Trauma in Pregnancy

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KEYWORDS
- Trauma
- Pregnancy
- Maternal cardiopulmonary arrest
- Perimortem cesarean section

KEY POINTS
- Pregnant women are at significant risk for injury. Counseling of all pregnant women, regardless of reason for presentation to the emergency department, should include a discussion of seat belt use and screening for domestic violence.
- When treating pregnant trauma victims, the initial focus should be on maternal stability. Any emergent measures necessary to maintain it should be performed, including transfusion (of O-negative blood) and imaging, (even, if needed, emergent computed tomography).
- Follow the basic Advanced Trauma Life Support algorithm: Airway, Breathing, Circulation, Disability, and Exposure, with uterine displacement (30° to the left) during circulation assessment to increase caval return.
- Once maternal stability has been assured, focus on the fetus (the \textit{F} after \textit{A}, \textit{B}, \textit{C}, \textit{D}, and \textit{E}): placental abruption, uterine rupture, and fetomaternal hemorrhage.
- Continuous fetal monitoring is essential once the mother is stable. If not available, arrange transfer to a facility where it is available. Monitoring should continue for at least 4 hours after the injury if the mother is otherwise asymptomatic but may be continued in patients with regular contractions, continued abdominal pain, vaginal bleeding, or nonreassuring tracings.

INTRODUCTION

The emergency treatment of pregnant patients who sustain trauma requires knowledge of the fundamental aspects of trauma management as well as an understanding of the unique physiologic and anatomic changes of pregnancy that may affect both the

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maternal and fetal victims involved. It is important to note that the initial stabilization efforts should focus on ensuring maternal hemodynamic stability because the most common cause of fetal mortality is maternal shock. Once maternal stability is assured, focus can shift to the fetus, unless that initial goal is thought to be unobtainable (see later discussion of perimortem cesarean delivery).

Approximately 7% of pregnant women experience trauma during their pregnancies, with the greatest incidence of trauma occurring within the last trimester. Falls are the most common mechanism of injury (accounting for 51.6% of pregnancy-related injuries in a recent study), and 9.5% of all injuries during pregnancy are intentionally inflicted.1

PREVENTION OF INJURY

Although trauma is often unpreventable, the unique aspects of pregnancy and the fact that some emergency department (ED) patients may not seek prenatal care necessitate that emergency physicians treating pregnant patients discuss at least 2 fundamental aspects of injury prevention: domestic violence and seat belt use, regardless of the patients' reasons for visiting the ED.2

Domestic violence may either manifest or increase in frequency during pregnancy.3 Homicide, especially as a result of gunshot wounds caused by firearms, accounts for a significant proportion of prenatal mortality.4 A recent review found that of penetrating abdominal injuries sustained during pregnancy, 73% occurred as a result of gunshot wounds.5 Given the significant maternal and fetal mortality associated with domestic violence during pregnancy (3% and 16%, respectively, overall, in this same study), screening is essential. Although obstetric and primary care practices typically use standardized tools that may be too lengthy for the emergency use,6 even brief domestic violence screening tools have been found to be effective.7,8

The other major cause of maternal mortality is blunt trauma, commonly caused by falls and motor vehicle accidents. Although fall prevention is somewhat intuitive, pregnancy-related anatomic changes and their impact on seat belt position should be discussed. The initial focus should be the use of seat belts themselves; a study of pregnant patients involved in motor vehicle accidents found that severe crashes in which the pregnant woman was not wearing a seat belt resulted in adverse outcomes 100% of the time.9 Once worn, seat belts require correct positioning to prevent force transmission to the uterus and direct uterine trauma; lap belts should pass under (not over or in front of) the gravid uterus, and shoulder belts should pass between the breasts and lateral to the uterus.10

