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*The traumatically injured pregnant patient presents multiple challenges for the emergency physician. Not only are there urgent clinical matters to manage, but emotions also can run high, both on the part of the patient and the health care provider. Accordingly, a comprehensive understanding of diagnostic strategies, possible complications, and a cool head are needed to prevail and optimize patient outcomes. As every clinician knows, pregnancy induces a number of physiological and anatomical changes—alterations that make it more difficult to evaluate pregnant patients using standard parameters.*

*Another challenge, of course, is the presence of a second patient—the fetus. Depending on the gestational stage of the pregnancy, which cannot always be readily determined in the trauma bay, the fetus may or may not be viable. As a rule, the best approach to optimizing care for the fetus is to provide optimal care for the mother. The patient, however, may have concerns regarding her fetus and the risks posed by radiation, blood products, and medications that routinely are used during trauma resuscitations.*

*That the fetus is more sensitive than the mother to decreases in oxygenation and hypotension complicates management. There are times, however, when efforts to save the mother are futile, in which*

*case instantaneous decisions must be made regarding the delivery of the fetus, preferably with an obstetrician in attendance. In the best case scenario, care of the pregnant trauma patient requires a multidisciplinary approach. The emergency medicine physician, trauma surgeon, obstetrician, and the pediatrician or neonatologist are important members of this team.*

*With these issues in mind, the purpose of this article is to outline the presentation, evaluation, and management of the pregnant patient who has sustained physical trauma, and to identify a team leader role for the emergency physician. In addition, this issue reviews the physiological changes that occur during pregnancy. The most common mechanisms of significant trauma and the value of specific diagnostic*

*studies and their relevance to the management of the injured pregnant patient are discussed in detail. Finally, issues regarding the fetus, perimortem cesarean section, and sequelae for the infant are considered.*

— The Editor

## Trauma in Pregnancy: Optimizing Maternal and Fetal Outcomes A Systematic Approach to Assessment and Management of the Injured Pregnant Patient

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## Introduction

Trauma occurs more commonly during the third trimester of pregnancy than at any other time during a woman's life.<sup>1</sup> It has

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been estimated that about 7% of pregnancies are complicated by trauma.<sup>1,2</sup> Despite this, having to treat the pregnant trauma patient remains a relatively infrequent occurrence in the practice of any single emergency physician.<sup>3,4</sup> The most commonly cited causes of injury in the pregnant patient include motor vehicle accidents, falls, and assaults.<sup>5</sup> However, the role of domestic violence or intentional injury has been found to play an increasingly significant role. In fact, a nine-year study from the Mississippi Medical Center reported that 31.5% of hospitalized, injured pregnant patients were victims of interpersonal violence.<sup>4</sup> A study of New York City's Medical Examiner records (1987-1991) found a high rate of homicide deaths among deceased, pregnant, injured patients; domestic violence was associated with the majority of these homicides.<sup>6</sup> Trauma is the leading cause of nonobstetric maternal deaths, and in Cook

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County, IL, between 1986 and 1989, traumatic injuries were responsible for 46% of all maternal deaths.<sup>7</sup>

It is convenient to classify the injured pregnant patient into one of four groups. The first group includes women who are early in their pregnancy, so early they may be unaware that they are pregnant. Ironically, this is the group in which unnecessary radiographs may have the most significant teratogenic effects. The second group includes pregnant women who have fetuses that are not yet viable. At this stage, the fetus is fairly well protected by the bony pelvis and requires maternal survival for further gestational development. The third group is the most challenging, inasmuch as it includes those women whose pregnancies are of an adequate gestational age to permit viability outside the mother. The earliest age most authors consider adequate for viability is 23 weeks.<sup>8</sup> Almost all authors agree that by 26 weeks the fetus should be considered viable.<sup>9</sup> At this point in the pregnancy, there are now two patients requiring assessment and management. The fourth group includes those women who are perimortem. In these situations, perimortem cesarean section may be critical for the resuscitation of the fetus and, moreover, may improve the outcome of the mother.<sup>8</sup>

As a rule, the condition of pregnancy, in and of itself, usually does not affect maternal survival in cases of severe trauma.<sup>9,10</sup> In cases of severe burns or blunt trauma, for example, survival of the mother is consistent with her degree of injury and is similar to the anticipated survival of a nonpregnant female with equivalent injuries. In penetrating trauma, the gravid uterus may be protective of the mother's other organs. Frequently, however, the maternal or fetal outcome may be affected by early decisions made in the trauma bay. It should be stressed that the most common cause of fetal death is maternal death, followed by placental abruption.<sup>8,9,11-13</sup>

### Clinical Pathophysiology

In order to meet the challenges of managing a pregnant trauma patient, it is important to understand the physiologic changes that occur during pregnancy. During the first trimester, the uterus is considered a pelvic organ. After 12 weeks, uterine enlargement begins to displace the bowel laterally and superiorly.<sup>8,13</sup> In addition, the bladder also moves into the peritoneal cavity.<sup>8</sup> With the displacement of abdominal organs from the peritoneal surface, there is also decreased sensitivity by the patient to peritoneal injury.<sup>8,14</sup> These anatomic changes can make it difficult to diagnose injuries in a pregnant patient.

