Trauma In Pregnancy: Double Jeopardy

A radio call interrupts your otherwise routine night shift. The EMS driver reports, "We are en route to your emergency department with a 31-year-old female, G2P1 at 33 weeks, belted driver, in a moderate-speed motor vehicle collision. Patient’s car was heavily damaged in the front, and the airbag did deploy. Following a brief loss of consciousness, patient is now awake but slightly confused. She has an obvious deformity of the right ankle and is complaining of lower abdominal pain and mild shortness of breath. Patient's vital signs are as follows: heart rate is 110 and BP is 100/45. Our arrival time to your facility is approximately 3 minutes." You now have 3 minutes to collect your thoughts and prepare your team for what is sure to be a challenging resuscitation.

**Trauma** occurs in approximately 5% of pregnancies.¹ These cases can be challenging for an emergency physician to manage for several reasons. The well-being of 2 patients, the mother and fetus, must be considered simultaneously. The normal physiologic and anatomic changes associated with pregnancy can make the detection of hemorrhagic shock challenging. The need to perform diagnostic x-rays for the mother must be weighed against the risk of radiation exposure to the developing fetus. Important diagnoses that are unique to pregnancy such as abortion of the placenta and preterm labor may occur even after minor trauma. This issue of *Emergency Medicine Practice* focuses on the key issues in the initial management of the pregnant trauma patient in the emergency department.

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**CME Objectives**

Upon completion of this article, you should be able to:

1. Cite the unique anatomic and physiologic changes of pregnancy that affect the management of trauma in a pregnant patient.
2. Assess and employ the initial stabilization and emergency department evaluation of a pregnant trauma patient.
3. Recognize the presentation and practice proper treatment of pregnancy-specific conditions following trauma, such as abortion of the placenta, uterine rupture, and preterm labor, and the indications for fetal monitoring.
4. Demonstrate the indications for and technique of a perimortem cesarean section.

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Abbreviations Used In This Article

ATLS: Advanced Trauma Life Support  
BP: Blood Pressure  
BPM: Beats Per Minute  
BUN: Blood Urea Nitrogen  
CPR: Cardiopulmonary Resuscitation  
CT: Computed Tomography  
DPL: Diagnostic Peritoneal Lavage  
EAST: Eastern Association for the Surgery of Trauma  
EMS: Emergency Medical Services  
FAST: Focused Abdominal Sonography in Trauma  
FRC: Functional Residual Capacity  
IPV: Intimate Partner Violence  
KB: Kleihauer-Betke  
mIU: International Units  
MRI: Magnetic Resonance Imaging  
OB-GYN: Obstetrics Gynecology  
RhIG: Rho(D) Immune Globulin

Critical Appraisal Of The Literature

A search of Ovid MEDLINE and PubMed for articles related to trauma in pregnancy was performed. The search was limited to the English language and to human studies. Key words used in the search included trauma in pregnancy, placental abruption, perimortem cesarean section, Rh immunization, cardia toco monitoring, Kleihauer-Betke test, and radiation in pregnancy. Bibliographies from the selected articles were reviewed for additional references.

The most credence was given to scientific articles including clinical trials, prospective cohort studies, and aggregate studies including meta-analyses of clinical trials. Retrospective studies, case-controlled studies, and other meta-analyses provided secondary evidence for analysis followed by panel consensus, cross-sectional studies, and case reports. In addition, guidelines from the Eastern Association for the Surgery of Trauma (EAST) and the American College of Obstetrics and Gynecology were reviewed.  

Epidemiology, Etiology, And Pathophysiology

In a retrospective cohort study of 10,316 pregnant patients hospitalized following trauma, motor vehicle collisions were the most common mechanism followed by falls and assaults. In this cohort, orthopedic injuries such as sprains, fractures, and dislocations were the most common injuries.  

In another retrospective cohort study of 582 patients, pregnant women hospitalized following motor vehicle crashes were found to be at increased risk for placental abruption, preterm labor, cesarean delivery, and fetal death, regardless of injury severity. A population-based review of 3292 pregnant patients following fractures and another study of 2070 patients following assaults also demonstrated increased risk of these pregnancy complications even with seemingly minor injuries.

Anatomy And Physiology Of Pregnancy

There are many anatomic and physiologic changes in pregnancy that impact the evaluation and management of a pregnant trauma patient. The enlarging uterus remains protected within the bony pelvis until about 12 weeks and is only vulnerable in cases of severe trauma or if the mother is hemodynamically unstable. At 20 weeks, when the fetus is potentially viable, the uterus becomes an abdominal organ and reaches the level of the umbilicus. At 34-36 weeks, the uterus reaches the level of the costal margins. The distance measured in centimeters from the pubic bone to the top of the uterine fundus can help approximate the gestational age of the fetus.  

As the uterus enlarges, it can compress the inferior vena cava whenever the patient is lying on her back. This compression can reduce cardiac output by up to one-third, resulting in hypotension. In general, the physiologic adaptations of pregnancy are the result of either the direct effect of the increased circulating progesterone levels or the hemodynamic changes that occur to meet the increased perfusion requirements and metabolic needs of a developing pregnancy.