THE INITIAL EVALUATION AND MANAGEMENT OF PREGNANT TRAUMA PATIENTS

The initial ED evaluation of all patients with trauma, pregnant or otherwise, should follow the American College of Surgeons Committee on Trauma’s Advanced Trauma Life Support guidelines.11 Maternal stability should be assessed and maintained because this will simultaneously maximize the likelihood of positive maternal and fetal outcomes. In centers with the available resources, obstetric (and neonatal if >24 weeks’ estimated gestational age) specialists should be mobilized as early as possible during the evaluation of pregnant trauma patients. It is, however, important to remember that effective team-based care requires coordination by a central team leader, who should be the emergency physician or trauma surgeon primarily responsible for the patient. This leader should in turn ensure appropriate closed-loop communication, prioritization of interventions, and ongoing assessment with the nursing and consultative staff caring for the patient.12
Relevant Aspects of Patient History

The focused history obtained during the emergent evaluation of a pregnant patient with trauma should be directed toward clarifying those factors that may alter initial patient management:

- Injury mechanism: Both blunt and penetrating traumas, if intentional, are typically directed toward the abdomen.
- Medications/allergies: Young and otherwise healthy women may develop pregnancy-induced heart failure, gestational diabetes, or venous thromboembolic disease and may be taking medications not otherwise typical in their age group.
- Last menstrual period: If this information is known, it will help determine fetal viability to guide the appropriateness of fetal interventions.
- Fetal movement: Although less important if immediate bedside ultrasonography or fetal monitoring is available, this can serve as a proxy for fetal stability until these objective tests are performed.
- Contractions: Uterine irritability caused by trauma and early labor can necessitate posttraumatic fetal monitoring.
- Abdominal pain/vaginal bleeding/premature rupture of membranes: These situations should prompt a more thorough consideration of trauma-related uterine complications and early labor.

Primary Survey

As with any trauma patient, the primary survey is focused on identifying immediate threats to life and limb. Pregnant trauma patients, however, should have a fetal assessment performed immediately after the maternal primary survey to allow for prompt fetal intervention if appropriate. As mentioned previously, the obstetric service (if available) should be on hand to assist with evaluation and to guide the determination of whether emergent cesarean delivery is indicated.

Airway

The determination of whether a pregnant patient with trauma requires airway intervention necessitates the evaluation of her ability to protect her airway, oxygenate and ventilate, and also a consideration of her anticipated clinical course. It is important to intervene as early as possible, with the understanding that prolonged bag valve mask ventilation of a pregnant patient (who has increased abdominal pressure and decreased lower esophageal tone) significantly increases her risk of aspiration of gastric contents.

It should be anticipated that women in late pregnancy have difficult airways. One study of maternal airways at both 12 and 38 weeks found that the proportion of Mallampati class 4 airways (with only the hard palate visible and with no view of the soft palate or uvula) increased by 34% between the two periods. The additional fact that these patients have sustained trauma and will likely be in cervical collars simply compounds an already difficult situation. Given this, the use of video laryngoscopy, if available, is paramount because it allows for the maximization of first-pass success in these intubations. Once intubation is accomplished, nasogastric decompression should be performed to minimize the ongoing risk of aspiration.

Breathing

Regardless of whether intubation is needed, supplemental oxygen should be used liberally in pregnant trauma patients. Oxygen consumption increases by almost 20% during pregnancy to meet the increased metabolic demands of the placenta, fetus,
and maternal organs. In addition, pregnant women develop a decrease in their functional reserve capacity after 20 weeks, therefore maximizing oxygenation can improve the amount of apneic time tolerable without desaturation if intubation becomes necessary.

Because of the increase in abdominal pressure and elevation of the diaphragm, tube thoracostomy should be performed higher than it would otherwise be performed in nonpregnant patients. Rather than insertion of the chest tube in the fifth or sixth intercostal space, one should use the fourth or fifth intercostal space. If available, bedside ultrasonography can help guide placement of a thoracostomy in pregnant patients with pneumothoraces because the location of the diaphragm on expiration can be directly visualized (Fig. 1).