Oxygen consumption increases with the increased metabolic demands of the pregnant patient.<sup>15</sup> Specifically, tidal volume and minute ventilatory volume are increased as the pregnancy advances. However, functional residual capacity is decreased as a direct effect of the elevated diaphragm.<sup>13</sup> These changes result in a physiologic respiratory alkalosis in the pregnant patient.<sup>8</sup> During pregnancy the diaphragm elevates about 4 cm, while the diameter and circumference of the thoracic cage also increase. It should be noted that if there is need for a closed thoracotomy, then the chest tube must be placed one or two interspaces higher than in the nonpregnant patient.<sup>16</sup> (See Table 1.)

**Table 1. Critical Physiologic Changes that Occur During Pregnancy**

<b>System</b>	<b>Physiologic Change</b>	<b>Consequences</b>
<b>CARDIOVASCULAR</b>	Cardiac output is increased by 40%; pulse increased by 20-30% to 80-95 beats/min; mild decrease in BP seen in second trimester; blood volume is increased by 40% at term; CVP declines during gestation from 9 mmHg to 4-5 mmHg in third trimester.	Supine position reduces venous return (treat with left lateral displacement of the uterus); relative tachycardia is normal; blood loss will exceed 30% of total blood volume before hypotension is manifest. Retroperitoneal bleeds may not be readily manifest.
<b>ECG</b>	A left axis shift occurs from elevation of the diaphragm.	Flattened T waves, possible inversion in lead III, possible Q waves in III and AVF.
<b>PULMONARY</b>	Tidal volume and respiratory rate increase; minute ventilation increased by 40-50%; reduced functional residual capacity; increased sensitivity to CO <sub>2</sub> with resulting partially compensated respiratory alkalosis. Oxygen consumption increased 10-20% by term.  Diaphragm is elevated by 4 cm at term.	Persistent respiratory alkalosis; mild tachypnea; shorter anesthesia induction time.  Thoracostomies performed 1-2 interspaces higher than usual.
<b>HEMATOLOGIC</b>	Blood volume is increased, more than RBC mass, resulting in dilutional "anemia"; WBC increased (to 18,000); sedimentation rate increased, but CRP remains normal; fibrinogen factors VII, VIII, IX, and X increased.	False dilutional anemia may be diagnosed; potentially false diagnosis of infection based on WBC; change in coagulation factors increases risk for thromboembolic problems, especially with immobilization.
<b>GASTROINTESTINAL</b>	Hypomotility present; gastric emptying delayed; esophageal reflux more frequent; increased acid production.	Risk of aspiration increased with anesthesia induction or unconsciousness.
<b>GENITOURINARY</b>	Hypomotility of collecting systems; increased GFR. Anterior and superior displacement of bladder with progressing gestation.	Ureteral dilation on radiographic studies (right > left) as early as 10th week; risk of infection increased with stasis and catheterization; BUN and creatinine normally decrease.
<b>CENTRAL NERVOUS</b>	Some decreased coordination in later gestation.	Increased emotional lability.

BP = Blood pressure; CVP = central venous pressure; ECG = electrocardiogram; AVF = arteriovenous fistula; RBC = red blood cells; WBC = white blood cells; CRP = C-reactive protein; GFR = glomerular filtration rate; BUN = blood urea nitrogen.

Source: Lavery JP, Staten-McCormick M. Management of moderate to severe trauma in pregnancy. *Obstet Gynecol Clin North Am* 1995;22:69-90.

It is also common for gastric motility to decrease during pregnancy. A decrease in gastric emptying can lead to an increase in gastric aspiration. This is compounded by the increased laxity of the gastroesophageal junction that occurs during pregnancy.<sup>8</sup> Increased risk of aspiration is therefore a risk during the trauma or when securing the patient's airway. In addition, the bladder becomes an intra-abdominal organ and is more susceptible to injury. Ureteral dilation and hydronephrosis are known sequela of pregnancy.

Maternal blood volume significantly increases during pregnancy. Hypervolemia helps meet oxygen demands of the fetus.<sup>13</sup> While the erythrocyte volume increases about 33%, the plasma volume in a pregnant patient increases between 45% and 50% until delivery. These changes produce a physiologic anemia, in which a hemoglobin level as low as 10g/dL may be considered normal.<sup>15</sup> In addition, leukocytosis occurs, peaking

during the third trimester.<sup>8,13</sup> Most importantly, pregnancy-induced hypervolemia can mask hemorrhagic shock until 30-35% of the patient's blood volume has been depleted.<sup>8,17</sup>

Despite augmentation in both blood volume and cardiac output, there is a decrease in blood pressure and peripheral vascular resistance;<sup>8,13</sup> heart rate also is increased. The changes in blood pressure and heart rate are relatively minor, with the systolic pressure changing by 2-4 mmHg and the resting pulse increasing by 10-15 beats per minute.<sup>8</sup> Therefore, a decrease in blood pressure or tachycardia in an obstetric trauma patient should not be attributed to the physiologic changes that occur in pregnancy, but rather, these abnormalities should be considered serious warning signs of impending shock.<sup>14</sup>

It should also be noted that a supine, hypotensive syndrome can occur in patients who are at more than 20 weeks gestation. This condition occurs when the enlarged uterus obstructs the

