Trauma During Pregnancy

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INTRODUCTION

In the United States, traumatic injuries complicate 6% to 8% of pregnancies, causing approximately 30,000 women to seek care for injuries each year.1–3 The most common causes of trauma in pregnancy include motor vehicle collisions (54.6%), violent assaults (22.3%), and falls (21.8%). Other, less common, causes include suicide attempts, burns, puncture wounds, and animal bites.4,5

Several factors portend an increased risk of trauma during pregnancy. These include age less than 20, non-white race, low socioeconomic status, drug use, and alcohol use.1,6 Intimate partner violence, which affects approximately 324,000 pregnant women per year in the United States, tends to escalate during the pregnancy and postpartum periods.7

MATERNAL-FETAL MORTALITY FROM TRAUMA

The leading cause of nonobstetric death in pregnancy is traumatic injury.8–10 Nonobstetric deaths include those that are not caused by complications of gestation and parturiition (direct) or exacerbations of preexisting medical conditions that worsen in pregnancy (indirect). Though other causes of maternal death remain prevalent, traumatic injury is both widespread and burdensome.

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KEYWORDS

• Pregnancy • Trauma • Mortality • Abruption

KEY POINTS

• Trauma is the leading cause of nonobstetric death and affects 6% to 8% of all pregnancies.
• Adverse outcomes of pregnancy, including fetal loss, preterm delivery, and placental abruption, are more frequent following trauma.
• Optimal management includes transport to a site with obstetric services, proper positioning, fetal monitoring, laboratory studies, diagnostic imaging, and in some cases emergency cesarean delivery.
Trauma during pregnancy leading to maternal or fetal mortality is most often intentional. One Cook County series found 57% of traumatic maternal deaths attributable to homicide and 9% to suicide. A New York City series had similar findings; homicides accounted for 63% and suicides 13%.

The remainder of trauma-associated mortality follows motor vehicle collisions. As is true with the nonpregnant population, pregnant women documented as unrestrained had the highest rates of mortality. The most common cause of death in this setting was head injury.

Incidence of fetal mortality is difficult to estimate due to wide variance in mechanisms of reporting. It is clear that fetal loss after maternal trauma does occur as a function of direct trauma, hypotension, placental abruption, and preterm delivery. A review of fetal death certificates in Pennsylvania suggests maternal trauma resulting from motor vehicle collisions causes 90 to 367 deaths of viable fetuses each year in the United States. However, when first and second trimester losses are included, estimates include as many as 4000 fetal deaths per year related to motor vehicle trauma. Although severe trauma commonly leads to fetal loss, minor trauma is so common in pregnancy that these injuries are responsible for 60% to 70% of fetal losses.

**ANATOMIC AND PHYSIOLOGIC CHANGES OF PREGNANCY**

**Maternal Adaptation**

The physiologic maternal and fetal response to trauma may influence the severity of trauma as well as the optimal strategy for treatment. An understanding of the fundamental anatomic and physiologic differences that exist in the pregnant state facilitates the proper evaluation and treatment of the maternal response to stress, hypovolemia, and fetal perfusion.

Maternal adaptation to pregnancy involves several organ systems and, in many cases, represents a dramatic departure from the nonpregnant state. The most clinically relevant physiologic changes of pregnancy relate to the evaluation of occult hemorrhage and management of hypotension, including:

- Decrease in mean blood pressure of 10 to 15 mm Hg by the second trimester
- Increase in pulse of 5 to 15 beats per minute by the second trimester
- Decrease in hemoglobin to 9 to 11 g/dL due to volume expansion and iron deficiency
- Blood volume increases to approximately 6 L.

Management of the airway also carries additional risks in pregnancy. Changes in oncotic pressure and increases in blood volume create an edematous airway, which can lead to difficult intubation. Aspiration risk is increased by the progesterone-mediated delay in gastric emptying and estrogen-mediated relaxation of the esophageal sphincter. Eating patterns in pregnancy, spurred on by common advice to eat frequent, small meals, also increase the likelihood that a pregnant patient presenting with trauma will have a full stomach.

