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Trauma In The Pregnant Patient: An Evidence-Based Approach To Management

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Abstract

The management of acute trauma in the pregnant patient relies on a thorough understanding of the underlying physiology of pregnancy. This issue reviews the evidence regarding important considerations in pregnant trauma patients, including the primary and secondary survey as well as the possibility for Rh exposure, placental abruption, uterine rupture, and the need for a prompt perimortem cesarean section in the moribund patient. Because ionizing radiation is always a concern in pregnancy, the circumstances where testing provides benefits that outweigh risks to the fetus are discussed. Emergency clinicians are encouraged to advocate for trauma prevention, including proper safety restraints for motor vehicles and screening for domestic violence, as these measures have been shown to be effective in reducing morbidity and mortality in this population. Recommendations for monitoring, admission, discharge, and follow-up are also noted.

CME Objectives

Upon completion of this article, you should be able to:

1. Discuss the differences in maternal physiology that may complicate care of the pregnant trauma patient.
2. Describe the perinatal catastrophes inherent in obstetric trauma, including abruption, amniotic fluid embolus, uterine rupture, and maternal cardiac arrest.
3. Explain the imaging modalities that are used in assessing the pregnant trauma patient and their risks and benefits.
4. Assess the indications for and the timeline of a perimortem cesarean section as well as the technique used.

Prior to beginning this activity, see the back page for faculty disclosures and CME accreditation information.

Case Presentations

All shifts have a theme. Unfortunately, as you start your day in the ED, you realize that today's theme is not your favorite. In the first hour of your shift, a 30-week pregnant patient arrives from a relatively minor motor vehicle collision. She was ambulatory at the scene despite presenting with lower extremity pain with an obviously deformed ankle and a sore neck. Otherwise, she looks fine, and she reassures you that she isn't having any abdominal pain. She is insistent that she does not want any radiation, that she does not want to be observed, and that she would like to be discharged. Although rapid discharge seems attractive, you are concerned about the potential risk to the fetus and wonder what the best practice recommendations are for managing your 2 patients . . .

As you mull over how to best care for both this mother and baby, a second pregnant patient arrives. She is 24 weeks pregnant and fell while jogging. She thinks that she felt a contraction as the nurse was getting her into a gown. While well-appearing and embarrassed by her clumsiness, there is something about her that makes you feel uneasy . . .

Brooding that this just isn't your day, the radio brings you back to reality as a very distraught paramedic hurriedly relates that they're about 2 minutes out with another motor vehicle collision victim who looks sick and is tachycardic, hypotensive, and having agonal respirations. He relates that the husband is frantically screaming that she's due next month to have a baby girl. As your team gears up for the ensuing disaster about to descend on your trauma room, you realize that the ambulance is going to arrive much faster than your obstetrician on call (who is coming from home). You fully appreciate that the opening moves of this drama are going to be entirely up to you. . . .

Introduction

Few things in emergency practice evoke more anxiety than the pregnant trauma patient. The "package deal" of 2 patients in 1 requires that the emergency clinician simultaneously manage both patients, only 1 of whom may be able to verbalize complaints. Pregnancy provokes anxiety in the patient (who often is concerned about possible complications to her unborn child due to trauma) as well as healthcare providers (who realize that intrauterine complications can be hidden). Careful attention to differences in maternal physiology during pregnancy and a broad differential of the possible complications of pregnancy (even with relatively minor trauma) are requisite to avoid catastrophe, as the physiology and nature of injuries can be strikingly different in a pregnant patient. In this issue of *Emergency Medicine Practice*, the approach to the pregnant trauma patient is reviewed; pitfalls of management are highlighted; and controversies in testing and imaging are discussed, including issues regarding radiation exposure for the fetus. An evidence-based approach to clinical decision making from the care of minor injuries to the perimortem cesarean section are presented.

Critical Appraisal Of The Literature

A literature search of current articles from 1946 to present was conducted with Ovid MEDLINE® and PubMed utilizing the following search terms coupled with *pregnant* and *pregnancy: trauma, blunt trauma, penetrating trauma, motor vehicle collision, orthopedic injury, fracture, perimortem cesarean section, trauma management, radiation, imaging, ultrasound, abruption, fetal monitoring, Kleihauer-Betke, Rh immunization, amniotic fluid embolism, uterine rupture,* and *carbon monoxide.* The resulting 12,000 articles were limited to those published in the last 20 years, and they were evaluated for relevance and applicability. The remaining 162 articles were evaluated using standard evidence-level scales to determine their weight with regard to current practice. Bibliographies of relevant articles were then used to uncover further articles pertinent to the topic. The Cochrane Database of Systematic Reviews was searched using the terms *pregnancy* and *trauma*; the only relevant review concerned effective treatments for placental abruption. The Cochrane review authors concluded that there were no available data from which to draw any guidelines.[1]

In assessing the body of literature as a whole, it is apparent that this is an area of emergency medicine that lacks definitive evidence and well-designed studies. Pregnant patients are often excluded from major protocols, and they represent a smaller subset of trauma patients that is frequently excluded from outcomes research. Consequently, the literature is rife with case studies and reports of small series of patients, but it is relatively scant on large prospective studies with regard to outcomes or specific interventions. A large body of case reports detail rare conditions that are difficult to effectively study. As a result, much of the evidence that exists must be interpreted in the light of expert opinion, considering the potential hazards while keeping in mind that such complications are relatively rare but cannot be missed.

Several sets of guidelines exist in the current literature; however, even these are primarily grounded in expert consensus and class III evidence, rather than well-designed studies. The American College of Obstetrics and Gynecology (ACOG) has published guidelines regarding the care of obstetric trauma patients that were last updated in 1998[2] (replacing Number 151, January 1991 and Number 161, November 1991). ACOG issued separate guidelines for administration of anti-Rh antibodies that specifically addressed trauma patients (last updated in 1999)[3] and guidelines regarding appropriate diagnostic imaging (last updated in 2004).[4] In September 2004, the American College of Emergency Physicians (ACEP)

released guidelines on administration of Rh immune globulin to trauma patients in their first trimester as part of their first-trimester vaginal bleeding review,[5] which mirrors ACOG guidelines. The Eastern Association for the Surgery of Trauma (EAST) has published guidelines regarding the surgical approach to trauma patients as recently as 2010.[6] Likewise, Advanced Trauma Life Support® (ATLS®) general guidelines also exist for the surgical management of obstetric trauma. All of these guidelines were reviewed for this issue. To the authors' knowledge, there is no current set of guidelines endorsed by any emergency medicine association that specifically addresses the resuscitation and care of the obstetric patient in the emergency department (ED).