**Table 2. Use of Studies in Blunt and Penetrating Trauma**

	ADVANTAGES	DISADVANTAGES
<b>CT</b>	<ul style="list-style-type: none"> <li>• Good anatomical detail</li> <li>• Identifies retro-peritoneal injury</li> </ul>	<ul style="list-style-type: none"> <li>• Minimal but present radiation exposure</li> <li>• Need a stable patient</li> </ul>
<b>Ultrasound</b>	<ul style="list-style-type: none"> <li>• Can be used in an unstable patient</li> <li>• Non-invasive</li> <li>• No radiation</li> <li>• Good view of fetus as well as abdominal fluid collections</li> </ul>	<ul style="list-style-type: none"> <li>• Accuracy of results is user dependent</li> <li>• Source of fluid not necessarily clear</li> </ul>
<b>Deep peritoneal lavage</b>	<ul style="list-style-type: none"> <li>• Can be done in an unstable patient</li> <li>• Sensitivity for hemo-peritoneum is good</li> </ul>	<ul style="list-style-type: none"> <li>• Invasive</li> <li>• Does not identify retroperitoneal or intrauterine injury</li> </ul>

inferior vena cava, thereby reducing venous return to the heart. To relieve this condition, the patient should be placed in the left lateral decubitus position. If the patient is immobilized on a backboard, the board can be lifted by inserting a wedge on the right side of the backboard.<sup>14</sup> This technique will minimize compression of the inferior vena cava and maximize the oxygen delivery to the fetus.<sup>17</sup>

**Mechanisms of Injury:  
Blunt and Penetrating Trauma**

**Blunt Trauma.** The most common cause of blunt abdominal trauma in the pregnant patient is motor vehicle accidents (MVAs). In one study from the University of North Carolina Medical School, 54.6% of all traumatic events during pregnancy were due to MVAs. The next most common causes of blunt abdominal trauma were domestic abuse/assaults and falls.<sup>5</sup> The most common complications resulting from severe blunt trauma are placental abruption, fetal death or distress, and preterm labor.

From a practical, clinical perspective, it is helpful to distinguish between major and minor blunt trauma during pregnancy. Unfortunately, however, making this distinction in clinical practice may be difficult. Maternal physiological changes in pregnancy make it difficult to assess the pregnant trauma patient. In particular, increased blood volume, decreased hematocrit, and an increased pulse rate in the normal pregnant patient make it difficult to evaluate the traumatically injured patient in the manner to which emergency medicine physicians are accustomed.

Specifically, acute blood loss may be difficult to detect by the usual clinical parameters (i.e., vital signs) until the patient has sustained a 30% loss of blood volume. Although this blood loss is difficult to assess, much of the hypovolemia is at the expense of the fetoplacental unit and, therefore, may significantly affect fetal stability before detectable changes in maternal vital signs have been demonstrated. It is important, therefore, to monitor the fetus because fetal viability depends on maternal stability, and because fetal instability may be the earliest sign of significant maternal injury.

Injuries encountered in blunt abdominal trauma in the pregnant patient are somewhat different from those seen in the non-

pregnant patient. These differences can be attributed to both physiological and anatomical changes, as previously described.

In particular, the risk of splenic injury and retroperitoneal hematoma is greater due to the increased vascularity of pregnancy. In contrast, the incidence of bowel injury is lessened as the uterus progressively displaces the bowel into the upper abdomen.<sup>15,18</sup>

Injuries unique to pregnancy include placental abruption, which occurs in 1-5% of minor injuries and 20-50% of major injuries, and uterine rupture, which occurs in less than 1% of cases.<sup>15,18</sup> Placental abruption is characterized by premature separation of the placenta from the wall of the uterus. This is dangerous for both the mother and the fetus. Up to 2 liters of occult blood may be found in the uterus in placental abruption.<sup>9</sup> Signs of placental abruption can include vaginal bleeding; a growing, tense uterus; maternal hypotension; uterine cramping; and fetal heart rate alterations consistent with uteroplacental insufficiency.<sup>9</sup> Preterm labor is another complication of blunt trauma.

The incidence of fetal loss from minor trauma is 1.7%.<sup>14,19</sup> Morbidity is less common in minor trauma; however, because minor trauma more commonly occurs, overall morbidity due to injuries from minor trauma is significant.<sup>20</sup> A pregnant patient may present after a MVA with altered mental status. These patients should be evaluated as would any other patient in which a change in mental status has occurred. In addition, the clinician should consider the possibility that a pregnant patient who presents this way may be postictal following an eclampsia-induced seizure.

Important, prevention-oriented interventions can significantly reduce the risk of morbidity caused by common forms of blunt trauma. The proper use of seat belts, including both the lap belt and the shoulder harness, should be addressed at an early point in prenatal care. Risks for falls and heightening awareness of significant changes in balance also should be explained to the patient during her pregnancy. Falls most frequently occur in the last trimester, when these changes are most dramatic. Finally, the rate of domestic violence and assault increase during pregnancy. Pregnant women may be most receptive to intervention during this period. It is our responsibility as physicians to retain a high level of suspicion for abuse and offer services in a non-judgmental manner.