Important anatomic changes of pregnancy are primarily the function of the gravid uterus. Clinically relevant changes include:

- Superior displacement of the bowel, with potential for complex and multiple intestinal injuries with penetrating trauma of the upper abdomen
- Hypertrophied pelvic vasculature, with potential for massive retroperitoneal hemorrhage in the event of pelvic fracture
- Uterine compression of the inferior vena cava, with potential for impairment of up to 30% of cardiac output during supine positioning.
Fetal Structure and Function

Fetal anatomic and physiologic changes relevant to trauma in pregnancy include factors that predispose to maternal exsanguination and placental abruption and alter the process of maternal resuscitation. First, the growing fetus draws uterine blood flow of up to 600 mL per minute. In the event of laceration of the uterine vasculature or rupture of the uterus, rapid maternal exsanguination can occur unless emergent delivery and repair are achieved.

Second, the growing placental mass creates a large, relatively inelastic, vascular conduit capable of facilitating rapid maternal and fetal exsanguination in the case of abruption. Finally, the algorithm for resuscitation of the perimortem pregnant patient allows for consideration of fetal perfusion after the age of viability, a center-specific gestational age after which the fetus has the potential to independently survive. These fetal changes create several areas of vulnerability to poor outcomes in the event of trauma.

Predicting Outcome After Trauma

Maternal Outcomes

Short-term and intermediate outcomes for pregnant trauma victims may be worse than nonpregnant controls, even for minor injuries. Conversely, mortality among pregnant trauma victims is likely lower than nonpregnant controls. As with the nonpregnant patient, injury severity score predicts maternal outcome. Maternal abdominal injuries may produce worse outcomes than other score-matched injuries.

Fetal Outcomes

Prediction of fetal outcomes after trauma depends on the mechanism and severity of injury. Fetal loss is frequent after penetrating trauma to the uterus, including gunshot wounds (71%) and stabbings (42%). Placental abruption is the leading cause of fetal death after trauma, accounting for 50% to 70% of all trauma-related fetal losses. Rates of placental abruption vary by mechanism and tend to be highest with severe motor vehicle collisions (50%), maternal assaults (5%), and falls (3%). After abruption, maternal death is the second most frequent cause of trauma-associated fetal deaths; an estimated 10% of trauma-related fetal losses follow maternal death.

Schiff and Holt used injury severity score to assess the risk of fetal loss after maternal injury. Although the most severe maternal injuries were most likely to lead to adverse obstetric outcome, the severity score had otherwise limited negative predictive value for fetal outcome. By contrast, the extent to which minor injuries such as falls pose risk for adverse fetal outcomes is controversial. For example, in a series of 317 pregnant women with minor trauma, evaluation of the variables: positive Kleihauer-Betke (KB) test, fibrinogen less than 200, more than 5 contractions per hour, abdominal pain, anterior placenta, and direct abdominal trauma found that none of them were predictive of composite adverse outcome. In this series, there was only one placental abruption diagnosed many weeks after the traumatic event, suggesting that risk for adverse pregnancy outcomes after minor trauma is low. By contrast, other investigators have reported that even minor maternal injuries may result in fetal loss. A recent retrospective review identified an injury severity score greater than 2 in the presence of a positive KB test as an effective predictor of patients at risk for adverse perinatal outcomes. It seems that risk is increased for both short-term and long-term adverse perinatal outcomes, particularly with more severe trauma.

Minor trauma has also been associated with other adverse outcomes, including preterm labor and delivery, fetal distress, fetal hypoxia, cesarean delivery, and...
postnatal development of childhood attention-deficit hyperactivity disorder. A review of 78,176 deliveries in Tennessee found a correlation between minor injuries during the first and second trimester and subsequent fetal demise, preterm delivery, and low birth weight.

EVALUATION AND MANAGEMENT OF TRAUMA IN PREGNANCY

Care for injuries sustained during trauma in pregnancy often begins with first responders. In the field and in the emergency department, identification of injuries and stabilization of the mother is the clear first priority. In most cases, maternal resuscitation is the safest, fastest means of initial fetal resuscitation. Guidelines for emergency personnel providing care include

- Position in the left lateral decubitus position to relieve compression of the inferior vena cava
- During initial evaluation, leftward tilt of the spinal immobilization board can be achieved with a 6-inch rolled towel
- If possible, transport all pregnancies beyond 20 weeks to a trauma center with obstetric services.