Epidemiology And Outcomes

While modern medicine has made great strides in reducing maternal peripartum morbidity and mortality, humans routinely take great risks in their daily lives. The biggest risk for maternal death during pregnancy continues to be trauma, with motor vehicle accidents accounting for nearly half of all obstetric traumas in the United States, followed by falls and assaults.[7] Major trauma is estimated to complicate between 3% and 8% of pregnancies in the United States.[8-10] One retrospective analysis of 16,092 pregnant patients hospitalized in 2007 reported that 38% resulted in a delivery.[11] In a retrospective study in California of 10,316 deliveries due to a traumatic mechanism, the overwhelming majority were admitted with blunt trauma.[7] Another retrospective analysis in Baltimore, MD revealed that, of the 3976 patients arriving for Level I trauma during a 4-year period, around 3% were pregnant, and 8% of those pregnant traumas were newly diagnosed.[12] Trauma to pregnant patients is not rare, and while overwhelming complications may seldom be seen, most emergency clinicians will eventually encounter a pregnant patient with trauma who requires lifesaving interventions.

In 1990, one of the few prospective analyses of outcomes after trauma definitively showed that serious complications (such as abruption or premature delivery) occurred in a significant number of patients with only mild or moderate injuries.[13] This was further substantiated by a retrospective review of pregnant trauma patients in the state of Washington that showed that injury severity scores were poor predictors of adverse outcomes and that even minor injuries could result in fetal demise.[14] Other efforts to determine predictors of adverse fetal outcomes have produced variable findings, but few have found any predictors that can be reliably utilized to make determinations without a minimum of 6 hours of maternal and fetal monitoring.[15] Trauma during pregnancy has negative effects on both maternal and newborn morbidity, but the most disturbing trend is that while severe injuries on presentation predict poor outcomes for mother and neonate,[16-18] even minor trauma to the mother can result in seriously adverse perinatal outcomes. A pregnant trauma victim should raise heightened suspicion of occult injury and requires longer monitoring.

Pathophysiology

Pregnancy is typically divided into 3 trimesters. Weeks 1 through 13 mark the first trimester; weeks 14 through 26 comprise the second trimester; and weeks 27 through 40+ comprise the third trimester. During the course of pregnancy, a woman's physiology changes dramatically. The major changes are summarized in **Table 1.**

Table 1. Overview Of The Physiological Changes Of Pregnancy

Physiology	Clinical Significance
Cardiovascular	
• Diminished arterial blood pressure during second trimester • Increased cardiac output • Increased circulating volume • Supine hypotensive syndrome	• Relatively higher blood losses may be difficult to detect • Patients should be transported in left lateral decubitus position
Hematologic	
• Relative anemia (second and third trimester) • Leukocytosis • Diminished platelets • Elevated fibrinogen, normal coagulation	• Relative anemia and higher plasma volume may make blood losses difficult to detect
Pulmonary	
• Elevated diaphragm • Increased minute ventilation and tidal volume • Partially compensated respiratory alkalosis (pCO_2 30-40) • Diminished functional residual capacity	• Higher chest tubes • More difficult intubations
Gastrointestinal	
• Increased uterine volume • Displacement of abdominal contents • Relatively insensitive abdominal wall • Delayed gastric emptying • Diminished gastroesophageal sphincter tone	• Viable fetus roughly correlates with fundus at the umbilicus • Low sensitivity of abdominal physical examination • More difficult intubations
Musculoskeletal	
• Increased ligamentous laxity • Lower center of gravity • Greater back strain	• Higher rate of orthopedic injuries

Abbreviation: pCO_2, partial pressure of carbon dioxide.

Cardiovascular

Overall cardiac output increases during pregnancy. Resting heart rate increases approximately 10 to 15 beats per minute to accommodate a higher circulatory demand, while resting arterial blood pressure typically declines during the second trimester and slowly recovers to baseline near term. Any evidence of relative hypertension suggests the possibility of eclampsia. Venous pressure below the diaphragm tends to increase as the uterus enlarges, and later in pregnancy, the gravid uterus can cause mechanical obstruction to venous return when the patient is in the supine position, a condition known as the "supine hypotensive syndrome." Because some women with this syndrome are prone to dramatic decreases in cardiac output, pregnant patients should be transported in the left lateral decubitus position whenever possible, or with pillows propping a spine board toward the left to minimize supine hypotension.

Hematologic

Pregnancy induces increases in total plasma volume and erythrocyte production that progress over the course of the pregnancy; however, in the third trimester, erythrocyte production falls behind plasma production, commonly resulting in a relative anemia. Leukocyte counts can be slightly elevated (although these are postulated to be somewhat ineffective due to hormonal alterations); thus, pregnant women are thought to be more prone to infectious disease despite a slight leukocytosis. Platelets can decrease slightly as the patient nears full term, and fibrinogen levels are measurably higher, although clotting times remain normal. The relative increase in plasma volume means that a significant volume of blood can be lost in a pregnant patient prior to hemodynamic collapse, and pregnant patients with abnormal vital signs are typically more hypovolemic than their vital signs would suggest.

Pulmonary

During pregnancy, the increasing abdominal volume of the uterus causes a relative displacement of the diaphragm cephalad, often resulting in a dyspnea of pregnancy that causes a partially compensated respiratory alkalosis and tachypnea with increased minute ventilation and tidal volumes. Thus, partial pressure of carbon dioxide (pCO_2) values in the pregnant patient typically run in the range of 30 to 40, and functional residual capacity is diminished, resulting in an overall diminished respiratory reserve that can also worsen in the supine position. Consequently, normal respiratory values should alert the emergency clinician to respiratory compromise. The diminished respiratory reserve combined with underlying hypoventilation means that pregnancy makes for more difficult airways. The elevation of the diaphragm means that patients require higher chest tube placement to avoid entrance of the chest tube into the abdominal cavity. Typically, this requires that chest tubes be placed 1 to 2 intercostal spaces higher, in the third or fourth intercostal area.