Table 1. Clinical Policies On Trauma In Pregnancy

<table>
<thead>
<tr>
<th>Group</th>
<th>Practice Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Association for the Surgery of Trauma (EAST)</td>
<td>Diagnosis and management of injury in the pregnant patient</td>
</tr>
<tr>
<td>American College of Obstetrics and Gynecology</td>
<td>Obstetric aspects of trauma management</td>
</tr>
<tr>
<td>American College of Obstetrics and Gynecology</td>
<td>Guidelines for diagnostic imaging in pregnancy</td>
</tr>
<tr>
<td>American College of Obstetrics and Gynecology</td>
<td>Rh isoimmunization and Rho(D) immune globulin administration</td>
</tr>
</tbody>
</table>
Cardiovascular Changes
By the end of pregnancy, the uterus and placenta receive approximately 20% of the maternal cardiac output. To meet this increased demand, the resting heart rate is increased by 10-15 beats per minute (BPM). Cardiac output is increased by 1.0-1.5 liters per minute. Blood pressure is decreased 5-15 mm Hg in the second trimester because of decreased vascular resistance and vasodilatation secondary to the effects of progesterone on smooth muscle, and it returns to baseline close as gestation approached term. Maternal blood volume expands significantly during pregnancy. Since red cell production does not increase proportionately, dilutional anemia is common. Because of expanded blood volume, a pregnant patient may lose from 1000-1500 mL of blood or experience 30%-35% of total blood loss before exhibiting overt signs of shock.

Pulmonary Changes
Pulmonary physiology changes significantly during pregnancy. During pregnancy, oxygen consumption is increased. To meet the increased oxygen requirements, tidal volume and respiratory rate are also increased. Consequently, pCO₂ will decrease, usually to about 30 mm Hg; a normal pCO₂ may indicate respiratory compromise. Functional residual capacity (FRC) is decreased. The end result is a lower pulmonary reserve. The pregnant trauma patient should be aggressively treated when there are any signs of respiratory compromise since she can decompensate rapidly.

Gastrointestinal Changes
During pregnancy, gastric motility decreases, and gastric emptying time increases in combination with a decrease in lower esophageal tone which leads to an increased risk of aspiration.

Orthopedic Changes
Greater ligament laxity during pregnancy increases the risk of orthopedic injuries.

Differential Diagnosis
A pregnant trauma patient must be evaluated for the full range of injuries. This evaluation proceeds in a systematic manner identical to a non-pregnant patient evaluation. There are diagnoses unique to pregnancy that must be considered including placental abruption, preterm labor, and uterine rupture.

The placenta is a fixed structure relative to the uterus and is vulnerable to injury following abdominal trauma. The clinical presentation of placental abruption can be dramatic with marked fetal distress, or it can be subtle and difficult to diagnose. Abruption can occur following minor abdominal trauma. After trauma, complaints of abdominal pain are common but vaginal bleeding is not. Ultrasound may demonstrate a placental abruption but is notoriously insensitive and cannot be used to rule out the diagnosis. A recent retrospective cohort study found 24% sensitivity, 96% specificity, and 88% positive and 53% negative predictive value of ultrasound to detect abruption. Other studies have similar findings, and while an ultrasound suggestive of abruption is very useful, a negative ultrasound will potentially miss an abruption. Signs of fetal distress on cardiac toco monitors are often the earliest indica-

Table 2. Physiologic Changes In Pregnancy

<table>
<thead>
<tr>
<th>Cardiovascular</th>
<th>Increased cardiac output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increased blood volume</td>
</tr>
<tr>
<td></td>
<td>Increased resting heart</td>
</tr>
<tr>
<td></td>
<td>rate</td>
</tr>
<tr>
<td></td>
<td>Decreased peripheral</td>
</tr>
<tr>
<td></td>
<td>resistance</td>
</tr>
<tr>
<td></td>
<td>Decreased blood</td>
</tr>
<tr>
<td></td>
<td>pressure (second trimester)</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>Increased respiratory</td>
</tr>
<tr>
<td></td>
<td>rate</td>
</tr>
<tr>
<td></td>
<td>Decreased functional</td>
</tr>
<tr>
<td></td>
<td>residual capacity</td>
</tr>
<tr>
<td></td>
<td>Increased tidal volume</td>
</tr>
<tr>
<td></td>
<td>Increased minute</td>
</tr>
<tr>
<td></td>
<td>ventilation</td>
</tr>
<tr>
<td></td>
<td>Respiratory alkalosis</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>Decreased gastric motility</td>
</tr>
<tr>
<td></td>
<td>Decreased esophageal</td>
</tr>
<tr>
<td></td>
<td>sphincter tone</td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>Increased ligament laxity</td>
</tr>
</tbody>
</table>
tors for placental abruption. These signs include decelerations, tachycardia, bradycardia, and loss of heart rate variability.

Frank rupture of the uterus is a potentially devastating complication of severe trauma and is almost always associated with death of the fetus. A patient with uterine rupture presents with complaints of severe abdominal pain. Fetal parts may be palpable on physical examination. Preterm labor, defined as “uterine contractions accompanied by cervical dilatation,” may occur following even a minor injury. Any pregnant trauma patient with abdominal pain should be evaluated for signs of preterm labor.

Prehospital Care

Standard prehospital protocols for trauma patients also apply to pregnant patients, with a few important considerations. In the last half of pregnancy, the enlarged uterus may compress the inferior vena cava when the patient is lying flat, reducing cardiac output by 30%. Placing the woman in the left lateral decubitus position or manually displacing the uterus to the left can alleviate this phenomenon, which is known as “supine hypotension.” If the patient is on a backboard, alleviate hypotension by tilting the backboard using sheets or other materials beneath it. Early intravenous fluids should be given, especially following a severe mechanism of injury or if there are any signs of hemodynamic compromise.

