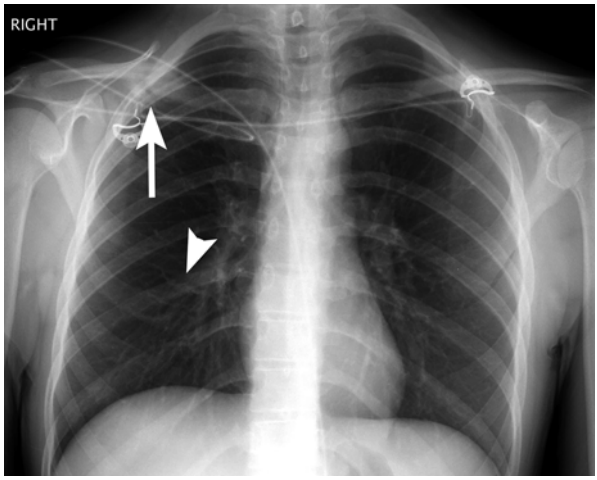

Fig. 43.2 Chest radiograph shows an acute, non-displaced rib fracture (*arrowhead*) and a healed clavicle fracture from possible prior domestic abuse

Table 43.1 Interpersonal violence screening questionnaire

Have you been kicked, hit, punched or otherwise hurt by someone within the past year?
Do you feel safe in your current relationship?
Is there are partner from a previous relationship who is making you feel unsafe now?

socioeconomic levels. Its been shown that abused mothers are twice as likely to begin their prenatal care in the third trimester. Women who report a history of abuse are at increased risk of poor fetal outcome. Interestingly, women who decline to be interviewed for interpersonal violence have even higher rates of fetal complications. Because a single trauma admission may be the only chance to pick up these types of events before a serious maternal or fetal injury may occur, screening using a validated three question questionnaire is currently recommended and included in advanced trauma life support (ATLS) recommendations (Table 43.1.) Interpersonal violence should be considered when:

- the injuries appear to be inconsistent with the history,
- the patient has a history of depression, substance abuse, self-abuse or suicide attempts,
- the patient blames herself for the injuries,
- the partner seems controlling and tries not allow the patient to be examined without him,
- the patient has had frequent visits.

Imaging Considerations for the Pregnant Patient

As in other trauma scenarios, imaging plays a major role in the diagnostic assessment of the pregnant trauma patient. Choosing the proper imaging examination to evaluate the pregnant patient can pose a dilemma for the clinician who is trying to facilitate prompt diagnosis while balancing radiation dose. Although imaging modalities that do not use ionizing radiation, such as US and magnetic resonance imaging (MRI), are strongly preferred when possible, their limitations can be substantial. The availability, speed and reliability of computed tomography (CT) are advantageous, but CT is associated with significant radiation exposure. Plain radiography and angiography are additional potential sources of ionizing radiation used in this setting. Although there are theoretical risks of fetal carcinogenesis, congenital malformations and mental retardation, there is no documented risk at current exposure levels commonly associated with diagnostic imaging. The risk of abnormality is considered to be negligible at 50 mGy or less. Practice guidelines for imaging the pregnant patient are based on the guiding principle that the mother's health is the most important factor for fetal survival and favorable outcome. Therefore, concerns regarding fetal radiation dose exposure should not delay or preclude radiologic evaluation in trauma patients requiring accurate and prompt diagnosis.

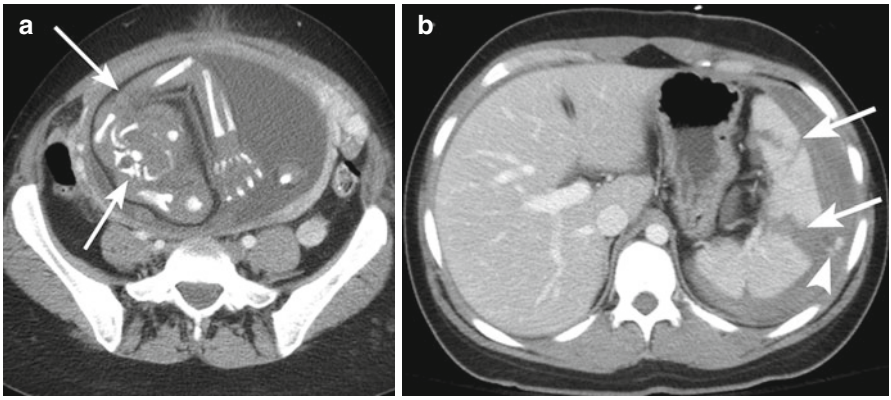

Fig. 43.3 (**a**) Post-contrast computed tomography (CT) of the pelvis shows a fetus within the gravid uterus (*arrows*). (**b**) More superiorly, there are multiple splenic lacerations (*arrows*) and focal active hemorrhage (*arrowhead*) with peri-splenic hematoma