Gastrointestinal

The enlarging uterus results in displacement of the majority of the gastrointestinal tract further superior in the abdomen, resulting in a higher incidence of bowel injuries with relatively superior abdominal trauma. Prior to the second trimester, the uterus is relatively low in the pelvis, resulting in a low rate of intrauterine injury. Late in pregnancy, the displacement of abdominal contents by the uterus as well as stretching of both the abdominal musculature and peritoneum makes the abdominal examination unreliable for diagnosis of intra-abdominal injury. Consequently, a benign abdominal examination does not rule out abdominal injury. Both mechanical and hormonal alterations result in a relaxed gastroesophageal sphincter with subsequent reflux and delayed gastric emptying, again setting up for a potential airway disaster should intubation be required.

Musculoskeletal

Hormonal alterations during pregnancy result in gradual laxity of the ligaments, which can lead to orthopedic injuries, particularly in the pelvis. Furthermore, the gravid uterus results in a lower center of gravity and exaggeration of kyphosis and lordosis, which can predispose the patient to back injuries.

Differential Diagnosis

While the majority of minor trauma in pregnant patients appears straightforward, even minor injuries can result in severe morbidity to the fetus. Consequently, the emergency clinician should be cognizant of several potential life threats to both mother and fetus, including placental abruption, which has been shown to occur in even relatively minor trauma.[19-21] **(See Table 2.)** Sheer forces to an elastic uterus with the relatively inelastic placenta sensitizes the mother to blunt force trauma (eg, placental abruption).[22] Uterine rupture is a less common but a much more significant life threat to the mother that can occur when the uterine wall is torn, resulting in intraperitoneal hemorrhage and placental abruption.[23,24]

Table 2. Life-Threatening Diagnoses In Pregnant Trauma Patients

- Placental abruption
- Premature labor
- Uterine rupture
- Amniotic fluid embolism
- Maternal-fetal hemorrhage and alloimmunization

Premature rupture of membranes and subsequent premature labor can result in significant morbidity for the fetus and can lead to potential infection.

Amniotic fluid embolism occurs in < 1% of all normal deliveries, but it has a fatality rate approaching 30%.[25] Amniotic fluid embolus may present similarly to a pulmonary embolus, with extreme cardiovascular collapse and hypoxia, and it necessitates immediate resuscitation. Additionally, exposure to fetal blood during trauma can result in Rh alloimmunization in Rh-negative mothers. While this is not an immediate life threat to the mother, it is essential to treat it in order to avoid significant problems with future pregnancies.

Prehospital Care

Transport of the pregnant patient follows the standard prehospital trauma guidelines for rapid assessment and transportation to the nearest appropriate facility, with a few notable exceptions. Whenever possible, early estimation of gestational age is useful to obtain from family members or the patient herself. This is essential to initial assessment, and later decompensation due to injury may make a reliable history difficult to ascertain. Due to maternal supine hypotension syndrome, it is imperative that any patient who is being transported later in her pregnancy be placed in the left lateral decubitus position or, if placed in spine precautions, that a pillow be placed under the right side of the spine board to improve venous return. When this is not possible, manual displacement of the uterus to the left may be necessary. Whenever possible, transportation should be to a center that is able to provide obstetrical care, as long-term monitoring is usually required for these patients. Nonetheless, remembering that the best possible outcome for the fetus is to take care of the mother, any immediately life-threatening injuries that may necessitate a perimortem cesarean section should be addressed at the nearest possible facility. Given the fragile state of the fetus and its susceptibility to relative hypotension and hypoxia, the mother should be placed on supplemental oxygen and intravenous (IV) crystalloid should be administered for any signs of hypotension.[26] In the event that cardiopulmonary resuscitation (CPR) is initiated, the patient should be kept with a wedge under the spine board to improve venous return; while this may result in less-effective compression force, it is thought to be adequate. Likewise, if defibrillation is indicated, normal adult doses are likely to be effective.[27]

Emergency Department Evaluation

Upon arrival at the hospital, pregnant trauma patients should be evaluated in the ED first, prior to transport to labor and delivery, in order to assess for life-threatening injuries that would be better addressed by the emergency and trauma teams. Ideally, any advance notification of an obstetric trauma patient with potential injuries should prompt notification of both the trauma surgeon and obstetrician in order to provide coordinated care. In the absence of any major trauma or pain, it may be appropriate to send the patient to labor and delivery after a primary and secondary survey is performed. The initial assessment focuses primarily on the mother.

History

History taking should include a brief pregnancy history. The emergency clinician should be aware that any female trauma patient of childbearing age may be pregnant. Therefore, every female trauma patient should be asked about pregnancy, and a pregnancy test obtained as soon as possible. Most bedside urine pregnancy tests will work equally well with a whole blood sample, which may expedite results in a patient who cannot urinate or does not require urinary catheterization.[28] In a patient who knows she is pregnant, gestational age is useful in determining the viability of the fetus. While 24 weeks is generally considered the cusp of viability at most institutions in the United States, in the absence of definitive knowledge of the gestational age, it is reasonable to lower the bar to 20 weeks in the case of a moribund patient who might require a perimortem cesarean section. Any complaint of abdominal pain or vaginal bleeding should prompt an immediate obstetrical consultation for possible intra-abdominal catastrophe.

Primary Survey

ATLS® protocols hold true for the primary survey, as the underlying assumption remains that the best situation for the fetus is a stable mother; hence, the primary survey in the pregnant patient focuses on the mother. Airway and breathing should be immediately addressed, as the fetus is particularly susceptible to hypoxia, and either oxygen administration or advanced airway management should proceed, if indicated. Keeping in mind the physiologic changes in pregnancy, airway management in the pregnant patient includes a greater risk of aspiration, increased airway edema, diminished functional capacity (and thus quicker desaturations during apnea), and diminished cardiovascular tone. None of these factors should delay or hinder airway management, but they should heighten awareness of the potential for a difficult airway. Medications used in rapid sequence intubation (such as succinylcholine) cross the placenta.[29] The effects of succinylcholine on the fetus have not been associated with adverse events in the setting of maternal intubation in the anesthesia literature.

Crystalloid is effective in improving neonatal oxygenation if there is evidence of maternal hypo-

tension,[26] but if hypotension is suspected to be due to hemorrhage, O-negative blood is the resuscitation fluid of choice. Little definitive research exists in regard to vasopressor choice in the hypotensive pregnant patient, but any thought of vasopressors in a pregnant trauma patient should first prompt consideration of hemorrhage and then an evaluation for any other underlying cause of hypotension to guide vasopressor choice.