**Circulation**

A drop in maternal blood pressure can result in decreased placental blood flow and fetal hypoperfusion, making maintenance of maternal blood volume especially important in this patient population. All of these patients should have 2 large bore (14 or 16 gauge) intravenous lines established immediately on their arrival in case emergent transfusion of blood or fluids is needed.

After 20 weeks’ gestation, the uterus is large enough to compress the inferior vena cava when pregnant women lie supine. This compression can decrease cardiac output by as much as 30%. It is imperative to displace the uterus of a woman in late pregnancy to the left off of the inferior vena cava, either manually or by tilting the backboard with a wedge or pillow.

In hemodynamically unstable pregnant women, a focused assessment with sonography for trauma (FAST) examination should be performed during the primary survey to assess for possible sources of bleeding. The specificity of FAST in pregnancy has been shown to be similar to that of nonpregnant patients, and positive findings in unstable patients should prompt emergent operative evaluation. However, FAST cannot detect retroperitoneal hemorrhage, which is more likely in pregnant women because of the increased blood flow to the uterus.

If a blood transfusion is needed emergently, Rh-negative blood should be used unless the patients’ Rh status is known in order to prevent sensitization to Rho(D) factors and erythroblastosis fetalis in subsequent pregnancies.

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**Fig. 1.** The appearance of the diaphragm (arrow) on a focused abdominal sonography for trauma (FAST) exam. (From Roberts HC. Imaging the diaphragm. Thorac Surg Clin 2009; 19(4):431–50; with permission.)
Disability/brief neurologic evaluation
The brief evaluation of disability performed during the primary survey of a pregnant trauma patient does not differ significantly from that of a nonpregnant patient. The examination should be a focused assessment of the patient’s level of consciousness using the Glasgow Coma Scale and also an evaluation of their pupillary size, gross motor function, and sensation in each limb. If signs, symptoms, or suspicion of spinal cord injury is present, it is especially important to note any lateralizing signs and the level of intact sensation.

Exposure and environmental control
Given the possibility of domestic violence during pregnancy, it is important to completely evaluate pregnant patients. Be sure to expose and briefly examine all areas of her body, especially the back, because abusers often cause injuries in hidden locations to minimize the risk of discovery. After this initial evaluation, however, ensure that patients are covered and stay dry because hypothermia contributes to coagulopathy, which can be especially detrimental in patients with trauma.

Fetal evaluation
Maternal trauma can result in uterine hypoperfusion and resultant fetal hypotension and hypoxia as well as uterine rupture and placental abruption (discussed later). Fetal monitoring is essential after the primary survey of the mother is complete. If formal continuous fetal monitoring is not available, periodic Doppler measurement or bedside ultrasound calculation of a fetal heart rate is an appropriate temporary substitute. Beware of the potentially tachycardic maternal heart rate in pregnant trauma victims, comparison of the fetal heart rate heard with the Doppler with the maternal pulse on the cardiac monitor can help ensure that it is the fetus’s pulse being measured.

In women with viable pregnancies and abdominal trauma, a prolonged period of fetal monitoring is recommended. This monitoring should be for a period of no less than 4 hours and may increase if contractions, vaginal bleeding, abdominal pain, or nonreassuring fetal heart rate variability continues. This monitoring should be performed by the obstetric team in an area conducive to rapid caesarean delivery if fetal distress is noted. The significance of fetal cardiac monitoring after trauma is underscored by a study of 441 pregnant trauma patients, which found that the deaths of 5 infants were caused by delayed recognition of nonreassuring fetal heart rates. Three of these were in only mildly or moderately injured mothers, so these deaths were potentially preventable if the nonreassuring fetal heart rates had been detected early and the patients had gone to emergency cesarean section.

Secondary Survey
The secondary survey of pregnant patients, which involves a more thorough evaluation after hemodynamic stability of both the mother and fetus has been confirmed, is very similar to that in nonpregnant patients. However, specific emphasis should be placed on the abdominal, skin, and vaginal examinations.