All pregnant trauma patients should receive supplemental oxygen since the changes in pulmonary function during pregnancy can cause the patient to desaturate quickly, and a developing fetus is very susceptible to hypoxia.

Following a major mechanism, most pregnant trauma patients should be evaluated at a designated trauma center with an OB-GYN consultation available. One prospective study of 205 pregnant patients in the second half of pregnancy found that patients presenting with contractions, vaginal bleeding, and uterine tenderness as well as those with direct trauma to the abdomen were more likely to have obstetric complications.

ED Evaluation

History

The initial emergency department evaluation of a pregnant patient following major trauma should follow standard Advanced Trauma Life Support (ATLS) protocols with a few important considerations. Many pregnant patients will present to the ED following minor trauma, such as a fall from standing or isolated musculoskeletal injury, for treatment of their injuries and with concerns regarding potential injury to the fetus. During the initial assessment, information regarding the gestational age, prior pregnancy complications, circumstances around the trauma, and the potential for any associated injuries should be obtained. The patient should be asked if she has had any vaginal bleeding, abdominal pain or contractions, leakage of fluid, and if applicable, if she continues to feel fetal movement. All injured pregnant patients should be screened for intimate partner violence.

Physical Examination And Triage Of The Pregnant Patient

Fetal well-being and survival is dependent on maternal well-being; therefore, maternal stabilization must be the first priority when evaluating the pregnant trauma patient. Life saving procedures should not be withheld because of the pregnancy.

Supine hypotension from compression of the inferior vena cava can occur, so attention must be paid to the patient’s positioning from the beginning of the evaluation. The physical examination follows the standard evaluation of the trauma patient: complete an initial primary survey and assess possible life threats. This is followed by a thorough secondary survey to look for all potential injuries. The next steps depend on the severity of the trauma, the patient’s specific injuries, the presence of any symptoms suggesting placental abruption or preterm labor, and the gestational age of the fetus. Fetal monitoring, if available, should be initiated in the emergency department if the patient is greater than 20 weeks gestation. A vaginal examination to assess for bleeding and amniotic fluid should be performed. Amniotic fluid turns nitrazine paper blue and exhibits a characteristic ferning pattern on a slide. These simple tests can be helpful if the diagnosis is not clear. To decrease the risk of infection, a sterile speculum should be used to perform the examination. In patients with minor injuries that do not have symptoms suggestive of pregnancy complications, the vaginal examination is not necessary. However, placental abruption and preterm labor can occur following minor trauma, and patients greater than 20 weeks with any potential trauma to the abdomen should have a minimum of 4-6 hours of fetal monitoring after treatment of their injuries. Monitoring is typically done in the labor and delivery suite, but protocols may vary across institutions.

ED Management Of Major Trauma In Pregnancy

Aggressive fluid resuscitation is essential in the pregnant patient because of the dilutional anemia of pregnancy; up to 30% of blood volume can be lost before obvious signs of maternal shock appear.
Maternal shock may also be associated with severe fetal distress.

Early intubation is recommended if the patient is obtunded or has any signs of respiratory compromise. A pregnant patient in the third trimester is more likely to be a difficult airway for a number of reasons, and it is important to be prepared for this possibility. Pregnancy causes fluid retention and weight gain, which leads to swelling of the airway tissues. Additionally, pregnant patients have decreased oxygen reserves and may desaturate quickly. Progesterone causes relaxation of the lower esophageal sphincter and increases the risk of aspiration. In pregnancy, pCO₂ is normally decreased; a normal level may suggest respiratory compromise.

Induction and paralytic agents may be used during pregnancy; however, these medications do cross the placenta in small amounts and may affect the initial resuscitation of the baby if delivery is imminent.¹⁴

Pressure from the gravid uterus pushes the diaphragm up several centimeters, so if a chest tube is required, it should be placed 1-2 interspaces higher than usual to avoid entering the abdomen. When evaluating the patient’s circulation and volume status, it is important to keep in mind the normal hemodynamic changes of pregnancy. A pregnant patient may lose a significant amount of blood, even more than a liter, before showing any signs of instability. Fetal distress may be the earliest sign. Aggressive fluid resuscitation and transfusion with O negative blood should be initiated in any unstable patient. Vasopressors should be avoided, if possible, since they compromise blood flow to the uterus and lead to decreased fetal oxygen delivery. If vasopressors are needed to save the life of the mother or maintain maternal vital signs, they should not be withheld. After the initial primary survey, a systematic evaluation similar to non-pregnant patient evaluations should be performed.

**Diagnostic Studies**

**Laboratory Tests**

A trauma laboratory panel is ordered following major trauma and generally includes a complete blood count, basic chemistry panel, toxicology screen, and lactate and base deficit. It should be taken into account when interpreting these laboratory panels that the physiological changes of pregnancy alter some laboratory values. One of the most critical changes to be aware of in the setting of trauma is the physiological anemia of pregnancy. Blood volume increases by 50% in pregnancy with red blood cell production increasing by only about 30%, resulting in a dilutional “anemia.” Some of the other laboratory values that are changed in pregnancy are:

- Decreased hematocrit
- Decreased blood urea nitrogen (BUN)
- Increased white blood cell count
- Decreased platelets
- Increased clotting factors
- Increased D-dimer, fibrinogen

Elevated D-dimer, decreased fibrinogen, and elevated fibrin split products may be seen with abruption of the placenta but are not sensitive or specific and cannot be used to definitely rule out abruption.

