*Special Article*

# Trauma in Pregnancy

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Trauma is the leading cause of nonobstetric maternal morbidity and mortality in this country. Maternal survival does not guarantee fetal survival, even in cases of apparently minor trauma. The injured pregnant patient presents unique diagnostic and therapeutic challenges. Physicians who make obstetrics or emergency medicine part of their practice must be aware of these unique problems. Prevention of traumatic injury should remain the focus of office practice.

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Trauma is the leading nonobstetric cause of morbidity and mortality in pregnancy, and in some studies it accounts for twice the number of deaths caused by obstetric complications.[1,2] The incidence of trauma in pregnancy is estimated at 6% to 7%, with blunt trauma being most common.[1–6] Blunt trauma is usually due to motor vehicle accidents; falls and assaults are less frequent causes.[1–7] The incidence of minor trauma, especially falls, increases as pregnancy progresses. This increase is most likely due to fainting, pelvic joint laxity and pain, and the awkwardness of movement caused by a protuberant abdomen.[5,8]

When a pregnant patient suffers trauma, maternal survival does not guarantee fetal survival.[2,5,6] Fetal death rates in pregnant trauma victims exceed maternal death rates three- to ninefold.[4] Many of these fetal deaths occur in cases of insignificant maternal injury.[2,4–6,8,9] For this reason, physicians who practice obstetrics or emergency medicine must develop a rational approach to the evaluation of traumatized pregnant patients that will optimize both maternal and fetal survival and incur the least costs from medical testing and hospital confinement.

## Changes in Pregnancy

As pregnancy progresses, the uterus enlarges from a pelvic to an intra-abdominal organ, becoming more susceptible to injury. As the uterus expands into the abdominal cavity, other organs are displaced, changing the spectrum of injuries seen in abdominal penetrating trauma. Stretching of the abdominal wall decreases the signs of peritoneal irritation in pregnant women.[2,8,10,11]

Changes in maternal physiology during pregnancy alter the patient's hemodynamic status and therefore may mask the signs and symptoms of hypovolemic shock.[2–4,6,10–12] For example, plasma volume, cardiac output, and heart rate are all increased in pregnant patients. Blood pressure can be decreased by as much as 15 mm Hg by midtrimester. Laboratory changes associated with pregnancy are outlined in Table 1.

By the end of pregnancy, plasma volume has increased 40% to 50% over prepregnancy values. This relative hypervolemia allows for the loss of 30% to 35% of blood volume without the development of hypotension.[3,4,6,11] Cardiac output has increased by 20% to 30%.[2,3,10,11] Maternal blood flow is often maintained at the expense of uteroplacental flow, placing the fetus at risk for hypoxic injury or death. This shunting of maternal blood away from the uterus is secondary to the greater adrenergic response and lack of autoregulation found in the uterine vasculature.[2–4,6,10,11] It is critical to remember that simply placing even a normal pregnant patient in the supine position can cause severe hypotension resulting from compression of the inferior vena cava and subsequent decreased venous return.[10,11]

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Table 1. Selected Laboratory Values in Pregnancy

| Variable | Value | Change from Prepregnancy Values |
|---|---|---|
| Hematocrit | 32%–42% | Decreased |
| Bicarbonate | 19–25 mEq/L | Decreased |
| $P_{CO_2}$ | 27–32 mm Hg | Decreased |
| BUN | 4–12 mg/dL | Decreased |
| Creatinine | <0.9 mg/dL | Decreased |
| White blood cell count | 5–18 × $10^9$/L | Increased |
| Fibrinogen level | 400–500 mg/dL | Increased |
| Arterial pH | 7.4–7.45 | Increased |
| ECG changes | NA | Flat/inverted T-waves or Q-waves in the inferior leads |

*Values based on data from Pearleman and Tintinalli,[2] Hoff et al,[3] Pearleman et al,[10] Dunn et al.[12]*
*$P_{CO_2}$ denotes carbon dioxide partial pressure; BUN, blood urea nitrogen; pH, hydrogen ion concentration; ECG, electrocardiogram.*

## Spectrum of Injury

The pregnant trauma patient is susceptible to a unique set of problems. Placental abruption is second only to maternal death as the most common cause of fetal death, complicating 1% to 5% of minor and 6% to 50% of major injuries.[3,4,8–10] Placental position does not appear to affect the incidence of abruption.[2] Vaginal bleeding is usually absent.[8]

