Trauma During Pregnancy: Outcomes and Clinical Management

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Abstract: Trauma affects up to 6% to 7% of all pregnancies, and accounts for up to 46% of maternal death. Adverse consequences such as preterm labor and delivery, abruptio, fetomaternal hemorrhage, and fetal demise may be seen with even apparently minor degrees of injury. Maternal physiologic considerations are reviewed and a protocol for evaluation and management of the injured gravida is presented.

Key words: wounds and injuries, pregnancy, trauma

Although often overlooked as a complication of pregnancy, trauma affecting the gravida is a common occurrence. Up to 6% to 7% of pregnancies are affected by some degree of traumatic injury,1 which is usually accidental but may include intentional violence. Traditional public health databases have often failed to include nonobstetric causes of maternal mortality, but several studies have reported that when wider criteria are used, trauma is the leading cause of maternal death, accounting for up to 46% of such cases.2-4

Complications associated with trauma include not only the more obvious, direct maternal consequences, but also unique pregnancy-related complications such as preterm labor and delivery, abruptio placentae, fetomaternal hemorrhage, the potential for attendant isoimmunization, direct fetal injury, and fetal demise.5-9 Such outcomes, particularly abruptio placentae, may be seen even with apparently minor degrees of injury, and fetal death is a more common occurrence than maternal death.10-12

Epidemiology

The most common causes of trauma in pregnancy are motor vehicle accidents (49%), falls (25%), assaults (18%), guns (4%), and burns (1%).13 When looking solely at injuries resulting in death, the 2 most common injuries are homicide and motor vehicle accidents, which account for 36% and 32%, respectively, with the remainder resulting from drug use, suicide, and other nonspecified causes.3

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Identified risk factors for trauma in pregnancy are infrequent, but include younger age, drug use, alcohol use, and domestic violence. In particular, drug and alcohol use appear significant as risk factors for both trauma and for adverse outcome. Berenson and associates found that women who were battered were more likely to use alcohol, drugs, and tobacco; and among women who had minor degrees of trauma in pregnancy, Holland and colleagues reported a 21% incidence of preterm birth when the drug screen was positive.

Sometimes, pregnancy itself can be a risk factor for trauma. Over recent years, attacks on pregnant women have gained prominence. These attacks are frequently targeted at the gravid abdomen, with intent to cause fetal injury.

**PHYSIOLOGIC CHANGES OF PREGNANCY**

Crucial to the resuscitation of the pregnant trauma victim is an understanding of both fetal and maternal physiology, particularly the physiologic response to stress and hypovolemia. Fundamental differences in the physiologic response to trauma occur during pregnancy, and the obstetrician’s specific knowledge becomes an invaluable asset to the team of physicians managing the pregnant trauma victim in all settings of trauma during pregnancy. An overview of some of these changes is found in Table 1.

**Fetal Physiology**

Several factors are important in determining what impact a traumatic event will have on pregnancy outcome, including gestational age, type and severity of trauma, and the extent of disruption of normal maternal and fetal physiology. In the first week of conception, the non-implanted embryo is relatively resistant to noxious stimuli. Even during the first trimester, the uterus resides safely within the confines of the bony pelvis and is largely protected from direct uterine trauma. However, at any gestational age after implantation, maternal hypovolemic shock may have a significant impact on the developing embryo/fetus. Blood flow to the uterine arteries are normally maximally vasodilated, thus blood delivery to the uterus is maximal in the normal physiologic state. Maternal hypovolemia may result in vasoconstriction in many vascular beds, including the uterine vasculature. Even without uterine artery vasoconstriction, a decrease in maternal blood pressure may result in a decrease in uterine blood flow. These facts underline the importance of maintaining adequate maternal blood volume as a first step in fetal resuscitation. The third trimester fetus can adapt to this decrease in uterine blood flow and oxygen delivery by diverting