**Kleihauer-Betke Testing**

There is some controversy in the literature regarding the utility of routine use of Kleihauer-Betke (KB) testing in pregnancy. The KB test detects the presence of fetal cells in the maternal circulation and is used as an indicator of maternal fetal hemorrhage. Currently, the test is an acid elution test based on the relative greater stability of fetal hemoglobin in an acid solution, but newer flow cytometry techniques may provide greater accuracy.

It is estimated that as little as 0.0001 mL of fetal blood can cause maternal sensitization in Rh-negative mothers. Therefore, the American College of Emergency Physicians and the American College of Obstetrics and Gynecology recommend the routine administration of Rho(D) immune globulin (RhIG) to all Rh-negative mothers following even minor trauma.⁵¹⁵ In major trauma, it is generally accepted to use the KB test to determine the need to administer additional doses of RhIG. The dose is 30 mL of RhIG for every 30 cc of fetal hemorrhage.

The utility of using the KB test routinely for all
pregnant trauma patients as a general predictor of obstetric complications is unclear. One study examined the incidence of positive KB tests in a retrospective cohort of 151 pregnant trauma patients as compared to 100 asymptomatic patients in a prenatal clinic; it found no difference in the number of positive tests. Of note, there were very few positive tests in each group (2.6% and 5.1% respectively). The authors concluded that the KB test was not specific for abruption of the placenta and provided no clinically useful information as a screening test. Another retrospective review of 71 pregnant trauma patients found that independent of the severity of illness, a positive KB test was a predictor of preterm labor; conversely, none of the 46 patients with a negative KB test went on to have contractions. This study recommended routine use of the KB test to screen patients who are more at risk for preterm labor or abruption and to limit the duration of monitoring in asymptomatic patients with a negative test. Further prospective research with larger numbers of patients may help shed light on this issue.

**Diagnostic Imaging In Pregnant Trauma Patients**

X-rays and computed tomography (CT) scans are a standard part of the initial evaluation of a trauma patient, and a patient will often receive several radiographic studies following a major trauma. Balancing the risk of radiation exposure to the fetus with the need to diagnose injuries in the mother is an important consideration. The East Society of Trauma Surgeons and the American College of Obstetrics and Gynecology have issued guidelines that are helpful when making decisions regarding imaging in pregnancy. It is well established that exposure of the fetus to less than 5 rads is considered safe. Table 3 lists the radiation dose to the fetus from common studies performed in pregnancy. Multiple studies can be performed as needed and still be well below this threshold. Of course, it is beneficial to avoid unnecessary studies and place a lead shield over the fetus if possible.

**Ultrasound**

Ultrasound has become an important tool in the assessment of the pregnant patient with trauma. A retrospective review of 3976 female trauma patients found that 114 were pregnant and incidental pregnancy was diagnosed at the time of the trauma in 13 patients. In a follow-up study of 144 patients, ultrasound detected the new pregnancy in 8 of 9 patients with a gestational age of less than 8 weeks; the authors recommended using ultrasound as a screening tool for pregnancy in female trauma patients of reproductive age. Focused abdominal sonography in trauma (FAST) has been well estab-

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**Table 3. Fetal Dose Of Radiation With Standard Trauma Imaging Studies**

<table>
<thead>
<tr>
<th>Diagnostic Study</th>
<th>Fetal Dose of Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest radiograph</td>
<td>0.02-0.07 mrads</td>
</tr>
<tr>
<td>Pelvis radiograph</td>
<td>100 mrads</td>
</tr>
<tr>
<td>Head CT</td>
<td>&lt; 1 rad</td>
</tr>
<tr>
<td>Chest CT</td>
<td>&lt;1 rad</td>
</tr>
<tr>
<td>Abdominal / lumbar spine CT</td>
<td>3.5 rads</td>
</tr>
<tr>
<td>Cervical spine CT</td>
<td>&lt; 1 rad</td>
</tr>
<tr>
<td>Pelvis CT</td>
<td>250 mrads</td>
</tr>
</tbody>
</table>

*from the American College of Obstetrics and Gynecology Educational Bulletin. Guidelines for Diagnostic Imaging in Pregnancy*

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**Figure 3. Ultrasound Also Allows For A Quick Assessment Of The Pregnancy, Including The Presence Of Amniotic Fluid**

Ultrasound demonstrating normal amount of amniotic fluid around the developing fetus. Image courtesy of Seric Cusick, MD, UC Davis Department of Emergency Medicine. Used with permission.

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**Figure 4. Ultrasound Assessment Of Fetal Heart Rate**

Image courtesy of Seric Cusick, MD, UC Davis Department of Emergency Medicine. Used with permission.
Clinical Pathway For Management Of Major Trauma In Pregnancy

Gather prehospital information (if available).
- Gestational age
- Mechanism of trauma
- Vital sign abnormalities
- Apparent injuries / signs of pregnancy complications

Initial assessment: Is the mother unstable?

NO

Is the fetus 24 weeks or older?

NO

Identify and treat maternal injuries. Avoid excessive radiation if possible.

YES

Provide early intubation and aggressive resuscitation. Does maternal arrest occur?

YES

Perform perimortem C-section if fetus > 24 weeks.

NO

Initiate fetal monitoring and continue for 4-6 hours.