**Penetrating Trauma.** Knife and gunshot wounds are the most common forms of penetrating trauma. The enlarged uterus shifts the maternal organs cephalad and, as a result, the fetus is injured in 60-70% of gunshot wounds, while maternal visceral injuries occur in only 19% of cases.<sup>10,21</sup> One group studied penetrating wounds of the uterus during the civil war in Lebanon, and reported the following observations and conclusions. First, entrance wounds in the upper abdomen or the back are more likely to be associated with maternal visceral injuries. This is because the bowel is compressed into the upper abdomen, and therefore, is more susceptible to injury if the wound is in that area.<sup>9</sup> The second observation was that if the wound was below the uterine fundus and anterior, visceral injuries were absent in their patients. The third observation

was that death of the fetus occurred in one-half of the patients because of either maternal shock or direct injury to the fetus, placenta, or uterus.<sup>22</sup>

Not surprisingly, stab wounds carry a better prognosis for both the patient and fetus. However, penetrating trauma, in general, has a worse prognosis for the fetus than for the mother, no matter what the etiology is. In most cases, the standard approach to gunshot wounds to the abdomen and flank is surgical exploration. The location of the wound and condition of the fetus can influence how stab wounds are managed. The use of diagnostic peritoneal lavage (DPL), ultrasonography, and CT scan can offer non-surgical options depending on the results. However, exploratory laparotomy remains the most reliable approach for identifying and treating injuries that have occurred from penetrating trauma.<sup>17</sup>

**Domestic Violence.** It is estimated that between 0.9% and 20.1% of pregnant women are victims of domestic violence.<sup>23</sup> These numbers are believed to underestimate the actual number of victims. Many victims are unwilling to report or press charges against their abusers. It appears that the violence worsens as the pregnancy progresses through the third trimester.<sup>8</sup> Domestic violence in the pregnant patient has been associated with low birth weights and maternal risk factors that include: low weight gain, anemia, and drug and alcohol use.<sup>4,8,24</sup> In order to care for the domestic violence patient, it is imperative that the health care provider identifies these victims. Once the victims are recognized, educational efforts can be made about the services that are available for them. However, if the patients remain unidentified, it is possible they will go on to receive serious injuries that can threaten both the mother and fetus.<sup>4,8</sup>

**Suicide.** Suicide was the cause of death in 13% of maternal deaths by injury in a study of medical examiner records conducted from 1987 through 1991.<sup>6</sup> The autopsy reports for all women, aged 10-44 years old, who committed suicide in New York City during the years 1990-1993 were studied. The actual number of suicides in pregnant women were compared with what might be expected from age-adjusted and race-adjusted standardized mortality ratios, and it was found that the rate of suicide among pregnant women was between 33% and 40% of what might be expected.<sup>25</sup> Possible causes for the dramatically lower suicide rate are unknown. Suicide attempts more commonly occur when women first discover their pregnancies and during the early third trimester.<sup>9</sup> Although the risk of suicide is lower in women who are pregnant, suicide is still responsible for a significant number of deaths because of injury. Pregnant women, in the appropriate clinical context, should have the possibility of suicidal ideations addressed.

## Burns

Burns are a significant cause of maternal morbidity and mortality, especially in developing countries where cooking is done over open fires, frequently on the floor.<sup>26</sup> Burns occur less often in developed countries, but when they do, they can cause significant morbidity. Small or minor burns seem to have little or no effect, but major burns can affect both mother and fetus.<sup>27</sup>

The older classification system of burns (first-, second-, and third-degree) is now being replaced by a new system. The Parkland Trauma Handbook divides burns into minor and major burns.<sup>28</sup> Minor burns are otherwise uncomplicated burns that cover less than 10% of the body surface area (BSA) of the patient and include just the surface of the skin or are partial thickness. A burn automatically is classified as major if the patient also has a chronic or severe illness; if the burn involves the face, hands, or perineum; if the burn has resulted from an electrical injury; or if there are associated, concurrent injuries. A burn also may be classified as a major burn if the size of the burn is more than 10% of the BSA and there are areas of partial or full thickness burn. A major burn is further classified according to the size of the area burned. A moderate major burn covers 10-19% of BSA; a severe burn covers 20-39% of BSA, and a critical burn covers more than 40% of BSA.<sup>28</sup> Pregnant burn patients require the same approach and initial treatment as non-pregnant burn patients. Tetanus immunization and immunoglobulin are safe when indicated.<sup>21</sup>

Fortunately, severe burns in pregnancy are relatively rare. The limited number of affected patients has led to multiple case reports or small studies, but no studies with large numbers of affected patients. Hence, there is significant variability in the results of these small case series. Most of these reports have found that the burned pregnant patient does not fare worse than the non-pregnant patient.<sup>29,30</sup> However, some studies suggest that when critically burned pregnant women are compared with non-pregnant women of similar age, socioeconomic status, and severity of burn, pregnant patients fared much worse.<sup>26</sup> In this trial, critical burns included a BSA greater than 25-30%, and they noted that 63% of the pregnant women in this group died, as opposed to 39% of the nonpregnant patients. There were 18 patients in the critically burned, nonpregnant group and eight patients in the critically burned pregnant group. The causes of death in the critically burned pregnant group include adult respiratory distress syndrome (ARDS), massive pulmonary emboli, and sepsis.<sup>26</sup>

The risk to the fetus of a burned mother is maternal death, fetal death, and preterm labor. The fetoplacental unit is particularly sensitive to hypovolemia and hypoxia.<sup>31,32</sup> Hypoxemia decreases blood flow to the placenta, and therefore, decreases oxygenation of the fetus.<sup>33</sup> It is believed that preterm labor may occur because prostaglandin E2 is released from burned tissue.<sup>26</sup> This causes uterine contractility, which can cause premature labor and abortion.