**TABLE 1. Anatomic/Physiologic Changes of Pregnancy**

<table>
<thead>
<tr>
<th>Cardiovascular</th>
<th>Hematologic</th>
<th>Gastrointestinal</th>
<th>Reproductive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac output</td>
<td>Blood volume</td>
<td>Intestines</td>
<td>Uterine size</td>
</tr>
<tr>
<td>Increases 1-1.5 L/min</td>
<td>Increases 40%-50%</td>
<td>Displaced into upper abdomen in later</td>
<td>Increases to 36 cm, 1000 g</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>13-28 wk</td>
<td>gestation</td>
<td>organ</td>
</tr>
<tr>
<td>Decreases 5-15 mm</td>
<td>Decreases 1-2 g/dL as</td>
<td>Displaced cephalad becoming an abdominal</td>
<td>Increases from 60 to</td>
</tr>
<tr>
<td>in mid-trimester</td>
<td>plasma volume to a</td>
<td>in the second and third</td>
<td>600 mL/min</td>
</tr>
<tr>
<td>Heart rate</td>
<td>greater degree than</td>
<td>trimesters</td>
<td></td>
</tr>
<tr>
<td>Increases 15-20 bpm</td>
<td>does RBC mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supine positioning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May decrease cardiac output up to 30%</td>
<td></td>
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<table>
<thead>
<tr>
<th>Urinary</th>
<th>Ureters</th>
<th>Uterine blood flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder organ</td>
<td>Dilated (R &gt; L)</td>
<td>Increases from 60 to 600 mL/min</td>
</tr>
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<td></td>
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blood distribution to the heart, brain, and adrenal glands. Furthermore, because fetal hemoglobin has a greater affinity for oxygen than does adult hemoglobin, fetal oxygen consumption does not decrease until the delivery of oxygen is reduced by 50%.

Blunt or penetrating trauma to the fetus may result in rupture of the amniotic membranes. In the second trimester, rupture of membranes without reaccumulation of fluid may result in pulmonary hypoplasia or orthopedic deformity. In addition, infection may develop with premature rupture of the membranes at any gestational age. Injury to the placenta may result in separation or laceration leading to fetal anemia, hypoxemia, or hypovolemia.

Maternal Anatomic and Physiologic Changes

Nearly every organ system undergoes anatomic or physiologic changes during pregnancy. The description below emphasizes the importance of some of these changes in managing the trauma victim, particularly as these differences impact on the usual practice of managing trauma victims.

A major concern when caring for trauma victims is internal hemorrhage and hypovolemia. The sentinel findings of hypovolemia are changes in vital signs, typically hypotension and tachycardia. The practitioner must be aware of the normal decrease in systemic vascular resistance resulting in a drop in blood pressure and increase in pulse (5 to 10 bpm), particularly in the second trimester. These changes can be attenuated if the gravida is placed in the supine position (eg, strapped to a long board with the spine secured). The resultant potential decrease in venous return from the lower extremities can reduce central venous volume and result in a diminished cardiac output (up to 28%). Simple manual displacement of the gravid uterus to the left or placement of a rolled towel under the backboard (while assuring the spine remains secure) can alleviate most of this effect.

Plasma volume increases up to 50% in the singleton gestation, maximal by 28 weeks. RBC mass increases to a lesser degree than does plasma volume, resulting in a slight decrease in hemoglobin and hematocrit during pregnancy. Iron deficiency anemia is also common during pregnancy, and together with the "physiologic" anemia, it is not infrequent to see hemoglobin in the 9 to 11 g/dL range. These hematologic changes have 2 potential implications in the management of the trauma victim: (1) confusion with anemia due to active bleeding and hypovolemia, and (2) blood volume estimates should be modified upward during fluid resuscitation.

The 2 major pregnancy-induced changes in the gastrointestinal tract, which have implications for trauma management are compartmentalization (ie, cephalad displacement of the bowel), and decreased bowel motility resulting in increased transit time of bowel contents. Compartmentalization protects the bowel during lower abdominal trauma, but is particularly concerning when there is penetrating trauma to the upper abdomen in the latter half of gestation. Complex injuries to the small bowel can occur under these circumstances, which may result in multiple entry and exit wounds. Decreased gastric motility results in prolonged gastric emptying time increasing the risk of aspiration. Rebound tenderness and guarding may be less apparent in advanced gestation, making clinical diagnosis of hemoperitoneum potentially less reliable; changes that are likely due to stretching of the abdominal musculature and peritoneum by the gravid uterus.

Dramatic increases in uterine blood flow (from 60 to 600 mL/min) may result in rapid exsanguination if there is avulsion of the uterine vessels or rupture of
the uterus. Retroperitoneal hemorrhage is also a common complication of pelvic fracture owing to the tremendous increase in vascularity resulting from pregnancy. Enlargement of the uterus makes it susceptible to direct abdominal trauma. Injury to the uterus itself (uterine rupture), adjacent organs (bladder rupture), or contents of the uterus (abruptio placentae or direct fetal injury) are possible. While some occur typically with direct and violent trauma (eg, uterine rupture), others may occur with minimal maternal trauma (eg, abruptio placentae). Other changes that have potential importance in managing pregnant trauma victims are listed in Table 1.