Secondary Survey

As the secondary survey proceeds to assess all potential maternal injuries, attention should also be paid to the second other patient in the trauma, the fetus. Gestational age can be estimated by fundal height with the patient in the supine position. A fundus at the height of the umbilicus is equivalent to approximately 20 weeks' gestation. **(See Figure 1.)** Given the potential for several weeks' error with this method and the possibility of a viable fetus at around 24 weeks, any pregnant woman with a fundus at the umbilicus should be considered to be carrying a viable fetus. In third-trimester pregnancies, vaginal speculum examination is generally avoided due to risk of infection and bleeding, but if there is vaginal bleeding, it may be necessary to determine the source. As soon as possible, fetal cardiotocographic monitoring should be initiated to determine the well-being of the fetus. In the absence of immediate fetal cardiotocographic monitoring, fetal heart rate via Doppler or bedside ultrasound is recommended to assure that the fetus is viable, with normal heart rates being between 120 and 160 beats per minute.

Diagnostic Studies

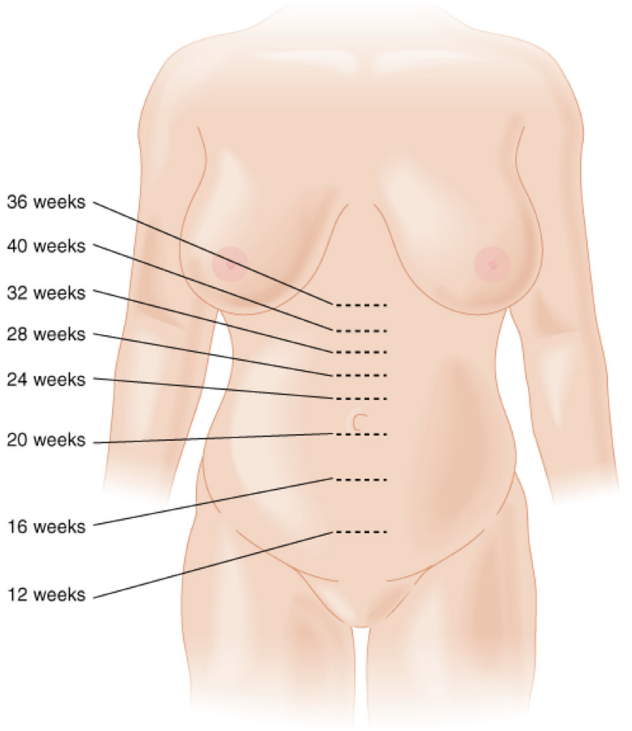
Laboratory Abnormalities

Physiologic anemia of pregnancy results in decreased maternal hemoglobin during later phases of pregnancy, due in part to an increased circulating plasma volume. Because white blood cells can be mildly elevated due to pregnancy and are frequently elevated in the setting of trauma, the test is an unreliable indicator of infection. Circulating clotting factors may be increased throughout pregnancy, rendering the qualitative D-dimer a useless screening tool for pulmonary embolus in pregnancy.

Kleihauer-Betke Testing

Detection of fetal-maternal hemorrhage is imperative to prevent maternal alloimmunization in Rh-negative mothers. A type and screen should be sent immediately upon the patient's arrival to determine maternal Rh status. Rh-negative patients should be considered for anti-Rho antibodies (Rho(D) immune globulin) if there is concern for bleeding or abruption. ACOG guidelines suggest that while there is no compelling evidence regarding who should receive anti-Rho antibodies, all Rh-negative women in their second or third trimester who experience abdominal trauma should be given a standard dose of Rho(D) immune globulin, usually 300 mcg.[3] It is suggested that further screening be undertaken to evaluate for massive fetal-maternal hemorrhage, as a standard dose of Rho(D) immune globulin is capable of protecting only up to 30 mL of fetal blood exposure. Measurement of fetal blood exposure is accomplished via quantitative analysis on a maternal blood sample via the Kleihauer-Betke (KB) acid elution test, which detects fetal red blood cells in maternal blood. It can be used to quantify the estimated volume of fetal-maternal hemorrhage and guide further Rho(D) immune globulin administration. Positive KB testing is associated with higher rates of preterm labor, even in Rh-positive mothers,[30] and studies show that larger hemorrhages may occur more often than previously thought.[31] However, Rho(D) immune globulin is effective in preventing alloimmunization within the first 72 hours, which means that this is largely not a problem with which the emergency clinician needs to be concerned. The ACEP clinical policy on first-trimester bleeding includes a C-level recommendation that first-trimester

Figure 1. Fundal Height And Estimated Gestational Age



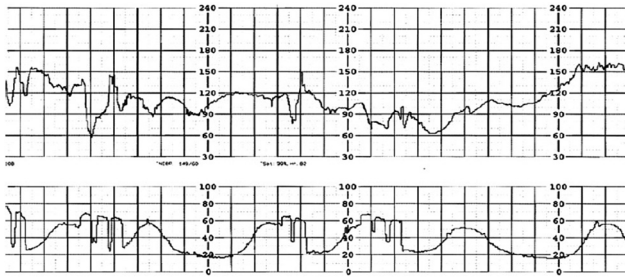
Tintinalli J, Stapcyznski JS, Ma OJ, Cline DM, Cyduka RK, Meckler GD. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 7th Edition*, http://www.accessmedicine.com. Copyright © The McGraw-Hill Companies, Inc. Used with permission.

trauma victims who are Rh-negative receive a dose of Rho(D) immune globulin to prevent alloimmunization.[5] Therefore, any significant abdominal trauma in an Rh-negative woman should prompt both immediate administration of Rho(D) immune globulin as well as KB testing to be followed up by the obstetric team.

Fetal Cardiac Monitoring

Electronic fetal monitoring, also known as cardiotocography, is widely used during routine labor and delivery in the United States as well as during any time the pregnant patient and her fetus require close monitoring. While still the subject of much debate regarding its utility and consequences in normal labor and delivery, electronic fetal monitoring is the best indicator of fetal distress, and it is typically the only measurement available for a trauma patient. Fetal distress following trauma can be an early indicator of placental abruption, potentially allowing for earlier intervention. Signs of fetal distress include fetal bradycardia (fetal heart rate < 120 beats/min), fetal tachycardia (fetal heart rate > 160 beats/min), absent heart rate variability, or late or prolonged decelerations.[32] (**See Figures 2-4** for examples.) Any evidence of fetal distress should prompt immediate notification of the obstetric team, as delivery may be indicated and should be performed in a more controlled environment, if possible. Monitoring of contractions is also useful (as the absence of contractions is generally a reassuring indicator), and studies point towards the absence of contractions and reassuring fetal cardiac activity after 4 to 6 hours as being appropriate indicators for release to home.[15] At most institutions, fetal cardiac monitoring should be deferred to the inpatient obstetrical team, where such long-term monitoring is likely to occur.