Uterine rupture is very rare, present in only 0.6% of pregnant trauma victims.[2,10] Although maternal mortality is low (around 10% and due to associated severe injuries), fetal mortality approaches 100%.[2,10]

Direct fetal injury resulting from trauma is also rare, especially in the first trimester when the uterus is shielded by the pelvis. Most direct fetal injuries involve the cranium and its contents, and are usually associated with maternal pelvic fractures in the second and third trimesters.[2,7,8,10,11]

Fetomaternal hemorrhage, or loss of blood from the fetal to the maternal circulation, is four to five times more common in the traumatized patient than in uninjured controls. This complication is associated with anterior placental location, the presence of uterine tenderness, and motor vehicle accidents rather than other types of blunt trauma. Severity of maternal injury does not appear to correlate with the presence of fetomaternal hemorrhage, but large hemorrhages (>5 mL) are seen only in patients with physical evidence of trauma.[2,9,10]

If mild, fetomaternal hemorrhage results only in fetal and subsequent neonatal anemia. If more severe, signs of hypovolemia may be evident on fetal heart rate monitoring, such as fetal tachycardia, a sinusoidal pattern, or late decelerations. In severe cases, fetal death due to exsanguination may occur. Maternal isoimmunization may occur if there is blood group or Rh incompatibility between the mother and the fetus.[2,9,10,13,14]

Amniotic fluid embolism may also occur secondary to trauma. Patients with this usually rapidly fatal condition present with hypoxia, hypotension, and disseminated intravascular coagulopathy.[15]

Other unique problems of the traumatized pregnant patient include retroperitoneal hemorrhage with or without accompanying disseminated intravascular coagulopathy, and preterm labor or premature rupture of membranes.

## The Severely Injured Patient

First and foremost, poor maternal outcome is associated with poor fetal outcome. Therefore, the basics of trauma care remain the highest priority.

The primary survey and resuscitation are the same as for any other trauma patient, as outlined by the Advanced Trauma Life Support course[16] summarized in Table 2. The airway must be carefully maintained, as delayed gastric emptying and relaxation of the esophagogastric junction predispose the pregnant patient to aspiration. Because oxygen consumption at rest increases by 20% in pregnancy, and because the fetus is extremely sensitive to hypoxia, all pregnant trauma victims should receive supplemental oxygen. Even a minimally depressed $P_{O_2}$ may not be compatible with fetal survival. If pneumatic antishock trousers are used, the abdominal compartment should not be inflated. Of particular importance, the supine position should be avoided in order to prevent hypotension and resultant uteroplacental hypoperfusion. This fact should be kept in mind during transport as well as in the emergency department. If the

Table 2. Primary and Secondary Trauma Surveys for Pregnant Patients

| |
|---|
| The Primary Survey |
| Supplemental oxygen |
| Ventilatory support |
| Fluid resuscitation |
| Blood replacement |
| The Secondary Survey |
| Fundal height |
| Uterine activity |
| Fetal heartbeat and movement |
| Assessment for vaginal bleeding |
| Assessment for ruptured membranes |
| Pelvic examination to assess cervix |

patient is immobilized, a wedge under the right hip or manual displacement of the uterus to the left should be used, or the entire backboard tilted 15°. Otherwise, the patient can be placed in the left lateral decubitus position. Aggressive fluid resuscitation with crystalloid or cross-matched type-specific blood, or both, is indicated.[2,3,10,11]

The secondary survey, as outlined in Table 2, is modified for the pregnant patient. Investigation for uterine contractions, fetal viability, placental abruption, and ruptured membranes should be undertaken. Initially, these assessments can be done rapidly and with minimal equipment. An examiner's hand resting on the abdomen can detect obvious uterine contractions or a hard, tender, tetanically contracted uterus associated with abruption. Presence of a fetal heartbeat can be readily detected with a 2- to 3-MHz Doppler stethoscope. The presence of vaginal bleeding indicates placental abruption, and a watery vaginal discharge indicates ruptured membranes until proven otherwise. A fluid sample taken from the vagina can be placed on a slide to dry, and if it crystallizes in the characteristic "fern" pattern, rupture of membranes is confirmed. A more detailed pelvic examination is necessary to investigate the source of vaginal bleeding, or to detect occult bleeding, and to assess dilatation and effacement of the cervix and fetal presentation.