Abdomen
In patients who do not know their gestational age, it can be estimated by using the umbilicus as a guide. Fundal height increases by approximately 1 cm above the umbilicus for every week of gestation beyond 20 weeks. This information can be especially useful when determining fetal viability because premature infants born at less than 25 weeks gestational age have extremely high mortality.

In addition, it is important to assess for ecchymoses, especially in blunt trauma. These ecchymoses may be present underneath a gravid uterus (especially late in
pregnancy) and may be caused by seat belt injuries, indicating significant abdominal force.

Lastly, tocolraphic monitoring should be initiated alongside fetal cardiac monitoring because ongoing contractions may necessitate continued evaluation by obstetric specialists.

**Skin**

Although a cursory examination of the skin for significant evidence of trauma should be performed during the exposure step of the primary survey, the secondary survey allows for a more thorough examination. Specific attention should be paid to the breasts, abdomen, and upper extremities because these can be sites for intentional blunt trauma. Suspicion should be heightened if there are bruises in various states of healing.

**Vaginal**

The vaginal examination should preferably be performed with an obstetric specialist present. Initial examination should involve a sterile speculum examination to evaluate for vaginal lacerations or bony fragments that may indicate pelvic fractures. If fluid is present, it can be tested for ferning and also for its pH (normal vaginal secretions have a pH of 5.0, whereas amniotic fluid has a pH of 7.0). Bimanual examination should be deferred unless the capability of performing a rapid cesarean section is available because of the possibility of membrane rupture.

**USE OF DIAGNOSTIC IMAGING**

Given concerns regarding the risks of ionizing radiation (discussed later), the use of X ray and computed tomography (CT) in pregnancy should be minimized, especially if alternative diagnostic modalities (eg, ultrasound or magnetic resonance imaging) may provide similar information. However, in hemodynamically unstable pregnant women with suspected diagnoses for which there are no alternate appropriate studies (eg, those with a suspected retroperitoneal hemorrhage), the benefits of CT imaging far outweigh the fetal risks of radiation, especially given the significant fetal risk of continued uterine hypoperfusion caused by maternal shock. With that caveat in mind, there are 3 main concerns regarding the use of ionizing radiation during pregnancy: loss of viability, radiation-induced malformation, and radiation-induced malignancy. For reference, the typical trauma examinations expose the average patient to the following effective doses: chest X ray (0.002 rad), pelvic X ray (0.06 rad), and abdomen/pelvis CT (1.5 rad).

The earliest concern, loss of viability, is greatest when it occurs within 2 weeks of conception, a time period when most pregnant women are unaware that they are pregnant. There is a significant risk of failure to implant with exposure to more than 50 rad of ionizing radiation. However, those embryos that implant should not have significant noncancer health effects.

The risk of radiation-induced malformation is greatest during embryonic organogenesis (2–7 weeks after conception). Although there is no detectable risk with less than 5 rad of exposure, risk of growth retardation increases with more than 5 rad, with growth retardation likely with more than 50 rad of exposure. The risk of malformation decreases later in pregnancy because of the completion of organogenesis.

Although there are little data regarding the risk of in utero ionizing radiation exposure and cancer risk, it is thought to be constant throughout pregnancy. The Centers for Disease Control and Prevention classify the risk as minimal when cumulative exposure during the pregnancy is limited to 0 to 5 rad (<1% risk of malignancy) but state that the
risk increases to 1% to 6% when cumulative exposure increases to 5 to 50 rad and more than 6% when cumulative exposure exceeds 50 rad.\textsuperscript{26}

In addition to the decision of when to use imaging, it is important to remember that certain pregnancy-related anatomic changes may seem to be abnormalities on plain imaging routinely obtained during trauma. Chest radiographs may have slight cardiomegaly, a slightly widened mediastinum, and mild pulmonary vascular cephalization, whereas pelvis radiographs may have widening of the sacroiliac joints and the symphysis pubis, both of which occur normally in pregnancy.