Are there signs of pregnancy complications?
- Fetal heart rate >160 or < 110
- Vaginal bleeding
- Leakage of amniotic fluid
- Contractions

YES

Perform stat OB consult. Consider emergency C-section and patient admission.

NO
lished for the detection of intraperitoneal hemorrhage following trauma. In a retrospective review of 127 pregnant patients who had FAST examinations, ultrasound detected hemoperitoneum in 5 of 6 patients with hemoperitoneum at surgery. While the study has a small number of injuries, the FAST examination seems to have a similar accuracy in pregnant as well as non-pregnant patients (Figure 2). Ultrasound can also be used to quickly assess the pregnancy, with documentation of the fetal heart rate, and the presence of amniotic fluid (Figures 2, 3, and 4).

Magnetic Resonance Imaging
Early evidence suggests that in pregnant patients with non-traumatic abdominal pain, magnetic resonance imaging (MRI) is a reasonable option to avoid the radiation associated with CT scans. It is plausible that MRI may soon provide a viable alternative to evaluate for intraabdominal injuries following trauma as well, but this has not been well studied to date.

Diagnostic Peritoneal Lavage
There is very little in the literature discussing the use of diagnostic peritoneal lavage (DPL) to detect intraperitoneal hemorrhage in pregnant patients. A recent study describes experience with 2500 DPLs in one trauma center. In this series, 92 patients were pregnant and DPL was performed using an open supraumbilical approach with no complications. Most reviews recommend using the open technique on pregnant patients to avoid inadvertently puncturing the uterus with the catheter. One obvious advantage of DPL is the avoidance of radiation from a CT scan. However, many solid organ injuries no longer require an operation, and in a hemodynamically stable patient, it is likely that a positive DPL would be followed by a CT scan to determine the specific source of the hemorrhage. One possible role for a DPL would be the rapid triage of an unstable hypotensive patient to determine if the source of the hemorrhage is intraabdominal. Even so, DPL is rarely performed on pregnant patients in most centers.

Cardiac Toco Monitoring
As soon as the mother is stabilized, a cardiac toco monitor should be placed to assess the fetal heart rate and the presence of uterine contractions. Fetal distress is often the first sign of placental abruption and may be an early sign of impending hemorrhagic shock in the mother. The normal fetal heart rate is 110-160 BPM. Fetal distress may manifest by fetal heart rate decelerations, tachycardia, bradycardia, or a flat baseline. Figure 5 illustrates examples of these changes. In general, every patient over 20 weeks should have a period of cardiac toco monitoring following major or even minor trauma directly to the abdomen. Some authors recommend 4 hours of monitoring; others, including the EAST guidelines, recommend 6 hours of monitoring. If uterine contractions or fetal heart rate abnormalities are seen, the patient should be admitted for monitoring for at least 24 hours.

Treatment
Injuries in a pregnant trauma patient are generally treated similarly to non-pregnant trauma patient injuries. Most medications that are used routinely in trauma management can be safely given to pregnant patients. Table 4 lists some of the medications commonly used in trauma care and some of the important considerations with pregnant patients.

All Rh-negative patients should receive a dose...
of RhIG to prevent maternal sensitization to fetal antigens. This dose is 50 mIU (international units) intramuscularly if given prior to 12 weeks and 300 mIU after 12 weeks.5,15

In most cases, an obstetrician should be consulted early in the management of the pregnant trauma patient to assist in management of potential pregnancy-related complications. If there is evidence of fetal distress on the monitor, the patient may require an emergency cesarean section. In the setting of preterm labor, tocolysis may be appropriate depending on the gestational age. Terbutaline (0.25 mg given subcutaneously) is a first-line treatment. Intravenous magnesium is also used. Corticosteroids should be given if the patient is between 24 and 34 weeks to promote fetal lung maturity if delivery seems probable. Table 5 lists the doses of drugs used in the management of preterm labor.

Special Circumstances

Penetrating Abdominal Trauma

Penetrating abdominal trauma can be very challenging to manage in pregnancy. Penetration of the uterus is often devastating for the fetus, and the associated mortality is high. Small caliber bullets rarely penetrate through the posterior wall of the uterus, so in one sense, the pregnant uterus provides a protective barrier to the mother.10 In the second and third trimester of pregnancy, the bowel is displaced superiorly by the gravid uterus which changes the typical pattern of injury during this stage of pregnancy. Injuries of the bowel occur less commonly with lower abdominal wounds but are more likely with upper abdominal wounds. Amniocentesis may be considered to assess uterine penetration. Many patients with penetrating injuries to the uterus require an emergency cesarean section if the fetus is viable.

### Pelvic Fractures

The management of pelvic fractures during pregnancy deserves special mention. Because a large amount of force is required to fracture the pelvic ring, pelvic fractures are a marker of severe trauma. Given the proximity to the pregnant uterus, the fetus is particularly vulnerable to injury in even minor pelvic fractures.23 A prospective registry of pregnant patients with fractures included 151 patients with pelvic fractures and found these patients to be at particular risk for placental abruptions, need for blood transfusion, and maternal and fetal death.8 Because of venous engorgement in the pelvis during pregnancy, blood loss can be particularly severe. Angiography and embolization of bleeding vessels have not been well studied. Orthopedic fixation can be performed on pregnant patients similar to non-pregnant patients.23