EFFECTS OF TRAUMA

Maternal Effects of Trauma
Mechanisms of maternal injury may directly relate to the trauma, or may develop independently. For example, if a pregnant woman is in a motor vehicle accident and suffers a penetrating trauma, the cause of injury may be apparent, although the spectrum of injury may be altered owing to the changes previously reviewed. Even without visible injury, however, a sudden deceleration involved in the accident can create a shearing force sufficient to tear the placenta away from the uterine wall resulting in placental abruption. Abruptio may pose risks for preterm labor and delivery, coagulopathy, massive hemorrhage, and isoimmunization. Notably, blunt injuries in pregnancy do not appear to pose higher risk for death than they do in nonpregnant patients, with most deaths occurring as the result of either head injury or hemorrhage.27–29

In a more extreme example, uterine rupture, although rare, may result from trauma. This unusual occurrence is estimated to complicate only 0.6% of traumatic injury.30 This complication seems to occur more often later in pregnancy, and usually results from a direct, high-energy blow to the maternal abdomen. Risk factors that may play a role, although not entirely clear in order of importance, include parity, history of uterine surgery, and uterine overdistention, such as may be seen with polyhydramnios and multiple gestation.31,32 Outcomes in these cases almost always include fetal death.

Fetal Effects of Trauma
Most trauma in pregnancy is blunt trauma. In cases of blunt trauma, direct fetal injury is relatively uncommon because the maternal soft tissues, uterus, placenta, and amniotic fluid all tend to absorb and distribute the energy of the blow. In such cases, indirect fetal injury, such as placental abruption and fetomaternal hemorrhage are more common. Abruptio results from deformation of the uterine wall, and the resultant shearing effect on the underlying placenta.8,33 This complication occurs in approximately 6% of women with maternal trauma in pregnancy.33

Outcomes such as fetal death and delivery are important consequences of trauma. Investigators have found that injury severity is not universally predictive of these complications, and that adverse outcomes can be seen even with relatively minor degrees of injury.33–35 More recently, Theodorou and colleagues,36 in a study of risk factors for such adverse outcomes, found that moderate and severe degrees of injury, as indicated by an Injury Severity Score (ISS) of 9 or greater, were the lone predictive factors. They reinforced the earlier findings, however, because adverse outcomes were seen even without severe injury, and the authors concluded that all patients with injury require close surveillance.36

Although indirect mechanisms of fetal injury predominate, direct fetal injury can, in fact, occur and is usually a result of penetrating injury such as stabbing or
gunshots. For example, 70% of abdominal gunshot wounds in the third trimester result in fetal injury.\(^37\) Although relatively uncommon, blunt trauma can result in direct fetal injury. This sort of scenario is most likely to be seen in a cephalic presentation with pelvic trauma, probably because the fetal head has less protection, being closely approximated to the bony pelvis. Such injuries can include skull fracture and intracerebral hemorrhage.\(^12,38\) Other fetal injuries such as long bone fracture and visceral injuries have also been described, although they are very uncommon events.

**Fetomaternal Hemorrhage**

As mentioned earlier, fetomaternal hemorrhage is a result of trauma that may pose risks for both current and future pregnancies. Although a recent study of 151 women who experienced trauma showed no increase in the rate of fetomaternal hemorrhage above the general population, finding it in only 2.6% of patients,\(^39\) fetomaternal hemorrhage has traditionally been reported to occur in up to 9% to 30% of cases of trauma in pregnancy, which is about a 4 to 5-fold increase over the baseline rate.\(^8,11,33,40\)

One study suggested that fetomaternal hemorrhage occurs more commonly after trauma in pregnant women with anteriorly located placentae\(^33\) and in patients who experience uterine tenderness after trauma. Motor vehicle accidents are a more frequent cause of this complication than are other types of trauma.\(^8,33\) Severity of injury and gestational age do not seem to reliably predict fetomaternal hemorrhage, but large transfusions of blood from the fetal to maternal compartment are generally seen only in patients with physical evidence of trauma.\(^8\)

Fetal consequences of hemorrhage, including anemia, supraventricular tachycardia, and death have been described. These outcomes, however, are not common, even when fetal blood is detected in the maternal circulation. Longer-term, the concern with fetomaternal hemorrhage is the development of isoimmunization in the mother. Fetomaternal hemorrhage is a particular concern in Rh-negative women, who are at high risk for sensitization if the infant is Rh-positive. As such, these women should receive Rh immune globulin, at least 300 µg intramuscularly, after trauma. This dose will provide adequate prophylaxis for fetomaternal transfusions of up to 30 mL of fetal whole blood. Unfortunately, a limited number of patients will have a hemorrhage in exceed this volume, and a single dose of Rh immune globulin will not suffice.\(^8,33\)