Ideally, an attempt should be made to initially image mother and fetus with a modality that does not require ionizing radiation if possible. US provides appropriate first-line imaging, if necessary allowing rapid triage. The Focused Assessment by Sonography for Trauma (FAST) is considered to be positive when a significant volume of intra-peritoneal fluid or a pericardial effusion is present. However, the finding of a small amount of pelvic free fluid is less specific than free fluid elsewhere in the abdomen. Unfortunately, drawbacks of using US include operator dependence and suboptimal performance compared to body CT (Fig. 43.3a, b). Overall, the sensitivity and specificity of US for detection of abdominal injury in the pregnant patient are 61–86 % and 98–100 %, respectively. However, US is notoriously insensitive for detection of most pancreatic, renal, retroperitoneal, mesenteric and bowel injuries.

After the mother has been stabilized, US can be used to evaluate the fetus and placenta, since placental abruption is one of the most critical diagnoses to make in the pregnant trauma patient and a leading cause of fetal demise. Although US is the imaging modality of choice in this setting, its accuracy for determination of placental abruption is estimated to be only 50 %. US findings of abruption include visualization of separation of the placenta from the uterine wall, identification of retroplacental hematoma and echogenic amniotic fluid due to hemorrhage. In addition to placental evaluation, US allows rapid assessment of fetal anatomy, heart rate and biometry.

If the initial US is negative, consideration may be given to MRI evaluation of the abdomen and pelvis in an attempt to avoid radiation. However, there is no literature support for emergency use of MRI to evaluate the abdomen and pelvis in pregnant patients. Despite the exquisite soft tissue contrast resolution of MRI, its use in the pregnant trauma patient is often impractical due to examination length, patient comfort and potential difficulty monitoring patients. Additionally, although there is no definitive evidence that MRI harms the fetus, potential concerns related to acoustic

exposure and tissue heating have been raised. However, the American College of Radiology (ACR) advocates use of MRI if the imaging results are of direct benefit to the mother or fetus. Otherwise, elective maternal MRI examinations should be postponed until after pregnancy.

In most trauma cases an imaging modality that uses ionizing radiation, such as CT or radiography, may be chosen if the benefits of the information obtained from the scan outweigh the risks to the mother and fetus. CT is primarily used to assess for maternal injuries, but theoretically CT can also assess placental and fetal trauma. The CT appearance of such injuries is highly variable and may not be readily recognized prospectively.

The spectrum of CT findings of abdominopelvic trauma in pregnant patients is similar to that of the non-pregnant population. However, retroperitoneal hemorrhage is more common in pregnant patients due to the increased blood flow associated with pregnancy. Additionally, the liver, spleen and bladder are more susceptible to trauma due to their displacement by the gravid uterus. Maternal injuries more commonly associated with fetal demise include penetrating trauma, significant head injury and pelvic and acetabular fractures. In the setting of maternal stabilization, the most common cause of fetal demise is placental abruption. Placental abruption is due to shear forces between the uterus and the placenta. It is characterized on CT by uteroplacental separation, retroplacental hematoma or devascularization of a portion of the placenta shown as a nonenhancing region. The accuracy of CT in the diagnosis of placental abruption is unknown. In some instances, retroplacental clot can not be distinguished from uterine thickening or contraction, resulting in a false negative CT. Conversely, chronic infarctions, venous lakes and chorionic villa indentations may be confused with acute pathology in some cases. It is therefore very important to always correlate imaging findings with fetal monitoring.