Many burn victims also are exposed to smoke inhalation, and it should be stressed that carbon monoxide poisoning poses a special risk for the pregnant patient. Maternal carbon monoxide levels are a poor predictor of fetal carboxyhemoglobin.<sup>34</sup> Fetal hemoglobin has a higher affinity for carbon monoxide than adult hemoglobin.<sup>29</sup> Hyperbaric treatment is appropriate if the maternal carbon monoxide level is 20 or higher or if the mother exhibits any symptoms of carbon monoxide poisoning.<sup>35</sup> Twenty is a lower level than that usually used for a cutoff in deciding whether to use a hyperbaric chamber to treat a carbon monoxide

exposed burn patient who is not pregnant. The higher affinity of the fetal hemoglobin for carbon justifies use of the lower level.<sup>35</sup> If hyperbaric treatment is not available, then oxygen should be administered by a tight fitting mask for six hours.<sup>35</sup>

The more severely burned the patient is, the more likely it is that she will experience fetal loss. In 1982, one author recommended that women with critical burns covering more than 50% of their BSA and who are in the second or third trimester, should be delivered immediately. The study reported that it improves maternal survival and that the fetus does not demonstrate any improvement in survival if delivery is delayed.<sup>36</sup> Another study reported the cases of two burn patients, each with greater than 60% BSA severe second- and third-degree burns. One woman was in her 36th week of pregnancy and one was in her 38th week. They were both delivered by cesarean section shortly after arrival at the burn center. Both infants and mothers survived.<sup>29</sup>

### **Initial Assessment and Stabilization**

The primary survey of an obstetric trauma patient should be no different than that of a nonpregnant patient. Priorities include evaluation and stabilization of the airway, breathing, and circulation. Supplemental oxygen should be administered continuously throughout their resuscitation. Minimal changes in the oxygen content of the mother can result in serious fetal oxygen compromise. Fetal erythrocytes have an increased affinity to oxygen, and fetal blood tends to function on a left-shifted oxygen-hemoglobin dissociation curve.<sup>13</sup> Therefore, increasing oxygen tension provides significant improvement in fetal saturation.<sup>16</sup> While pulse oximetry is a standard and helpful adjunct in recognizing problems in oxygen saturation in the maternal patient, arterial blood gas can identify hypoxia and, more importantly, signs of acidosis.<sup>17</sup>

As previously emphasized, hemorrhagic shock may be undetectable by our standard measurement of vital signs in a pregnant trauma patient until 30-35% of the blood volume has been lost.<sup>8,13</sup> Monitoring blood pressure and pulse should not be the only values used to assess the pregnant trauma patient. The mechanism of injury, suspicion of injuries, skin color, temperature, character of pulses, urine output, and mental status are all important clues that can help detect potential occult hypoperfusion.<sup>17</sup> It is even more important to monitor lactate levels and arterial blood gases to assess acidosis in this patient population.<sup>17</sup>

There are some differences in the management of a cardiac arrest in a pregnant trauma patient. During advanced cardiac life support (ACLS), there should be a member of the team displacing the gravid uterus in order to perform closed chest massage. Open thoracotomy and internal massage are recommended after 15 minutes of ACLS resuscitation. When indicated, perimortem cesarean sections can improve maternal resuscitation.<sup>17</sup>

Establishing intravenous access and administering lactated Ringer's solution or normal saline provides a physiologic fluid that can enhance blood volume and oxygen carrying capacity in the patient. If there is any doubt about the intravascular volume

of the patient, central venous pressures should be obtained.<sup>17</sup> If the patient has any evidence of severe injuries, she should be stabilized and then promptly transferred to the nearest trauma center with obstetric capabilities.<sup>21</sup>

Once maternal injuries are assessed and stabilized, a secondary assessment can be performed. The physical exam should include assessment of the fetus. A more detailed history, including a pertinent prenatal history and physical exam can be done at this time. Evaluation of the uterus should be done for size and evidence of irritability. Pelvic exam should assess for trauma and for dilation and effacement of the cervix. Finally, evidence should be sought for the presence of amniotic fluid. Nitrazine paper will turn blue because of a pH greater than seven when amniotic fluid is present.

Tetanus toxoid should be administered to a pregnant woman if indicated. Tetanus immunoglobulin is also recommended if appropriate. During the assessment of the patient and the fetus, anatomic and physiologic changes of pregnancy should be kept in mind in order to appropriately manage the patient.<sup>14,17</sup> Diagnostic tests, such as x-rays, CT scans, and sonography, and other specialized procedures, can be used to evaluate and manage the patient as needed. Appropriate maternal resuscitation will help achieve the best fetal outcome.<sup>14</sup> Fetal assessment can be accomplished with the use of a doppler ultrasound and cardiotocographic monitoring, which are used to evaluate fetal distress.<sup>14</sup>

Doppler ultrasound of the fetal heart tones can be auscultated by the emergency physician, but cardiotocographic monitoring should be performed under the obstetrician's supervision. Fetal heart tones can be heard by doppler beginning at 10-14 weeks.<sup>19</sup> The fetal heart rate should be between 120 and 160 beats per minute. If the heart rate is out of this range then fetal distress is likely.<sup>8</sup> If the fetus is pre-viable, it is adequate to do intermittent monitoring, but if the fetus is felt to be viable it is necessary to perform continuous cardiotocography.<sup>8</sup>