A simple fundal height measurement can provide a rapid assessment of gestational age. Under normal circumstances (eg, normal fetal size and amniotic fluid volume and a singleton pregnancy), the fundal height in centimeters (pubus to top of the fundus) equals the number of weeks of gestation between 20 and 36 weeks. In the conscious patient, maternal perception of fetal movement is a reassuring sign. If the estimated gestational age is greater than 20 weeks, fetal cardiotocographic monitoring can be instituted as soon as it is safe to do so.[2,10] In any case of suspected placental abruption in a woman in the late second or third trimester of pregnancy, a physician capable of performing an emergency cesarean section should be consulted. Early consultation is also suggested in cases of severe trauma when perimortem cesarean section is being considered.[2,17,18]

## Diagnostic Studies

Routine radiographic examination of the trauma victim should not be withheld because of pregnancy. The radiation exposure to the fetus is minimal, and studies have confirmed the absence of deleterious effects.[2]

Diagnostic peritoneal lavage (DPL) and abdominal computed tomography are the two most common modalities used in evaluating the abdomen of trauma victims. Although neither is contraindicated in pregnancy, it may be more prudent to use DPL in the first trimester to avoid radiation exposure. In one study, DPL was associated with increased fetal loss. However, DPL was used only in the most seriously injured patients, who would have had poor fetal outcomes irrespective of the procedures performed. The authors concluded that DPL should not be withheld if indicated.[4,6,7]

Diagnostic ultrasonography can be extremely helpful, especially if immediately available, preferably right in the emergency department. Within a few seconds, diagnostic ultrasonography can reveal a fetal heartbeat, fetal presentation and number, amniotic fluid quantity, and placental location. Ultrasonography may also reveal a placental abruption, but the absence of sonographic signs of abruption does not rule abruption out.[5] An abnormal fetal position and free fluid within the peritoneal cavity immediately suggest uterine rupture.

Retrospective studies correlate poor fetal outcome with increasing severity of maternal injury by various scoring systems.[3,4,6] Decreasing maternal pH and $Po_2$[3,4] and large amounts of fluids required during the first 24 hours[3] have been correlated with poor outcome. Maternal pelvic fracture has also been shown to predict fetal demise.[4] Pelvic fracture can also be associated with trauma to the dilated pelvic veins with resultant massive retroperitoneal hemorrhage.[11]

The most helpful serum test appears to be the maternal serum bicarbonate level. The normal value for bicarbonate in pregnancy is 19 to 25 mEq/L (19 to 25 mmol/L).[12] A depressed bicarbonate level is a sensitive indicator of tissue hypoperfusion, even in the presence of normal vital signs. Tissue hypoperfusion may indicate fetal hypoxia with resultant poor outcome. A serum lactate level may be used in the same way.[6,7]

## The Minimally Injured Patient

Evaluation and management of the less severely traumatized patient should focus on examining the patient for

Table 3. Management of Mild Blunt Abdominal Trauma in Pregnancy

1. Perform primary survey (Table 2)
2. Perform secondary survey (Table 2)
3. Check blood type, Rh, hematocrit
4. Consider checking bicarbonate and clotting studies
5. Consider diagnostic ultrasonography
6. If >12 weeks, consider Kleihauer-Betke test
7. If >20 weeks, institute cardiotocographic monitoring
   - If <3 contractions per hour, monitor for 4 hours and discharge if criteria are met
   - If 3–7 contractions per hour, monitor for 24 hours and discharge if criteria are met
   - If >7 contractions per hour, consider patient high risk for abruption
   - Do ultrasound and clotting studies if not yet done
   - Deliver if indicated
8. Discharge criteria
   - Resolution of contractions
   - Reassuring fetal heart tracing
   - Intact membranes
   - No uterine tenderness
   - No vaginal bleeding
   - Patient understands discharge instructions and follow-up plans
   - All Rh-negative mothers receive a minimum of 300 μg of $Rh_o(D)$ immune globulin ($Rh_oGam$) (more if indicated by results of Kleihauer-Betke testing)

placental abruption and accompanying fetomaternal hemorrhage and uterine contractions. Cardiotocographic monitoring, the Kleihauer-Betke test and other blood tests, and ultrasonography are useful tools, as outlined in Table 3.