Ideal care for the injured pregnant patient includes a multidisciplinary team of emergency medicine providers, trauma surgeons, and obstetricians. The authors suggest that in the viable fetus (beyond 23–24 weeks) a brief initial assessment of fetal heart rate and well-being should be performed in the emergency department. However, fetal assessment should not deter from the initial efforts of maternal resuscitation; delays in correction of maternal hypovolemia and hypoxia are counterproductive to care for the fetus. Once clearance for life-threatening maternal injury is achieved in the emergency department, viable pregnancies should begin extended observation in the labor and delivery suite.

Assessment of Fetal Well-being

Because even minor injuries may be associated with placental abruption and other adverse obstetric outcomes, fetal monitoring after trauma is recommended. Clinical correlates of placental abruption include abdominal pain, vaginal bleeding, and in almost every case, uterine contractions. Although many placental abruptions may be detected by ultrasound, the sensitivity of ultrasound to detect abruption is about 40% in the trauma setting. Because preterm labor following trauma is also a concern, fetal heart rate tracing and tocometry remain the surveillance modality of choice.

Fetal middle cerebral arterial Doppler studies may have a role in fetal assessment after maternal trauma in some cases. In severe cases of fetal anemia following placental abruption and/or maternofetal hemorrhage, the peak systolic velocity of the fetal middle cerebral artery demonstrates a characteristic increase reflective of fetal brain sparing. Ultrasound measurement of this parameter may aid in the identification of fetal hemorrhage in otherwise ambiguous cases. The academic or hypoxemic fetus will display a progressive loss of normal fetal behavior. Thus, a biophysical profile may at times be a helpful adjunct to the fetal heart tracing and tocometer.

The presence or absence of uterine contractions may also be helpful in assessing the risk of placental abruption after minor trauma. Placental abruption is unlikely to occur in patients with contractions less frequent than every 15 minutes for more than 4 hours of observation. Patients without contractions for more than 4 hours of monitoring following minor trauma may be appropriate for discharge. However, the presence of contractions, other clinical or laboratory signs of placental abruption, a history of direct
abdominal trauma, or fetal distress should lead to extended monitoring. Placental abruption can present up to 48 hours after trauma; a minimum of 24 hours of fetal surveillance is recommended for the viable fetus with a high-risk presentation.25,41

**Laboratory Evaluation**

Laboratory testing is directed toward identification of trauma sequelae, including acute blood loss anemia, disseminated intravascular coagulopathy, and maternofetal hemorrhage. As such, the low-risk, Rh-positive patient who has sustained minor trauma, may only require screening for illicit drugs and alcohol. The possible exception to this principle is the use of the KB test, an acid elution quantification of fetal blood in the maternal circulation, to assess risk for adverse perinatal outcome. The KB has been suggested as a means of triaging patients into a higher risk group for preterm delivery and, more recently, multiple adverse perinatal outcomes.30,42 These uses remain experimental, but should lend caution when considering early discharge.

The KB is potentially useful in the Rh-negative patient; fetomaternal hemorrhage is four times more common in trauma-exposed pregnancies when compared with controls.43 Although empiric intramuscular Rho(D) immune globulin in the Rh-negative patient is likely to prevent sensitization in most cases, approximately 10% of traumas lead to a fetomaternal hemorrhage exceeding the coverage of a single vial of intramuscular Rho(D) immune globulin (30 mL).41 Identification of this population for administration of additional intramuscular Rho(D) immune globulin should prevent future adverse perinatal outcomes related to Rh sensitization.