TRAUMATIC COMPLICATIONS OF PREGNANCY

Placental Abruption

While placental abruption can occur spontaneously, it is most often described in the setting of trauma, especially abdominal trauma. One case series noted that the incidence of abruption increased with the severity of injury, from 8.5% in noninjured pregnant women involved in car accidents to 13% in women with severe injuries.\textsuperscript{29} Although the diagnosis is classically made based on the presence of abdominal pain, uterine tenderness, or vaginal bleeding, it can also be present in asymptomatic mothers. Ultrasound is also not sensitive enough to rule out abruption, necessitating the use of routine posttraumatic fetal cardiac and tocographic monitoring.\textsuperscript{30}

Uterine Rupture

Both blunt and penetrating trauma can cause uterine rupture, and the diagnosis should always be considered in pregnant trauma patients with a significant mechanism of injury. Although pregnant patients are typically counseled to avoid placing their seat belts directly over their uterus, inappropriate seat belt placement can result in significant force directed directly on the uterus. In addition, intentional penetrating trauma is often directed at the uterus in pregnant women, putting them at greater risk for uterine rupture. In contrast to nonpregnant patients for whom operative intervention is typically appropriate after penetrating trauma, pregnant women with lower abdominal penetrating trauma may be treated more conservatively given the superior displacement of other abdominal organs by the uterus. Pregnant women with upper abdominal trauma, on the other hand, are typically taken for operative evaluation similar to their nonpregnant counterparts.\textsuperscript{18,31}

Fetomaternal Hemorrhage

Fetomaternal hemorrhage (FMH) causes alloimmunization in Rh-negative mothers gestating Rh-positive fetuses. Fetal blood that leaks into the maternal circulation following trauma poses a significant concern to the fetus, which results in hemolytic disease of the newborn, fetal anemia, fetal distress, and fetal death.\textsuperscript{32} FMH should be considered a possible sequela of trauma in pregnant patients as early as the fourth week of gestation when the fetal circulation develops. As little as 0.1 mL of fetal blood is needed to sensitize the mother.

The Kleihauer-Betke test is an inexpensive, readily available test to measure the percent of fetal red blood cells in a maternal blood sample. The test is sensitive enough to detect 5 mL of FMH. Because less than 5 mL is required to sensitize the mother, all Rh-negative pregnant patients having sustained abdominal trauma should receive Rh immune globulin (RhIG). A 50-µg dose of RhIG is used during the first trimester. After 12 weeks’ gestation, a RhIG dose of 300 µg is recommended. The test is useful when it detects greater than 30 mL of FMH, which requires increased doses of RhIG. A positive Kleihauer-Betke test can be combined with other
parameters, such as third trimester trauma, abdominal trauma, and an Injury Severity Score greater than 2, to create a composite morbidity model to identify those at risk for adverse perinatal outcomes.33

The Kleihauer-Betke test cannot be used to detect FMH in Rh-positive mothers or in Rh-negative mothers carrying an Rh-negative fetus. Although alloimmunization and hemolytic disease of the newborn are not a concern, significant FMH may lead to fetal exsanguination. Uterine tenderness, contractions, vaginal bleeding, and fetal distress may indicate FMH. Current research is looking at anti–fetal hemoglobin flow cytometry as an alternative to detecting FMH.34