Intimate Partner Violence

It is well established that intimate partner violence (IPV) increases during pregnancy.24 The first episode of violence may occur during the pregnancy, or the violence may escalate in a relationship already characterized by violence. In a classic article on the subject, MacFarlane reported a prevalence of physical or sexual abuse of 17% in a cohort of 691 pregnant patients, using a 3-question screening tool. The abuse was recurrent in 60% of the patients. The author reports that pregnant patients who were victims of interpersonal violence were unlikely to seek prenatal care until the third trimester, when injuries to the abdomen are more common.25 In a cohort of 1203 patients presenting for prenatal care, 20.6% of teens and 14.2% of adult women reported abuse during the pregnancy. These women were more at risk for delivering low birth weight babies.26 Victims of IPV frequently use the emergency department for treatment of their injuries, and it is critical that the physician inquire about this possibility especially when the patient

### Table 4. Medications In Pregnancy

<table>
<thead>
<tr>
<th>Medications</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetanus</td>
<td>Safe to give.</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Avoid fluoroquinolones and gentamycin. Most others are safe.</td>
</tr>
<tr>
<td>Rapid sequence</td>
<td>Medications May be used.</td>
</tr>
<tr>
<td>Analgesia</td>
<td>Narcotics may be used unless delivery is imminent. NSAIDS should be avoided because of potential compromise of the uterine blood supply.</td>
</tr>
<tr>
<td>Sedation</td>
<td>Propofol may be given. Benzodiazepines are class D and should be avoided if possible.</td>
</tr>
<tr>
<td>Seizure medications</td>
<td>Phenytoin, valproic acid, and benzodiazepines should not routinely be given in pregnancy but can be used in critical situations such as status epilepticus. Remember to consider eclampsia as a potential etiology in the seizing patient.</td>
</tr>
<tr>
<td>DVT prophylaxis</td>
<td>Pregnant patients are at increased risk for DVT. Low molecular weight heparins and SQ heparin can be used in pregnancy.</td>
</tr>
</tbody>
</table>

### Table 5. Medications Used In The Treatment Of Preterm Labor

<table>
<thead>
<tr>
<th>Medication</th>
<th>Dose/Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terbutaline sulfate</td>
<td>0.25 mg subcutaneously</td>
</tr>
<tr>
<td>Magnesium sulfate</td>
<td>4-6 gm IV given over 20 minutes</td>
</tr>
<tr>
<td>Betamethasone</td>
<td>12 mg IM (to promote fetal lung maturity)</td>
</tr>
<tr>
<td>Dexamethasone</td>
<td>6 mg IM (to promote fetal lung maturity)</td>
</tr>
</tbody>
</table>
1. Failing to obtain a pregnancy test in any woman of childbearing age.

A female trauma patient may be either unaware or unable to communicate that she is pregnant. A positive pregnancy test has important implications for the subsequent management of the patient including avoiding unnecessary radiation, monitoring the fetus, and assessment of potential pregnancy complications.

2. Leaving a trauma patient in the later stages of pregnancy in a supine position.

After 20 weeks, the gravid uterus can compress the vena cava when the patient is positioned on her back, which reduces cardiac output and results in hypotension.

3. Failing to anticipate a difficult airway when intubating a pregnant trauma patient.

Pregnant patients present a potentially difficult airway for several reasons including soft tissue edema, decreased pulmonary reserves, and increased aspiration risk.

4. Not obtaining necessary radiologic studies because of overconcern for radiation exposure to the fetus.

While it is prudent to limit radiation exposure to the developing fetus, many of the radiographs used in trauma patients are well below the threshold of 5 rads, a level believed to be safe for the fetus.

5. Neglecting to administer RhIG in pregnant trauma patients that are Rh-negative.

Small amounts of maternal fetal hemorrhage can result in sensitization of the mother; therefore, routine administration of RhIG is recommended to avoid this complication.

6. Failing to screen for intimate partner violence in pregnant patients that present with injuries from an assault.

Intimate partner violence is common in pregnancy and associated with multiple pregnancy complications. Routine screening is important in pregnancy and particularly in patients with injuries suggestive of abuse.

7. Missing impending hemodynamic instability because of misinterpretation of the vital signs.

Hemodynamic compromise may be subtle and overlooked initially because of the increase in maternal blood volume and elevated heart rate that are normally seen in pregnancy.

8. Failing to monitor a patient for preterm labor or abruption of the placenta after minor abdominal trauma.

Placental abruption or preterm labor can occur following minor trauma and may not be apparent at the initial time of presentation. Routine monitoring of all pregnant trauma patients following abdominal trauma is recommended.

9. Failing to consider eclampsia as an etiology of seizures or altered mental status in a pregnant trauma patient.

In the second half of pregnancy, remember to consider eclampsia in a patient with new onset seizures or altered mental status because the seizure may be the cause of the trauma and not the result of head injury.

10. Not administering appropriate medications to the mother because of overconcern about adverse effects on the fetus.

In general, the best care of the fetus is the appropriate care of the mother, and the majority of medications used in trauma can be given in pregnancy.
has injuries suspicious for IPV. The American College of Obstetrics and Gynecology recommends the universal screening of pregnant patients for IPV, and emergency departments should have programs in place to provide appropriate resources for referral of these patients. Safety Administration currently recommends the use of airbags in pregnancy. The origin of the airbag should be positioned at least 10 centimeters from the abdomen. Educating pregnant patients regarding seatbelt and airbag use is an important public health intervention that emergency physicians can do.