In patients with a fetomaternal hemorrhage greater than 30mL of fetal blood, additional Rho(D) immune globulin should be given as follows: multiply the percentage of fetal cells by 50 to estimate the volume of hemorrhage and give at least an additional 300mcg Rho(D) immune globulin per 15mL of hemorrhage. Individual blood banks often round up or add an additional vial of Rho(D) immune globulin in order to avoid underdosage.44

In the setting of severe trauma, internal bleeding, or placental abruption, it is reasonable to perform evaluation of the complete blood count, prothrombin time, partial thromboplastin time, and fibrinogen. Urinalysis may reveal hematuria in the setting of urinary tract injury.24 Given the strong association between trauma in pregnancy and drug and alcohol abuse, urine toxicology screening is also recommended. Fetal fibronectin has not been evaluated for the prediction of preterm delivery after trauma, though it has proved to predict preterm delivery in other settings.45

**Diagnostic Imaging**

**Ionizing radiation**

In the setting of severe maternal trauma, future theoretical risks to the fetus should be weighed against the risk to the fetus and mother of undiagnosed maternal injury. Indicated diagnostic procedures to evaluate life or limb-threatening injuries, considered standard of care in the nonpregnant patient, should not be delayed or abandoned due to concerns about fetal radiation.46,47

Teratogenesis and carcinogenesis are the main theoretical concerns after in utero ionizing radiation exposure. The levels of ionizing radiation required to cause microcephaly or mental retardation far exceed the doses incurred in common clinical use (Table 1). In utero exposure to a 50 mGy (5 rad) dose of ionizing radiation may be associated with a 2% lifetime attributable risk of malignancy. This dose still allows for most common radiologic procedure to be safely performed, including a single-phase CT scan of the abdomen and pelvis (Table 2).48
It is preferable to perform a single CT scan with iodinated contrast rather than perform multiple suboptimal studies without contrast. Although iodinated contrast agents cross the placenta and may be taken up by the fetal thyroid, no cases of fetal goiter or abnormal neonatal thyroid function have been reported in connection with in utero contrast exposure.

With the exception of low-risk, nonpenetrating abdominal injury, most diagnostic imaging of the pregnant trauma victim begins with an obstetric ultrasound and a study requiring the use of ionizing radiation (Fig. 1).

**MRI**

The use of MRI may be a helpful modality in pregnancy because there are no known associated adverse fetal outcomes related to its use. Although the Food and Drug Administration considers the safety of MRI to not be established, there are no reports of adverse perinatal outcomes or long-term pediatric outcomes related to MRI use in pregnancy. Currently, the use of gadolinium in pregnancy is controversial. In rare instances, gadolinium exposure has resulted in a syndrome of nephrogenic systemic

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### Table 1

<table>
<thead>
<tr>
<th>Menstrual</th>
<th>&lt;50 mGy (&lt;5 rad)</th>
<th>50–100 mGy (5–10 rad)</th>
<th>&gt;100 mGy (&gt;10 rad)</th>
</tr>
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<tbody>
<tr>
<td>&gt;27 wk</td>
<td>None</td>
<td>None</td>
<td>None at diagnostic doses</td>
</tr>
<tr>
<td>18th and 27th wk</td>
<td>None</td>
<td>None</td>
<td>IQ deficits not detectable at diagnostic doses</td>
</tr>
<tr>
<td>11th and 17th wk</td>
<td>None</td>
<td>Potential effects are uncertain and likely minimal</td>
<td>Increased risk of deficits in IQ or mental retardation that increase in frequency and severity with increasing dose.</td>
</tr>
<tr>
<td>5th and 10th wk</td>
<td>None</td>
<td>Potential effects are uncertain and likely minimal</td>
<td>Possible malformations increasing in likelihood as dose increases.</td>
</tr>
<tr>
<td>3rd and 4th wk</td>
<td>None</td>
<td>Likely none</td>
<td>Possible spontaneous abortion.</td>
</tr>
<tr>
<td>0–2 wk</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
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*Data from American College of Radiology. ACR practice guideline for imaging pregnant or potentially pregnant adolescents and women with ionizing radiation. Reston (VA): American College of Radiology, 2008."