Cardiotocographic monitoring should be initiated in those at or beyond the 20th week of gestation. Results of a prospective study[9] found that a 4-hour monitoring period and a Kleihauer-Betke test (to detect fetal cells in a maternal blood sample) identified all pregnant patients who had an immediate adverse outcome after trauma. These outcomes included placental abruption within 72 hours, fetal death within 7 days, ruptured membranes within 7 hours, and preterm labor or delivery. Only patients with more than eight contractions per hour suffered placental abruption. Those with three to seven contractions per hour were monitored for 24 hours, and discharged if uterine activity had stopped. Those contracting less than three times in an hour were discharged at the end of 4 hours of monitoring. Both groups were discharged only if fetal heart tracings were reassuring, membranes were intact, and there was no vaginal bleeding or uterine tenderness. No difference in pregnancy outcome was found between the discharged patients and uninjured controls. If discharged, the patient should be given clear instructions to return if vaginal bleeding occurs, membranes rupture, uterine contractions return, or fetal movement decreases.

Alternative recommendations range from only a nonstress test and discharge if normal[8,14] to a full 24-hours' monitoring for all patients.[5,7] Monitoring before the age of viability (middle to late second trimester) is not advised because delivery would not be an option.

Helpful blood work includes blood type and Rh typing, and determination of the hematocrit. Kleihauer-Betke testing is advocated after the 12th week of gestation, when the uterus becomes an abdominal organ. Other tests to be considered include serum bicarbonate, arterial blood gases, and clotting studies.

The Kleihauer-Betke test is used to detect fetal red blood cells in the maternal circulation.[19] Fetal hemoglobin (HgF) is relatively resistant to citric acid elution. Therefore, red blood cells (RBCs) containing HgF will stain dark while other RBCs appear as "ghosts." In a mother with persistent HgF caused by a hereditary hemoglobinopathy, the maternal cells containing HgF will stain, giving a false-positive result. Maternal cells containing HgF have variable staining characteristics, depending on the pH of the Kleihauer-Betke test reagents.[19] Although subject to interpretive error, and often unreliable in the average laboratory, the Kleihauer-Betke test is still considered to be the best test to screen for and quantitate fetomaternal hemorrhage.[4,14,19]

One fetal cell per 1000 maternal cells represents a 5-mL hemorrhage, assuming a maternal blood volume of 5 L.[14] As few as 1 to 3 fetal cells per 500,000 maternal cells may sensitize up to 70% of Rh-negative women. Therefore, all Rh-negative mothers should receive at least 300 μg of $Rh_o(D)$ immune globulin after trauma. If the fetohemorrhage is quantitated, 300 μg of $Rh_o(D)$ immune globulin should be given for every 15 mL of fetal cells.[4,10]

The performance of serial Kleihauer-Betke tests to detect continuous hemorrhage is controversial.[4] Fetomaternal hemorrhage may be managed by serial testing (Kleihauer-Betke and cardiotocographic), with either cord blood sampling and intrauterine fetal blood transfusion or delivery indicated for fetal distress.[13,14]

Diagnostic ultrasound examination of less severely traumatized pregnant patients has not been well studied, but can yield important information that is clinically useful in the immediate evaluation of the patient and in her subsequent follow-up. Fetal life, number, and presentation can be diagnosed. The position of the placenta

and the amniotic fluid volume may be ascertained. Biometric measurements and determination of estimated fetal age are useful to gauge future growth. Abruption may or may not be visible.[5]

The use of tocolytic agents in trauma is controversial. Tocolysis masks the most sensitive indicator of abruption, ie, uterine contractions, and is therefore believed by some to be contraindicated.[2,9,10] Others[5] have used tocolysis successfully.

## Conclusions

It is important to develop skills in the management of the traumatized pregnant patient, but office practice should focus on the prevention of trauma in pregnancy. Appropriate use of seat belts should be encouraged. The seat belt should be worn over the lap, not over the abdomen. Shoulder belts should also be used. Seat belts prevent ejection from the motor vehicle, and have been shown to decrease maternal and fetal morbidity and mortality.[7,8,14,17]

Because pregnancy may be associated with an increase in domestic violence, screening for abuse should be encouraged.[14,20,21] Until trauma can be prevented, the physician who makes emergency medicine or obstetrics part of his or her practice should be skilled in the management of trauma, and in the special needs of the traumatized pregnant patient.

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