Figure 2. Fetal Heart Rate Tracing Demonstrating Prolonged Deceleration



Fetal heart rate is on the top; contractions are on the bottom. Time is on the x-axis. In the latter portion of the tracing, the fetal heart rate drops below 100 beats/min and stays there for a prolonged period of time following a contraction. Prolonged decelerations can indicate fetal distress.

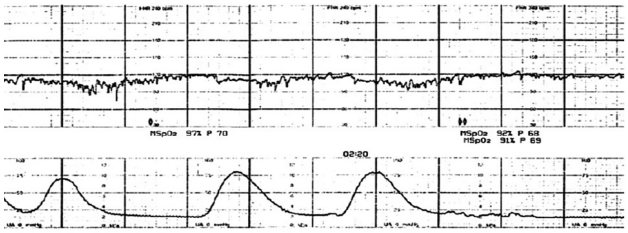
Figures 2, 3, and 4 are reprinted from *Clinics in Perinatology*, Vol. 38, issue 1, Molly J. Stout and Alison G. Cahill, "Electronic Fetal Monitoring: Past, Present, and Future," pages 127-142, Copyright 2011, with permission from Elsevier.

Imaging

Ultrasound

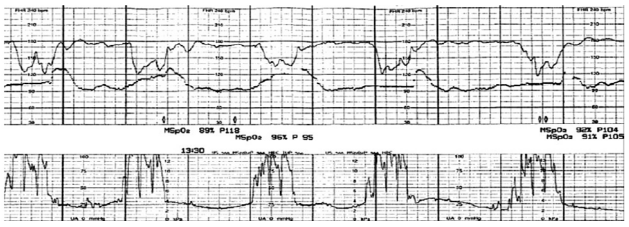
Ultrasound is the preferred imaging modality in pregnant women as it avoids the risk of radiation to the fetus and is readily and rapidly available in most settings. The focused assessment with sonography for trauma (FAST) examination is commonly used in both pregnant and nonpregnant trauma patients. A large retrospective review of the FAST examination to detect free fluid in pregnant trauma patients found a reasonable specificity and accuracy (> 90%) but, not surprisingly, a rather low sensitivity (61%), demonstrating that the FAST examination remains a reasonable screening tool for intraperitoneal hemorrhage but that it does not rule out intra-abdominal pathology.[33] **(See Figures 5-7, page 8.)** The same study showed that the FAST examination was more sensitive in nonpregnant women than in pregnant women,[33] although a smaller retrospective study showed similar sensitivities in pregnant and

Figure 3. Fetal Heart Rate Tracing Demonstrating Late Decelerations



Fetal heart rate is on the top; contractions are on the bottom. Time is on the x-axis. With the first and third contractions, the fetal heart rate drops toward the end of the contraction. Late decelerations can indicate fetal hypoxia.

Figure 4. Fetal Heart Rate Tracing Demonstrating Variable Decelerations

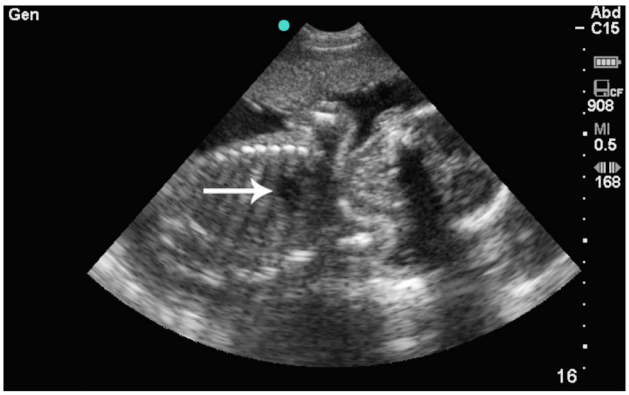


Fetal heart rate is on the top; contractions are on the bottom. Time is on the x-axis. Maternal heart rate is in the middle. Decelerations occur at varying times in relation to the contractions. Variable decelerations can indicate cord compression. In this tracing, the mother appears to be pushing, as evidenced by the multiple peaks within each contraction.

nonpregnant women.[34] Among pregnant women, the sensitivity of ultrasound for detecting traumatic injury is highest during the first trimester. Some experts believe that, in the stable pregnant trauma patient, computed tomography (CT) scanning is indicated only if the FAST examination is positive,[35] but this remains controversial. A recent retrospective review study including 176 pregnant trauma patients found that CT can accurately diagnose placental abruption, potentially suggesting another indication for CT even in the presence of a negative FAST examination.[36] Another benefit of sonography during initial resuscitation is the potential to identify pregnancy in a patient who is either unaware she is pregnant or unable to communicate her pregnancy. Bedside ultrasound is also useful during the initial evaluation to obtain fetal cardiac activity if it cannot be done via Doppler; however, it must be stressed that due to the relatively limited sensitivity of ultrasound, pregnant trauma patients require at least 4 to 6 hours of observation with fetal monitoring, even in the presence of a negative FAST examination. While there is a paucity of data specifically citing outcomes among patients with a negative FAST examination, this is considered best practice at this time.

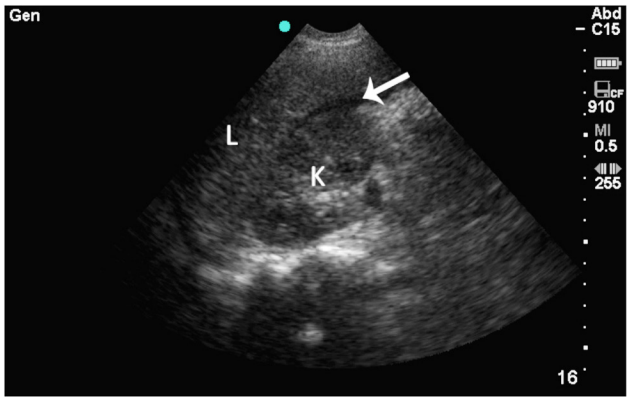
The decision to expose a pregnant patient to radiation must carefully balance the risks and benefits to the mother and the fetus. There are multiple factors involved in determining the impact of fetal radiation exposure, including age of gestation, type of imaging, and body site of exposure. Unfortunately, little prospective data exist on these risks, as most studies in this area are based on extrapolated studies of nuclear bomb survivors. The risk of teratogenesis is dose-dependent, and it is considered to be most harmful during weeks 8 to 15 of pregnancy, when organogenesis occurs. During the period of organogenesis in a fetus, radiation doses > 100 to 200 mGy have been associated with fetal malformations, including microcephaly and other central nervous system deficits as well as intrauterine growth restriction.[37] Consensus statements from both the American College of Radiology[37] and ACOG's 2004 guideline agree that the risk of adverse fetal outcomes—including fetal malformations and malignancy—is negligible in fetal radiation doses < 50 mGy (5 rad) when compared with the risk of background radiation.[37] Most routine imaging studies expose the fetus to < 50 mGy; however, trauma patients often require multiple imaging studies that could increase the dose and exceed