Fetomaternal hemorrhage can be detected and quantified by testing for fetal cells in the maternal circulation using the Kleihauer Betke, or acid elution test. This test can be performed in Rh-negative women to facilitate dosing of immune globulin. The importance of the test is unclear in Rh-positive women, and some authors do not advocate for its use in these patients. Muench and associates,\(^41\) however, studied 71 women who underwent Kleihauer Betke testing after trauma and found a strong correlation with risk for preterm labor and have advocated its use in all patients.

**Evaluation and Management**

As the well-being of the fetus is dependent on that of the mother, the first priority in the care of the injured gravida is maternal resuscitation. When performing resuscitation, the ABC’s refer to Airway, Breathing, and Circulation.\(^42\) Circulation, in trauma patients, refers not only to establishment of a heart rate, but also maintaining intravascular volume by controlling blood loss and replacing crystalloid. It is important to remember that by the third trimester maternal circulating blood volume has increased by 50% above baseline. Consequently, when
calculating replacement, the volume infusion calculations should be increased to a similar degree.

Another important alteration in the circulation of the gravida must be considered. Beyond about 20 weeks in singleton pregnancies (or earlier in multiple gestation), the weight of the gravid uterus can compress the inferior vena cava, impairing return of blood from the lower extremities and hampering resuscitative efforts. To overcome this, the uterus should be deflected laterally (adding a “D” to the ABC’s, indicating deflection). Uterine deflection is most easily accomplished by placing the patient in the left-lateral decubitus position. In patients in whom such positioning is not possible, uterine displacement can be performed either manually, by applying pressure to shift the uterus, or by placing a wedge under the patient’s right side, or under the right side of the patient’s backboard, if necessary.

The secondary survey should proceed as in the nonpregnant patient. The fundal height should be determined, particularly if gestational age is unknown, and the uterus should be examined for tenderness and contractions. Pelvic examination should be performed to evaluate for bleeding, rupture of membranes, and cervical assessment. The fetal heart rate should be evaluated, and, in women beyond 24 weeks, cardiotocodynamometry should be instituted. Caution must be exercised to differentiate maternal from fetal heart rate, because many pregnant patients with trauma will be tachycardic and the 2 heart rates may easily be confused. Simultaneous palpation of the maternal pulse with the use of fetal heart Doppler will usually assure correct identification of the fetal heart rate. Any continued confusion can be resolved with direct visualization of the fetal heart using ultrasound, or the use of newer fetal monitors that permit continuous tracing of both maternal and fetal heart rates.

Although radiation exposure in pregnancy is not without risk, this should not preclude performance of necessary radiographic studies. There is not expected to be an increase in the risk for fetal loss, growth restriction, or malformation as long as the fetal dose of radiation is less than 5000 mrad. Although there may be an increase in the risk for childhood leukemia with lower doses of radiation, the risk of undiagnosed and untreated maternal injury certainly outweighs this risk. Indeed, among patients with fractures, particularly pelvic fractures, there is an increased frequency of complications for both the mother and the fetus. Identification of such patients is, consequently, of great importance. The estimated doses of radiation to the fetus with various radiographic procedures is shown in Table 2.

Laboratory studies should be performed as medically indicated, including complete blood count, blood typing, and antibody screen. Coagulation studies may be indicated in women in whom abruptio is suspected or when multisystem trauma is encountered. Interpretation of laboratory tests should take into account the physiologic changes normally seen in pregnancy. Finally, the Kleihauer Betke test can be performed in Rh-negative women, who should receive an appropriate dose of

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Fetal Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest x-ray (2 views)</td>
<td>0.02-0.07 mrad</td>
</tr>
<tr>
<td>Abdominal film (single view)</td>
<td>100 mrad</td>
</tr>
<tr>
<td>Intravenous pyelography</td>
<td>≥ 1000 mrad</td>
</tr>
<tr>
<td>Hip film (single view)</td>
<td>200 mrad</td>
</tr>
<tr>
<td>Mammography</td>
<td>7-20 mrad</td>
</tr>
<tr>
<td>Barium enema or small bowel series</td>
<td>2000-4000 mrad</td>
</tr>
<tr>
<td>CT scan of head or chest</td>
<td>&lt; 1000 mrad</td>
</tr>
<tr>
<td>CT scan of abdomen and lumbar spine</td>
<td>3500 mrad</td>
</tr>
<tr>
<td>CT pelvimetry</td>
<td>250 mrad</td>
</tr>
</tbody>
</table>

CT indicates computed tomography.
Rh immune globulin within 72 hours of the traumatic event. If Kleihauer-Betke testing is not performed, 300 mcg of Rh immune globulin should be administered in all Rh-negative women.