Multiple parameters are used for cardiotocographic monitoring, and considerable expertise is required for accurate interpretation of the findings.<sup>37</sup> Cardiotocographic monitoring is useful because it permits the physician to follow the heart rate of the fetus as well as uterine contractions. If there are unexpected decelerations in the fetal heart rate, or inappropriate uterine contractions are detected, the likelihood of placental abruption or other complications is increased.<sup>19</sup> The optimal length of time for monitoring an injured, pregnant patient has yet to be determined;<sup>38</sup> however, one study found no placental abruptions in patients who either had no uterine contractions or if the frequency of contractions was less than one every 10 minutes four hours after the trauma occurred.<sup>39</sup> Accordingly, a four-hour period of fetal monitoring to detect fetal distress appears to be sufficient in a patient at greater than 20 weeks gestation.<sup>14</sup> However, if there are any irregularities in the tracing during this time period, fetal monitoring should be extended.<sup>16</sup> Abruption rarely has occurred days after trauma.<sup>18</sup>

Vasopressors are generally discouraged during the initial management of the trauma patient, whether or not the patient

is pregnant. Cardiogenic shock from a severe myocardial contusion or neurogenic shock from a spinal injury are the only indications that justify the possible use of vasopressors. Ultimately, vasopressors decrease oxygen delivery to the fetus by decreasing uterine blood flow. However, if there is an indication for vasopressors during the management of an life-threatening obstetric trauma patient they should not be withheld despite the risk to the fetus.<sup>14</sup>

During the resuscitation of an obstetric trauma patient, tocolytic therapy is controversial. Tocolysis is indicated for patients who are in pre-term labor and have been adequately treated with oxygen, hydration, and rest in the left lateral position. Tocolytic therapy only should be used in the absence of placental abruption, fetal maternal hemorrhage, and hypoperfusion.<sup>9,17</sup>

While there are some physiological changes that allow us to generalize the treatment of the pregnant patient, clearly each patient should be treated individually. Clinical decisions regarding management must take into account mechanism of injury, severity of injury, and status of the pregnancy.

**Diagnostic Studies.** Once the patient has undergone initial and secondary assessment, and has been stabilized, appropriate diagnostic procedures can be performed. (See Table 2.) It is important to take into account the history and mechanism of injury prior to ordering tests or performing any procedures. Essentially, a patient who is pregnant should receive all of the appropriate tests that a patient who is not pregnant would receive.<sup>17</sup> Maternal resuscitation is always the first priority.<sup>14</sup>

There is always concern on the part of the patient and the health care provider regarding the use of radiographs when evaluating a pregnant patient. Radiographic studies should be performed on pregnant patients as clinically indicated.<sup>17</sup> Whenever possible, the fetus should be shielded.<sup>9</sup> Teratogenic and mutagenic effects to the fetus within the first trimester are less likely to occur if the fetus is exposed to less than 5-10 rads. X-rays used in the initial trauma series, the cervical spine, and chest and pelvic x-rays, are all less than 1 rad of exposure.<sup>9,14</sup>

CT scans are commonly used as diagnostic adjuncts when evaluating a trauma patient. CT scans of the abdomen and pelvis will deliver 3-10 rads to the fetus that is within direct line of the beam.<sup>9,17</sup> The exposure of the fetus can be minimized by either shielding the fetus whenever possible, or reducing the number of imaging cuts, or modifying the area studied.<sup>8</sup>

Ultrasonography is a safe, noninvasive method that may be used to screen for intra-abdominal blood. If the ultrasound indicates presence of intra-abdominal and pelvic fluid, more invasive studies or laparotomy can be pursued.<sup>17</sup> Sonography carries no radiation risk to the patient or fetus and can be done at the bedside.<sup>8</sup> Ultrasonography can also provide important information about the fetus. Information regarding gestational age, presence of multiple gestations, presence of placental abruption, and fetal viability are important and may affect management.<sup>8</sup>

Diagnostic peritoneal lavage is a sensitive and safe procedure that can be used to identify hemoperitoneum. It is not organ specific, however, and it does not assess retroperitoneal

hemorrhage or intrauterine injury.<sup>11,17</sup> The procedure should be performed with involvement of a surgeon using an open technique, through a midline incision above the level of the uterine fundus.<sup>17</sup>

**Laboratory Studies.** During the initial assessment and management of the pregnant trauma patient, routine laboratory studies should be ordered. These labs should include: a complete blood count, type and cross match, electrolytes with BUN, creatinine and glucose, coagulation studies, a pregnancy test in a patient who is not obviously pregnant, and Kleihauer-Betke stain.<sup>9</sup> Some laboratory tests change their normal range during pregnancy. For example, during pregnancy, the fibrinogen level normally doubles. Therefore, if a normal non-pregnant fibronogen value is observed, consider that the patient may be developing early disseminated intravascular coagulopathy.<sup>9,14</sup>

If there is suspicion of fetal bleeding into the maternal blood stream (fetal-maternal hemorrhage [FMH]), Kleinhauer-Betke testing should be done. If the trauma patient is Rh negative, significant FMH may be life threatening to the fetus.<sup>9,17</sup> Using the Kleinhauer-Betke stain, the degree of fetal-maternal bleeding can be quantitated and the amount of Rh-immune globulin can be increased accordingly. Each 30 mL of fetal blood requires 1 mL of Rh-immune globulin to prevent isoimmunization.<sup>9</sup>

It is also important to check for the presence of alcohol or illegal drugs in a pregnant trauma patient. The use of alcohol or cocaine is associated with both maternal and fetal effects that impair the response to resuscitation.<sup>9</sup> Patients should also be counseled that serious fetal and developmental abnormalities have been associated with ongoing use of alcohol and other recreational drugs during pregnancy.