Technical Considerations

When deciding to use ionizing radiation, physicians involved in the care of the pregnant patient should strive to minimize radiation according to the principle of ALARA (As Low As Reasonably Achievable) without compromising the diagnostic quality of the examination. This principle accounts for deterministic and stochastic effects of radiation. Deterministic effects occur when a defined threshold of radiation exposure is reached; general examples include organ malformations and impaired neurologic development. In contrast, stochastic effects are not dose dependent and may occur after any level of radiation exposure; examples include childhood malignancies such as leukemia and lymphoma. In the first 14 days after conception, the only risk of radiation exposure is pregnancy loss; however, it should be noted that doses used for diagnostic medical imaging have not been associated with such an effect. Radiation reduction is most critical between 2 and 15 weeks of gestation, as this timespan encompasses organogenesis (2–8 weeks) and is the most radiation sensitive period for the fetus. Effects associated with radiation exposure

during this period include stunted growth, mental retardation, alterations of organogenesis, increased risk of malignancy and miscarriage. During organogenesis, the estimate for the approximate threshold dose for induction of these untoward events is greater than 100 mGy. The estimated threshold dose for mental retardation in fetuses between 9 to 15 weeks is also greater than 100 mGy. Comparatively, the estimated absorbed fetal dose from maternal CT is substantially less. Although much knowledge regarding the effects of radiation dose on the fetus has been gleaned from experimental animal studies and atomic bomb survival data, no specific safe threshold for radiation exposure has been determined. However, fetal doses below 50 mGy (5 rad) have not been proven to cause fetal malformations or to increase the risk of abortion, while fetal doses between 50 to 150 mGy (5–15 rad) may have potential detrimental effects. In practice, the fetal dose during CT is influenced by multiple factors such as CT scanner settings, maternal body habitus, ability to provide pelvic shielding and distance of the fetus from the center of the beam. Estimates of fetal dose from a maternal head CT are felt to be less than 0.1 mGy (0.01 rad) since the fetus is remote from the epicenter of the CT beam. Conversely, CT of the maternal abdomen and pelvis may incur a fetal dose of approximately 17–35 mGy (1.7–3.5 rad). While it is not possible to measure the fetal dose directly, effective dose calculations have resulted in estimated it to be 7.3–14.3 mGy/100 mAs (0.73–1.4 rad/100 mAs) during simulations. With newer CT technology, the patient's radiation dose can reduced through image reconstruction techniques and the use of dose modulation calculations based on the patient's weight and body habitus.

The typical CT protocol for pregnant patients with suspected abdominopelvic trauma consists of acquiring 5 mm images through use of helical technique. Multiplanar reformatted images are reconstructed from the original scan data. Additional excretory phase images can be obtained approximately 10 min after injection of intravenous contrast material in those patients suspected of sustaining renal collecting system rupture or to assess for active hemorrhage into a hematoma if the initial scan is inconclusive. Diluted contrast material can be instilled into the bladder through a Foley catheter if CT cystography is required to assess for bladder injury in the presence of hematuria, pericystic hemorrhage or pelvic fractures near the bladder. Excretory phase imaging and CT cystography are only used in select patients, as the additional scans will increase maternal and fetal radiation dose.

When imaging the pregnant patient, the use of intravenous contrast material must also be considered carefully. For CT, iodinated contrast material administered intravenously will cross the placenta, but is not teratogenic or mutagenic. The Food and Drug Administration considers iodinated contrast material a Class B drug and its use depends on evaluation of the risk/benefit ratio. On the other hand, intravenous gadolinium based contrast agents for MRI are considered a Class C drug by the FDA and have been shown to cause growth retardation and congenital malformations at high doses in animals. Although no definitive adverse effects have been reported in human fetuses, the ACR guidelines and most radiology departments do not advocate use of gadolinium based contrast agents in pregnant patients.

Teaching Points

1. Providing optimal care for the mother is critical to assure the best outcome for both mother and fetus. Initial assessment of the pregnant trauma patients should follow standard trauma protocols.
2. Early fetal monitoring and obstetric consultation is important after the fetus has reached the point of potential viability, even if the trauma seems minor.
3. A modality that does not use ionizing radiation is preferred for the initial imaging examination.
4. The inherent limitations of these examinations and the need for prompt diagnosis make CT the highest yield examination in many cases.
5. The risks of radiation are small compared to the risk of missed or delayed diagnosis in a pregnant trauma patient.