Figure 5. Third-Trimester Pregnancy Ultrasound



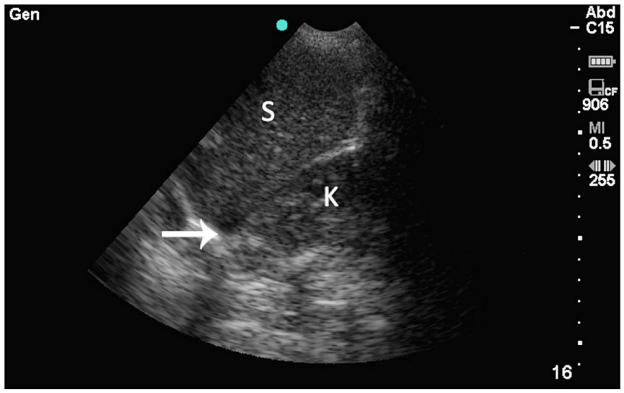
Arrow notes the location of the fetal heart, which can be used in M-mode to determine fetal heart rate during the FAST assessment.
Image used courtesy of Rob Ferre, MD.

Figure 6. Positive FAST Examination In Right Upper Quadrant



Arrow points to the thin rim of hypoechoic (dark) fluid in the space between the liver (L) and kidney (K). Such a stripe is indicative of free peritoneal fluid, likely hemorrhage.
Image used courtesy of Rob Ferre, MD.

Figure 7. Positive FAST Examination In Left Upper Quadrant



Arrow points to a thin triangle of fluid just below the superior pole of the spleen (S) next to the left kidney (K), indicating fluid in the perisplenic space, likely hemorrhage.
Image used courtesy of Rob Ferre, MD.

the 50 mGy cutoff. **(See Tables 3 and 4** for samples of radiation doses from common examinations.) The emergency clinician should proceed with standard trauma management utilizing the principle of "as low as reasonably achievable" (ALARA) radiation exposure, without compromising patient care. At no point should a diagnostic study that might significantly impact the welfare of the mother be delayed due to fear of fetal radiation exposure, as there is marked risk to the fetus if the mother has life-threatening injuries that go unrecognized without imaging. In a retrospective study by Richards et al, 328 pregnant trauma patients were identified, 23 of whom had intra-abdominal injury. Of those, 9 had false-negative ultrasounds when compared to the gold standard of CT and/or operative intervention.[33] Therefore, the consensus is that radiological evaluation should proceed for blunt and penetrating trauma as with other major trauma, with an emphasis on ordering only pertinent studies.

The carcinogenic effect of radiation on a fetus is less clearly delineated than that of teratogenesis. Some studies have demonstrated a correlation between in utero radiation exposure and childhood malignancies. Studies suggest that this risk of carcinogenesis may be greater when exposure occurs during the first trimester as opposed to later in pregnancy. One helpful statistic to use in conversations with patients about this risk is that radiation doses > 100 mGy may result in an increased risk of 1% for the combination of teratogenic effects and later development of childhood cancer.[37]

Iodinated contrast agents are known to cross the placenta and pose theoretical risk to the fetal thyroid, but no known case reports exist of adverse outcomes from the use of CT contrast agents in pregnancy; thus, recommendations are that they be used with caution.[37] Risks and benefits of imaging must be weighed individually in each case of a pregnant trauma patient.

Magnetic Resonance Imaging

The use of magnetic resonance imaging (MRI) in pregnant patients is highly recommended due to the lack of any known risk to the fetus in utero;[4,37] however, gadolinium and related contrast agents have theoretical teratogenic and abortive effects that contraindicate their routine use. While MRI would provide a reasonable way to safely image pregnant blunt trauma patients, its limited availability at most centers combined with its relatively long sequence time to obtain images limits its usefulness as an imaging modality in seriously ill pregnant patients. In the nonacute patient, however, MRI is an excellent imaging modality for evaluation of both intra-abdominal and intrathoracic complaints, as well as musculoskeletal injuries, when it is available.

Table 3. Estimated Conceptus Doses From Radiographic And Fluoroscopic Examinations

Examination	Typical Conceptus Dose (mGy)
Cervical spine (AP, lateral)	< 0.001
Extremities	< 0.001
Chest (PA, lateral)	0.002
Thoracic spine (AP, lateral)	0.003
Abdomen (AP)	
• 21-cm patient thickness	1
• 33-cm patient thickness	3
Lumbar spine (AP, lateral)	1
Limited intravenous pyelogram*	6
Small-bowel study†	7
Double-contrast barium enema study‡	7

Abbreviations: AP, anteroposterior projection; mGy, milligray; PA, posteroanterior projection.

*Limited intravenous pyelogram is assumed to include 4 abdominopelvic images. A patient thickness of 21 cm is assumed.

†A small-bowel study is assumed to include a 6-min fluoroscopic examination with the acquisition of 20 digital spot images.

‡A double-contrast barium enema study is assumed to include a 4-min fluoroscopic examination with the acquisition of 12 digital spot images.