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### Table 2

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Fetal Dose (mGy)</th>
</tr>
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<tbody>
<tr>
<td>Fluoroscopy of abdomen and pelvis</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Single-phase CT scan of abdomen, pelvis, and lumbar spine</td>
<td>&lt;35</td>
</tr>
<tr>
<td>CT scan chest view</td>
<td>&lt;1</td>
</tr>
<tr>
<td>CT scan head</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Hip film (single view)</td>
<td>200 mrad</td>
</tr>
<tr>
<td>Chest radiograph</td>
<td>0.02–0.07 mrad</td>
</tr>
</tbody>
</table>

fibrosis in children and adults with renal insufficiency. Thus, it is recommended that use of this agent be avoided during pregnancy except when absolutely necessary for adequate imaging. The most vexing problem for use of MRI in evaluation of trauma in pregnancy may be the absence of a well-defined role in management of life-threatening traumatic injuries.

Ultrasound
Abdominal ultrasound is a rapid and safe way to evaluate the pregnant trauma victim for fetal well-being and intraperitoneal hemorrhage. Safety of the use of real-time gray-scale ultrasound in pregnancy is well-established, though concerns remain regarding the mechanical and heat-related effects of prolonged Doppler interrogation. In addition to the parameters of fetal well-being discussed previously, the most relevant use of ultrasound for trauma patients is assessment of free intraperitoneal fluid. Although sensitivity for intraperitoneal hemorrhage is limited to 61% to 83%, specificity has been reported from 94% to 100%.

SPECIAL CONSIDERATIONS
Route of Delivery
Following successful resuscitation and treatment after trauma, the laboring process seems daunting to many patients and providers. However, there are very few injuries that necessitate cesarean delivery. Pelvic fractures have been suggested as a contraindication to vaginal delivery when the fracture obstructs the birth canal or is unstable. One series found that greater than 80% of women who sustained pelvic fractures could deliver vaginally. An associated bladder or urethral injury may also be a concern.

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**Fig. 1.** Algorithm for diagnostic imaging studies for pregnant trauma victims. (Modified from Patel SJ, Reede DL, Katz DS, et al. Imaging the pregnant patient for nonobstetric conditions: algorithms and radiation dose considerations. Radiographics 2007;27:1719; with permission.)
Spinal cord injuries during pregnancy also carry implications for labor and delivery. Autonomic dysreflexia, a life-threatening exaggeration of sympathetic activity in response to stimuli below the level of the spinal cord injury, is most commonly seen in labor in spinal cord injuries above T6. Concern for this condition has led some to recommend invasive hemodynamic monitoring in an intensive care setting if labor is contemplated. In one review of several series of pregnancy after acute spinal cord injury, the rate of spontaneous vaginal delivery was 37%, operative vaginal delivery 31%, and cesarean delivery 32%. Although newer series also reflect a higher rate of cesarean section, there does not seem to be an increased incidence of failure to progress or fetal intolerance of labor. Little is known about the risks and benefits of vaginal delivery in the setting of unstable vertebral injuries and consultation with spinal orthopedics is recommended.

**Perimortem Cesarean**

In the pregnant trauma patient with a viable fetus who is failing cardiopulmonary resuscitation or has an obviously nonsurvivable injury, perimortem cesarean section should be contemplated. The gravid uterus inhibits cardiac output by limiting cardiac preload. Early emergency cesarean seems to improve survival for pregnant women in cardiac arrest beyond 20 weeks gestational age or whose the uterine fundus is above the umbilicus. In one series of 20 perimortem cesareans, spontaneous circulation resumed in 12 patients immediately after evacuation of the uterus and no patients experienced a worsening in status.

Perinatal outcomes are optimized when delivery is performed within 5 minutes of cessation of maternal circulation. Beyond 30 minutes, benefit has not been demonstrated. The American Heart Association and others have recommended, and the authors agree, that cesarean delivery should be initiated within 4 minutes after maternal cardiac arrest if resuscitation has failed to restore circulation.

**SUMMARY**

Trauma in pregnancy is a common and morbid event. The most common causes of trauma in pregnancy include motor vehicle collisions, assault, and fall. Even minor trauma can lead to adverse perinatal outcomes such as preterm birth, low birth weight, placental abruption, and fetal loss. Challenges to the obstetrician include adjusting resuscitation strategies to the gravid state, conducting urgent fetal evaluation in the emergency setting, coordinating a multidisciplinary team, advocating for indicated diagnostic imaging, and monitoring for placental abruption and other adverse outcomes.

**REFERENCES**