PERIMORTEM CESAREAN SECTION

In the cardiopulmonary arrest of pregnant trauma patients, the emergency medicine physician must consider the survivability of both the mother and the fetus. The best chance of fetal survival is maternal survival, and the best chance of maternal survival may be fetal delivery. The perimortem cesarean section relieves the aortocaval compression, which will improve the effectiveness of cardiopulmonary resuscitation (CPR). This relief increases cardiac output by approximately 60% to 80%.35 The 2010 American Heart Association (AHA) guidelines recommend cesarean delivery if maternal resuscitative efforts are not successful by 4 minutes. There have been a few case reports and no clinical trials regarding perimortem cesarean section; however, between 1900 and 1985, the case reports showed that normal neurologic outcome in the fetus was more likely with delivery within 5 minutes of the mothers’ arrest.36 From these case reports, the 5-minute rule was established. Between 1985 and 2004, the case reports show that 12 out of 20 mothers had improved hemodynamics or return of spontaneous circulation with perimortem cesarean section.37 These same case reports continue to establish that the likelihood of normal neurologic outcome in the fetus relies on delivery within 5 minutes of maternal arrest, with 9 out of 12 infants delivered within that time showing normal neurologic function.38 It should be noted that the case reports and subsequent AHA guidelines focus on medical causes of maternal cardiac arrest. Traumatic hypovolemic cardiac arrest in a mother portends a worse outcome for the fetus because the fetus has already suffered prolonged hypoxia.

Another factor to consider before performing the perimortem cesarean section is gestational age. It is thought that aortocaval compression begins to occur at 20 weeks’ gestation. Most institutions will provide full support to a fetus between 22 and 24 weeks’ gestation. The 2010 AHA guidelines state that, with an obvious gravid uterus and no return of spontaneous circulation by 4 minutes, a perimortem cesarean section should be performed. The perimortem cesarean section is a reasonable option when the fetus is estimated to be 22 to 24 weeks’ gestation with the best information available or the uterus is at or above the umbilicus.

During the procedure, CPR should be continued and broad-spectrum antibiotics should be given to decrease any risk of postpartum infection. The most experienced physician, preferably an obstetrician, should perform the cesarean section; but because of the time constraints in which the procedure must be performed, the responsibility will likely be that of the emergency medicine physician or trauma surgeon. A neonatologist or pediatrician should be requested to the resuscitation room immediately, but this should not delay the procedure. The suggested incision is a vertical incision from the epigastrium to the symphysis pubis and carried through all layers to the peritoneal cavity (Fig. 2), which provides a fast entry and adequate visualization of the uterus. The uterus is exposed and initially incised at the bladder
reflection, with a retractor pulling the bladder caudally (Fig. 3). The incision should then be extended to the uterine fundus, with the operator’s hand used to palpate for fetal parts and prevent them from being damaged by the scissors being used to extend the incision (Fig. 4). The infant should be extracted with prompt clamping and cutting of the umbilical cord.

The physician is now faced with the resuscitation of 2 separate patients. With maternal CPR continuing, if hemodynamic stability is restored with the relief of venal compression, delivery of the placenta and closure of the uterus should be performed to limit further hemorrhage. The infant should be managed according to the 2010 AHA/American Academy of Pediatrics/International Liaison Committee on Resuscitation’s guidelines for neonatal resuscitative care. Additional resources (pediatric and obstetric/surgical) should be called and divided to continue both resuscitations; but if resources are limited or unavailable, the physician may need to focus on the patient deemed to have the greatest chance of survival.

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Fig. 2. The abdominal incision for a perimortem cesarean section. *(From Strong TH, Lowe RA. Perimortem cesarean section. Am J Emer Med 1989;7(5):489–94; with permission.)*

Fig. 3. The initial incision with a retracted bladder. *(From Strong TH, Lowe RA. Perimortem cesarean section. Am J Emer Med 1989;7(5):489–94; with permission.)*
SUMMARY

Trauma, both intentional and unintentional, is a significant cause of maternal morbidity and mortality. All pregnant women evaluated in the ED, regardless of their reason for the visit, should receive trauma prevention focused counseling. Although the initial treatment of pregnant trauma victims should follow the standard protocols of Advanced Trauma Life Support, knowledge about maternal anatomic differences (especially regarding uterine compression of the inferior vena cava) is essential. Fetal stability should be monitored via continuous fetal cardiac monitoring, and an emergent cesarean section may be indicated if this fetal monitoring is thought to be nonreassuring in a viable fetus.

REFERENCES