### Injury Prevention

Many studies have examined the use of seatbelts during pregnancy. The American College of Obstetrics and Gynecology recommends that pregnant patients wear seatbelts even in the last trimester of pregnancy. However, many pregnant patients do not wear seatbelts for a variety of reasons including discomfort, concerns over harming the fetus, or habit. Several large registries of pregnant trauma patients have demonstrated that both maternal and fetal mortality are increased in pregnant trauma patients who do not wear seatbelts. In pregnancy, the lap belt should be worn low across the pelvis, under the uterus, with the shoulder restraint placed between the breasts (Figure 6).

The safety of airbag use in pregnancy is less clear. As a recent case report describes, the force of the airbag deployment against the abdomen may result in abruption of the placenta; however, airbags also offer some protection against serious maternal injuries. A recent retrospective study reviewed 31 cases of pregnant trauma patients following motor vehicle crashes where there was airbag deployment; the study found no cases of placental abruption. The National Highway

### Controversies / Cutting Edge

#### Perimortem Cesarean Section

One of the most difficult decisions an emergency physician will ever have to make in their career is the decision to perform a perimortem cesarean section in a case of maternal cardiac arrest. Because this is fortunately a rare event, there is very little literature about this procedure. However, a recent retrospective review of 38 published cases of perimortem cesarean section noted 28 successful deliveries. Of these, only 8 mothers suffered traumatic arrest. Most cases documented improved maternal hemodynamics with the performance of the cesarean section. The authors acknowledge that there is a large selection bias in this study, with successful resuscitations far more likely to be published. Delivery of the fetus allows for more effective cardiopulmonary resuscitation (CPR) and diverts all circulating blood volume to the mother. If possible, it is recommended to begin the procedure within 4 minutes of maternal cardiac arrest, although cases of both maternal and fetal survival have been reported with times greater than 15 minutes. Figure 7 illustrates the technique of a perimortem cesarean section.

### Key Points

- A developing fetus is very sensitive to maternal hypovolemia and hypoxia; therefore, the best care for the fetus is aggressive resuscitation of the mother.
- Anticipate that a pregnant patient will be difficult to intubate and prone to desaturation.
- RhIG should be administered to every Rh-negative pregnant patient, even following minor trauma.
- All pregnant trauma patients over 20 weeks should have 4-6 hours of cardiac toco monitoring to detect placental abruption or preterm labor.
- Necessary diagnostic radiographs should not be withheld because of concern over radiation exposure to the fetus.
- Ultrasound is a safe and effective means to detect intraabdominal hemorrhage in pregnant trauma patients and should be used routinely.
- All pregnant patients should be encouraged to wear seatbelts throughout their pregnancy.
- Because of the expanded blood volume associated with pregnancy, hemorrhagic shock may be even more difficult to detect.
- Prevent supine hypotension by positioning the patient on her side or by manually deflecting the uterus.
- Consider performing a perimortem cesarian section in cases of maternal cardiac arrest.
Disposition

Most authors agree that any pregnant trauma patient with significant injuries or with a major mechanism of injury should be admitted to the hospital for further monitoring and treatment of her injuries. Even minor trauma may result in a placental abruption, and patients with any abdominal trauma should be monitored for a minimum of 4-6 hours. After this time period, if there have been no uterine contractions, the fetal heart rate tracing is reassuring, and the patient remains asymptomatic, she may be discharged home with instructions to follow up with her obstetrician. Discharge instructions should also include instructions to seek medical care immediately if she develops abdominal pain, vaginal bleeding, decreased fetal movement, or any other concerning symptoms.

Summary

Major trauma in pregnancy presents unique challenges for an emergency physician. Consideration of the normal physiologic changes in pregnancy, careful monitoring of the fetus, evaluation for potential pregnancy complications, and aggressive resuscitation of the mother are essential to managing these cases.

Case Conclusion

Upon arrival to the ED, your patient is awake and protecting her airway. Two 14-gauge IV catheters are placed and she is given 2 liters of crystalloid. The patient’s initial blood pressure is 90/40 systolic; a nurse manually displaces the uterus to the left, and the next pressure is 105/60. A portable chest x-ray reveals a 30% pneumothorax on the patient’s right side. A chest tube is placed in the right third intercostal space. OB-GYN is consulted upon the patient’s arrival and a cardiac toco monitor is placed. The fetal heart rate pattern is reassuring, but a couple of uterine contractions are noted. The patient has no appreciable abdominal tenderness, and a bedside FAST examination reveals no intraperitoneal hemorrhage. Vaginal examination reveals no evidence of bleeding or amniotic fluid. Given the loss of consciousness, the patient has a CT of the head which is negative, and a right ankle film reveals a right tib/fib fracture which is splinted. The patient receives pain medication and a dose of Rho(D) immune globulin.

Figure 6. Correct Seatbelt Placement For Pregnant Women

Figure 7. Technique For A Perimortem Cesarean Section

A. Abdominal incision. B. Incision through the fascia and muscles into the peritoneum. C. Vertical uterine incision. D. Delivery of the fetus. E. Removing placenta and membranes, and wiping the uterus clean with a sponge. Reprinted from Pearlman Mark D, Tintinally Judith E. Emergency Care of the Woman, Copyright 1998© McGraw–Hill. All rights reserved.
globulin is administered. She is admitted to the hospital and after a 24-hour period of monitoring reveals no other uterine contractions, she is taken to the operating room for repair of her ankle fracture. She is discharged from the hospital 5 days later and delivers a healthy baby 6 weeks later.