Table 4. Estimated Conceptus Doses From Single Computed Tomographic Acquisition

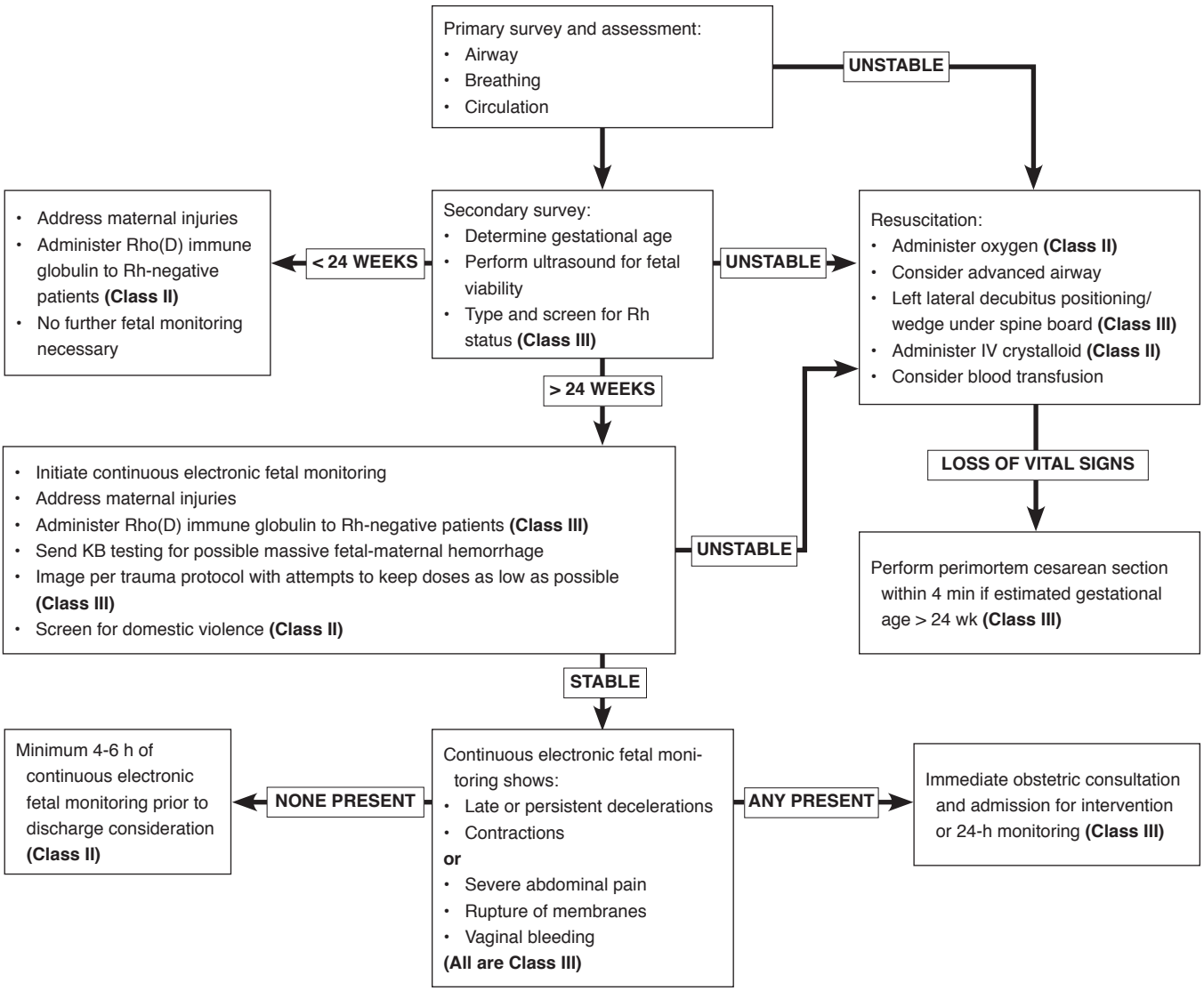
Examination	Dose Level	Typical Conceptus Dose (mGy)
Extraabdominal		
• Head CT	Standard	0
• Chest CT	Standard	0
◦ Routine	Standard	0.2
◦ Pulmonary embolus	Standard	0.2
CT angiography of coronary arteries	Standard	0.1
Abdominal		
• Abdomen, routine	Standard	4
• Abdomen/pelvis, routine	Standard	25
CT angiography of aorta (chest through pelvis)	Standard	34
Abdomen/pelvis, stone protocol*	Reduced	10

Abbreviations: CT, computed tomography; mGy, milligray.

*Anatomic coverage is the same as for routine abdominopelvic CT, but the tube current is decreased and the pitch is increased because standard image quality is not necessary for detection of high-contrast stones.

Tables 3 and 4 are reprinted from McCullough CH, Scheuler BA, Atwell TD, et al. Radiation exposure and pregnancy: when should we be concerned? *RadioGraphics.* 2007;27-909-917. Used with permission of Radiological Society of North America.

Clinical Pathway For Management Of Pregnant Trauma Patients



Abbreviations: IV, intravenous; KB, Kleihauer-Betke testing.

Class Of Evidence Definitions

Each action in the clinical pathways section of *Emergency Medicine Practice* receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

Significantly modified from: The Emergency Cardiovascular Care Committees of the American Heart Association and representatives from the resuscitation councils of ILCOR: How to Develop Evidence-Based Guidelines for Emergency Cardiac Care: Quality of Evidence and Classes of Recommendations; also: Anonymous. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Part IX. Ensuring effectiveness of community-wide emergency cardiac care. *JAMA.* 1992;268(16):2289-2295.

Treatment

The Clinical Pathway provides an initial algorithm for the management of trauma in the pregnant patient in the ED. Primary and secondary surveys should be performed to stabilize the mother and assess the fetus, with unstable maternal physiology addressed immediately to preserve the life of both the mother and the fetus. Basic measures to optimize maternal oxygen delivery, correct positioning with the uterus displaced to the left, and maintain maternal blood pressure should be undertaken to assure optimum fetal resuscitation. Cardiotocographic monitoring should be initiated as soon as possible to find evidence of either premature labor or fetal distress. Prompt obstetric consultation is recommended for evidence of either complication. If evidence of premature labor presents, discussion with obstetrics should include the indications for administering steroids for fetal lung immaturity (betamethasone 12 mg intramuscular [IM] or dexamethasone 6 mg IM) and tocolytics. All Rh-negative mothers should be administered a single dose of Rho(D) immune globulin, and KB testing should be performed to look for evidence of large fetal-maternal hemorrhage. Any patient beyond 24 weeks' gestation (ie, with a viable fetus) should be monitored for a minimum of 4 to 6 hours with cardiotocographic monitoring prior to consideration for discharge, even if there is no obvious injury.