In patients beyond 23 to 24 weeks, tocodynamometry is the most sensitive predictor of abruptio placentae after trauma, and in combination with electronic fetal monitoring, facilitates its diagnosis and treatment. Abruptio begins developing soon after trauma, and evidence of abruptio usually becomes apparent shortly after injury. Therefore, monitoring should begin as soon as feasible, although it should not take precedence over basic maternal resuscitation. Fetal heart rate changes to identify include tachycardia, bradycardia, periodic decelerations, loss of variability, and a sinusoidal pattern. Continuous fetal monitoring is preferred to intermittent auscultation, as the latter is limited in its ability to detect heart rate changes other than tachycardia and bradycardia. In a prospective study of fetal heart rate tracing in patients with traumatic abruptio placentae, the authors reported that of the 4 cases of fetal distress, 2 may have encountered delay in diagnosis with intermittent monitoring.

Uterine activity monitoring, tocodynamometry, plays an important role in the prediction of abruption, and therefore plays an important role in the evaluation and care of these women. Pearlman and colleagues prospectively studied 85 consecutive women with trauma in pregnancy. All patients with 3 or more contractions were monitored for 24 hours. At that point, patients were discharged if contractions had stopped and no evidence fetal compromise, rupture of membranes, vaginal bleeding, or other serious injury, had become manifest. They found that all cases of abruptio showed frequent (>8/h) contractions in the initial four hours of electronic fetal monitoring.

On the basis of these data, 4 hours of electronic monitoring has become a widely accepted minimum duration of monitoring. Patients who have fewer than 1 contraction every 10 minutes during this 4-hour period of monitoring and who also do not exhibit uterine tenderness, bleeding, fetal distress, or serious maternal injuries do not seem to be at risk for adverse pregnancy outcomes compared with uninjured controls. Among those women with significant contractions, the rate of fetal death or delivery is almost 20%.

Figure 1 shows the algorithm employed at the University of Michigan guiding care of the injured gravida.

**Prevention**

Strategies targeted at the prevention of traumatic injury in pregnancy have not been well studied. This is probably due at least partially to the fact that an active gravida will engage in typical day-to-day activities such as driving, which carry a degree of risk, but these are activities that are difficult to curtail in our mobile society. Thus our suggestions with regards to prevention are limited. First among these is education. Informing the patient of risks of trauma may increase awareness of activities that may particularly place them at risk. In addition, should injury or fall occur, a patient who is aware of the risks is almost certainly more likely to report to the hospital for evaluation.

Regarding automobile accidents, the cause of almost half of trauma, specific recommendations exist regarding the use of safety belts. The correct use of safety belts during pregnancy should be encouraged, as patients who are unrestrained are twice as likely to deliver within 48 hours of motor vehicle accidents as are restrained patients. Further, when placed incorrectly, safety belts have been reported to be associated with fetal injury. Unfortunately, many patients either do not wear safety belts or are unable to identify proper placement.
of Obstetricians and Gynecologists has emphasized that both the lap belt and shoulder harness should be worn, with the lap belt passing below the abdomen and over the anterior superior iliac spine and symphysis pubis and the shoulder harness passing between the patient’s breasts. Patients who receive information regarding this are significantly more likely to use their safety belts correctly.
Careful crash analysis has demonstrated that the proper restraint of pregnant occupants is independently associated with a lower risk of adverse fetal outcomes (ie, abruptio placentae, preterm birth, and stillbirth) in motor vehicle crashes involving pregnant women.48

The many issues related to domestic violence during pregnancy have been covered in another chapter and are not covered in-depth here. However, given that some sort of sexual or physical abuse affects up to 20% of pregnancies,20 it is important that physicians screen all patients for domestic violence. Patients who are in abusive relationships should be provided with referrals to appropriate social support systems and counseled appropriately regarding the risks of such violence in pregnancy.

As discussed previously, substance abuse during pregnancy is associated with increased risk for traumatic injury.18,19 Patients who are using alcohol or drugs should be counseled regarding the effects of such substances on the pregnancy. The patients should receive referrals to social work and specialists in addiction disorders.

References

40. American College of Surgeons. Committee on Trauma. ATLS, Advanced Trauma