## Perimortem Cesarean Section

If the mother presents in a state of cardiac arrest, or near cardiac arrest, the option of a perimortem cesarean section should be considered. There may be benefits for both the mother and fetus if this performed at the appropriate time.

If it survives, the fetus benefits with minimal morbidity. A fetus closer to term is more likely to survive than a younger fetus. In the non-trauma setting, a fetus of 22 weeks gestation has a 0% survival rate. At 24 weeks, the survival rate increases to 9.9%. At 26 weeks, the rate increases to 54.7%. By 30 weeks, the survival rate is 90.6%, and by 34 weeks the survival rate is 98.7%.<sup>40</sup> In the trauma setting, a survival rate of 75% was found in the subgroup that included fetuses with an estimated gestational age of 26 weeks or more and fetal heart tones delivered by cesarean section, due to fetal distress.<sup>37</sup> The use of ultrasound may accurately date the pregnancy, but may be too time consuming. A physical exam that demonstrates a fundal height a few finger widths above the umbilicus is adequate to proceed.<sup>37</sup>

To make this a viable alternative, it is important to know that the fetus has survived the initial trauma. Fetal heart tones are the quickest and easiest to determine if the fetus is alive. If there are

**Table 3. Pearls and Pitfalls in Managing the Pregnant Trauma Patient**

- The pregnant patient can lose up to 30% of her blood volume before she shows any of the classic vital sign changes of shock.
- Fetal heart rate is an additional vital sign that may be more sensitive than the maternal vital signs for blood loss.
- The majority of injuries during pregnancy are due to blunt trauma.
- The fetus is more sensitive to hypovolemia than the mother.
- Domestic violence increases during pregnancy.
- The suicide rate during pregnancy is lower than that for age-matched women who are not pregnant.
- Perimortem cesarean section should be begun if the mother arrests and does not respond within four minutes.
- Management of the pregnant trauma patient should be directed at maternal survival.
- Fetal outcome is best when the maternal outcome is good.
- Sonogram is a noninvasive way of looking for free fluid in the abdominal cavity.
- A patient at more than 20 weeks gestation can exhibit supine hypotensive syndrome secondary to an enlarged uterus obstructing the inferior vena cava.
- Any diagnostic test that is indicated for the care of the patient should not be modified or delayed because of the pregnancy.

no heart tones it is fruitless to consider an emergency cesarean section, except as an adjunct to maternal resuscitation. Infants with fetal heart tones and an estimated gestational age (EGA) of 26 or more weeks have a survival rate of 75% after emergency cesarean section, although the long-term morbidity may be high.<sup>37</sup> Other authors suggest that an EGA of 23 weeks should be used as a cutoff. One group established that an infant's risk of neurological damage from a hypoxic insult was much lower if the delivery occurred within five minutes of maternal arrest.<sup>40</sup> In addition, the international liaison committee on resuscitation also advises that a perimortem cesarean section be begun within five minutes of maternal arrest.<sup>41</sup>

**Timing and Procedure.** If the mother arrests and does not respond to resuscitation efforts within four minutes, preparation for both open cardiac massage and cesarean section should begin. Open CPR without cross-clamping of the aorta allows continuation of resuscitation efforts for the mother. This may improve whatever placental perfusion that is present while the cesarean section is performed.<sup>42,43</sup> In addition, there have been cases of maternal improvement after delivery of the fetus, presumably because of improvement in maternal circulation.<sup>37</sup>

A full, detailed description of a perimortem cesarean section is beyond the scope of this article. However, a brief description of the procedure will be provided. The procedure entails a large incision made along the linea alba through all layers of the abdominal wall from the xiphoid to the pubis. The bladder should be decompressed by a foley catheter and retracted. Then a midline vertical incision should be made across the upper

uterine segment. The incision is then extended caudally, using blunt dissection, employing the hand as a shield for the fetus. Once the head is delivered, the mouth and nares should be suctioned, the cord should be clamped, and neonatal resuscitation should begin. If there is an anterior lying placenta, the physician should cut through it and address the bleeding after the fetus is delivered.<sup>8,16,44</sup>

Fetal outcome is time dependent, and once the need for perimortem cesarean section is established, it is inappropriate to wait for another practitioner to arrive at the bedside. Ideally, an obstetrician would already be present, but if not, emergency medicine physicians should feel reassured that they are unlikely to make the maternal prognosis worse and may be able to provide the only opportunity that the fetus has for survival.