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available. In addition, the most informative references cited in this paper, as determined by the authors, will be noted by an asterisk (*) next to the number of the reference.

26. Parker B, McFarlane J, Soeken, K. Abuse During Preg-


CME Questions

1. A 30-year-old woman who is 36 weeks pregnant (gravida 1, para 0) presents to the emergency department following a motor vehicle collision. Which of the following statements correctly describes a physiologic change in pregnancy that would impact the resuscitation of this patient?
   a. Pregnant women will not efficiently compensate for blood loss because of a decrease in cardiac output.
   b. Functional residual capacity (FRC) is increased in pregnancy.
   c. A slight respiratory acidosis is common in late pregnancy.
   d. Hematocrit is decreased in pregnancy.

2. A 26-year-old woman who is 32 weeks pregnant (gravida 1, para 0) presents to the ED after she tripped over her cat and landed on her left side. She has abrasions over her left hip and knee. She denies abdominal pain. What further work up is appropriate for the evaluation of placental abruption in this patient?
   a. A sterile speculum examination to assess for vaginal bleeding
   b. Kleihauer-Betke (KB) test
   c. 6 hours of cardiac toco monitoring
   d. Admit for 24 hours of observation

3. Which of the following is the most common cause of trauma in pregnancy?
   a. Intimate partner violence
   b. Recreational Injuries
   c. Falls
   d. Motor vehicle collisions

4. A 28-year-old woman who is 28 weeks pregnant presents with an anterior abdominal stab wound. Which of the following is true regarding penetrating abdominal trauma in pregnancy?
   a. Emergency cesarean section is generally required if the uterus is penetrated.
   b. Ultrasound (FAST examination) is not accurate for the detection of intraperitoneal hemorrhage following penetrating trauma.
   c. Maternal bowel injury is seen in most cases.
   d. Diagnostic peritoneal lavage is contraindicated in pregnancy.

5. Regarding the primary survey in pregnant patients, which of the following is correct?
   a. Paralytic agents have no effect on the fetus as they do not cross the placenta.
   b. A chest tube should be placed 1 or 2 intercostal spaces higher than normal because of the gravid uterus.
   c. Maternal hypotension is a very early sign of volume loss and/or significant hemorrhage because of the hemodynamic responses to pregnancy.
   d. A pregnant patient should be placed in the supine position on a backboard for spine immobilization because of hypotension.

6. A 26-year-old woman who is 32 weeks pregnant (gravida 1, para 0) presents to the ED after she tripped over her cat and landed on her left side. She has abrasions over her left hip and knee. She denies abdominal pain. What further work up is appropriate for the evaluation of placental abruption in this patient?
   a. A sterile speculum examination to assess for vaginal bleeding
   b. Kleihauer-Betke (KB) test
   c. 6 hours of cardiac toco monitoring
   d. Admit for 24 hours of observation
7. Which of the following is accurate regarding evaluation of blunt abdominal trauma in a pregnant patient?
   a. The standard FAST examination (Focused Abdominal Sonogram of Trauma) is accurate for the detection of free intraperitoneal fluid in the pregnant patient.
   b. If a DPL is performed in the pregnant patient, the wire-guided Seldinger technique is associated with fewer complications than the open technique.
   c. MRI is not useful in pregnant trauma patients.
   d. An abdominal CT should always be avoided because of significant radiation to the fetus.

8. Which statement is correct regarding laboratory tests in pregnancy?
   a. An elevated D-dimer is specific for the diagnosis of placental abruption.
   b. Hematocrit is increased.
   c. White blood cell count is decreased.
   d. Clotting factors are increased in pregnancy.

9. All the following are true regarding airway management in trauma EXCEPT:
   a. Rapid sequence medications, including paralytics, cross the placenta.
   b. Aspiration risk is increased in pregnancy.
   c. Weight gain and fluid retention may affect airway anatomy.
   d. Because of difficult airway anatomy, intubation should be avoided if possible.

10. A 26-year-old woman who is 28 weeks (gravida 2, para 1) presents following a moderate-speed motor vehicle crash with regular contractions on the monitor. She does not seem to have sustained any additional injuries. Which of the following is TRUE regarding management of preterm labor in pregnant trauma patients?
    a. Tocolytics are contraindicated in trauma patients.
    b. Betamethasone should be administered.
    c. Emergency cesarean section is indicated.
    d. 4-6 hours of monitoring is required.

11. Which of the following statements regarding injury prevention in pregnancy is accurate?
    a. Airbags should be turned off in the last trimester of pregnancy.
    b. Universal screening for intimate partner violence is recommended in pregnancy.
    c. Seatbelts are shown to increase injury to the fetus in the last half of pregnancy.
    d. Falls are the most common mechanism of trauma in pregnancy.

12. All of the following regarding prehospital care of pregnant trauma patients is correct EXCEPT:
    a. Third trimester gestation and loss of consciousness are indications for a level I trauma center.
    b. Supplemental oxygen should routinely be placed.
    c. Early intravenous fluids should be given.
    d. Pregnant patients should be placed in the supine position on a spine board.

13. Which of the following regarding Rh isoimmunization in Rh-negative pregnant trauma patients is correct?
    a. Only patients with vaginal bleeding should be given Rho(D) immune globulin.
    b. Only patients with a positive KB test should receive Rho(D) immune globulin.
    c. Rho(D) immune globulin should only be given following major trauma or signs of hemorrhage.
    d. Rho(D) immune globulin should be given in any trimester following minor or major trauma.
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