### **Perinatal Sequelae**

Few studies have been done regarding fetal outcome after maternal trauma during pregnancy. It has been shown that the most commonly reported causes of fetal death are maternal death and placental abruption.<sup>12,43</sup> Predictors of fetal mortality include higher maternal injury severity scores (ISS), maternal shock, maternal DIC, vaginal bleeding, abdominal injury, or absence of fetal heart tones.<sup>12</sup> In addition, patients who suffer from penetrating trauma can frequently have direct injury to the fetus.<sup>9</sup>

An Australian study encompassing 770 women who required hospitalization for trauma over a 10-year period (1982-1992) found that the rate of cerebral palsy among the children of these women was not significantly different from the incidence of cerebral palsy among women who were not hospitalized for trauma during their pregnancies.<sup>2</sup> There are also reports which suggest that other neurological injuries may be sustained due to maternal trauma.<sup>45</sup> Most of those were attributed to decreased fetal perfusion.

### **Transfer of the Pregnant Trauma Patient**

There are some situations when it is advisable to consider interhospital transfer of the pregnant trauma patient. The availability and use of a trauma surgical intensive care unit, a neonatal intensive care unit, or a burn unit and associated experienced personnel may significantly affect maternal and/or fetal outcome. The need for transport must be considered individually, taking into account the stability of the mother and the fetus, the viability of the fetus, and the capabilities of the involved physicians and institutions.

Obstetric neonatal services are designated as levels I, II, or III. A level I is the most basic and can care for near-term deliveries and healthy neonates. They would stabilize other neonates and transfer them to a level II or a level III. A level II center would also be able to manage deliveries of fetuses of 32-36 weeks and the fetus once it is delivered. A level III center is the most comprehensive and could be expected to manage care for mothers and fetuses in all risk categories.<sup>46</sup>

The Consolidated Omnibus Budget Reconciliation Act of 1986 (COBRA) addressed patient transfers. It requires that a medical

screening exam be done before transfer and that a physician at the receiving institution be contacted and accept the patient as a transfer.<sup>47</sup> When possible, the patient should be stabilized before transfer. However, when the transfer occurs from a lower level of care to a higher level of care and the necessary interventions are beyond the abilities of the sending institution, it may not be possible to completely stabilize the mother or fetus. In these instances, transfer is still appropriate.<sup>48</sup>

Some of the reasons that transport might be considered include the need for operative management of the mother because of her traumatic injury, need of a burn unit, necessary monitoring of the mother or the unborn fetus, or advanced monitoring and care of the neonate. Maternal conditions that could be precipitated by a traumatic event that might require transport include premature rupture of the membranes, third-trimester bleeding, premature labor, or acute abdominal emergencies.<sup>47</sup> This is not a decision that should be made by the emergency medicine physician alone, but should involve the other appropriate disciplines as well, especially the obstetric consult.

### Discharge and Disposition

The pregnant patient who has been evaluated after a traumatic event may be concerned about potential complications. It is important that if the patient has been deemed stable for discharge, she needs to receive appropriate instructions. Patients who have either viable or nonviable fetuses (outside the mother) need to return to the physician if they have abdominal pain, leaking fluid that might signal a rupture of membranes, vaginal bleeding, or more than six uterine contractions an hour.<sup>21</sup> In addition, the woman who has a fetus that is viable must return if she has less than three fetal movements over 60 minutes or less than 10 fetal movements in a 12-hour period.<sup>49</sup> There is concern that abruption rarely can present in a delayed fashion and the patient needs to receive discharge instructions that reflect this fact. Women with non-viable fetuses and mild trauma still need to be informed of the small risk of fetal loss.<sup>18</sup>

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### Physician CME Questions

17. The most common cause of blunt abdominal trauma in a pregnant patient is a motor vehicle accident (MVA). Which of the following statements concerning MVA is correct?
  - A. The physiologic and anatomical changes in a pregnant patient do not influence the pattern of injury.

- B. There is less risk of splenic injury.
  - C. The incidence of bowel injury is less as the uterus enlarges.
  - D. The fetal distress is a late sign in injured pregnant patients.
18. Domestic violence in the pregnant patient has been associated with all of the following *except*:
  - A. low fetal birth weight.
  - B. maternal drug use.
  - C. maternal alcohol use.
  - D. low economic status only.
19. In managing an injured obstetric patient, all of the following should be done *except*:
  - A. administering supplemental oxygen during resuscitation.
  - B. administering vasopressors.
  - C. establishing intravenous access and administer lactated Ringer's solution.
  - D. attempting to displace the gravid uterus to the left side.
20. The most common cause of injury due to trauma in the pregnant patient is:
  - A. burn.
  - B. penetrating trauma.
  - C. motor vehicle accident.
  - D. suicide.
21. The best way to care for the fetus in the case of maternal trauma is usually to:
  - A. immediately perform a cesarean section on arrival.
  - B. not touch the mother and call the obstetrician.
  - C. not touch the patient and call the neonatologist.
  - D. give the best possible care to the mother.
22. The best time to consider a perimortem cesarean section is:
  - A. 1 minute after maternal arrest.
  - B. 4 minutes after maternal arrest.
  - C. 1 minute after fetal arrest.
  - D. 10 minutes after maternal arrest.
23. Suicide:
  - A. is more common during pregnancy.
  - B. is less common during pregnancy.
  - C. is just as common among pregnant and non-pregnant women.
  - D. never occurs in those who are pregnant.
24. The earliest sign of significant maternal injury is:
  - A. fetal instability.
  - B. maternal hypotension.
  - C. maternal tachycardia.
  - D. maternal anemia.

In Future Issues:

Acute HIV  
Seroconversion  
Syndrome Recognition