Special Circumstances

Carbon Monoxide And Cyanide Poisoning

Smoke inhalation can be harmful to the fetus, particularly when it occurs in combination with trauma. Carbon monoxide binds to hemoglobin and myoglobin, inhibiting the transport of oxygen. It passes through the placenta, and carbon monoxide levels in the circulation can ultimately be 15% higher in the fetus than in the mother.[38] The initial treatment of suspected carbon monoxide poisoning is 100% oxygen, which decreases the half-life of carboxyhemoglobin from approximately 5 hours to 1 hour. Hyperbaric oxygen therapy should also be a strong consideration, when it is available. While some experts consider pregnancy to be an indication for hyperbaric treatment in carbon monoxide poisoning, no robust guidelines exist in equivocal cases. ACEP's clinical policy on carbon monoxide poisoning has no specific recommendations regarding treatment in pregnant women, as no randomized controlled trials exist.[39] Although strong evidence does not exist, the authors recommend discussion with hyperbaric specialists, as potentially strong (albeit unproven) benefits may exist for pregnant women. A 1991 randomized controlled trial that followed obstetric and fetal outcomes of 44 pregnant women treated for acute carbon monoxide exposure concluded that hyperbaric oxygen is safe in pregnant women,[40] although definitive benefit in trauma patients has not been established, and hyperbaric treatment may be contraindicated due to the need for other treatments that may not be feasible in a hyperbaric chamber.

Hydroxocobalamin is approved by the United States Food and Drug Administration for use in pregnant women when cyanide exposure is suspected. The initial dose in adults is 5 g administered intravenously over a 15-minute period. A second dose of 5 g may subsequently be administered.[38] An important difference between this treatment and the previously used cyanide antidote kit is that the latter forms methemoglobin, which is potentially toxic to a fetus. Hydroxocobalamin does cross the placenta, so it, theoretically, directly treats the fetus as well as the mother.

Based on the best available evidence, pregnant trauma patients suspected of having significant inhalational injury should be provided 100% oxygen via a nonrebreather face mask and should be administered hydroxocobalamin. Following the initiation of these interventions, other treatments may be considered, including hyperbaric oxygen therapy or even delivery of the fetus.

Isolated Orthopedic Injuries

Several small studies of orthopedic injuries in pregnancy suggest that these patients (both with major and minor orthopedic injuries) have significantly higher rates of adverse obstetrical outcomes, including placental abruption, preterm birth, and low birth weight[41] as well as delayed complications including cesarean delivery, fetal death, and neonatal death.[42] It is suggested that patients with even minor orthopedic injuries who are pregnant with a viable fetus should be considered for transfer to a tertiary care center following stabilization, given the increased risk of adverse outcomes.[42] Major injuries are of even greater concern, with pelvic fractures (given the proximity to the uterus) having the highest risk of adverse obstetrical outcome among orthopedic injuries.[41] In 1 observational study, fetal demise occurred in approximately 30% of pregnant women with pelvic fractures.[42]

Unfortunately, even minor orthopedic injuries that do not require operative repair are correlated with an increase in adverse pregnancy outcomes. A suggested explanation for this correlation is that even single-extremity fractures are often due to high-energy mechanisms (such as motor vehicle collisions) that bode poorly for fetal outcomes.[42] Thus, it is not the injury itself but the mechanism of injury with the resultant possibility of other severe injuries to fetus or mother that should prompt consideration of transfer to a tertiary care center. Furthermore, pregnant women with orthopedic injuries who do

not have immediate complications while hospitalized continue to have increased obstetrical morbidity after hospital discharge. A subsection of 1 retrospective cohort study involving 2191 patients noted that the hypercoagulability of pregnancy may contribute to a 9-fold increase in thrombotic events among pregnant patients with orthopedic injuries.[41] No injury is too small to prompt observation and follow-up with an obstetrician.

Domestic Violence

Domestic violence results in more deaths each year than any given medical complication of pregnancy. Annually, up to 335,000 pregnant patients in the United States are affected by domestic violence.[21] One in 6 pregnant adult women and 1 in 5 pregnant teenage women are abused, either physically or sexually, during pregnancy.[43] Assault rates are higher in young women aged < 20 years, African American women, and multiparous women with > 3 pregnancies. Perinatal complications occur at significantly higher rates among pregnant women who are victims of assault, including preterm labor, uterine rupture, premature rupture of membranes, placental abruption,[44] maternal death, and fetal demise.[21] These outcomes have also been found to be intricately intertwined with the same socioeconomic factors that predispose to domestic violence. Abused women have double the rate of delayed entry into prenatal care.[43,45] Thus, an ED visit may be a pregnant woman's first healthcare visit during her pregnancy, so it is worthwhile for all clinically stable pregnant women to undergo screening in the ED for domestic violence. It is imperative that this occur in a private setting, alone with the female, without her partner present.[45]

Trauma Prevention (Seat Belts And Airbags)

While approximately 90,000 pregnant women are injured in motor vehicle collisions each year in the United States, the majority of women in 1 study denied being counseled about seat belt use during their prenatal visits.[46] Women who are ≥ 30 years of age or those who have more than a high school education have the highest rate of self-reported seat belt use.[46] Appropriate maternal use of seat belt restraint has a significantly positive impact on fetal outcomes in low-impact motor vehicle collisions (which comprise the majority of car accidents). Fetal outcomes in high-impact accidents, however, are less dependent on seat belt use. Use of a 3-point-restraint seat belt is safer than a shoulder belt alone,[47] and inappropriate seat belt use has been shown to result in a higher rate of poor obstetric and fetal outcomes. One study noted that half of fetal losses in motor vehicle collisions could be prevented if all pregnant women wore seat belts correctly and consistently.[48] Another retrospective review noted that pregnant women in motor vehicle collisions who were not wearing seat belts were 2.8 times more likely to experience a fetal death than pregnant women in motor vehicle collisions who were appropriately belted.[8]

While seat belt use has strong evidence to support positive impact on outcomes in pregnant patients, case studies raise concern that the force of a deployed airbag may result in fetal injury.[49] Few studies exploring this theory have been published, and there is no clear evidence that airbag use in pregnancy results in higher rates of placental abruption or other fetal risks.[50] In fact, 1 retrospective cohort study that included 3348 pregnant women in motor vehicle collisions found no significant difference in the risk of adverse outcomes in accidents with airbag deployment as compared to those without deployment.[51] At this time, the general practice of practitioners advising pregnant women about preventive care is that seat belts and airbags should be used consistently and correctly in pregnant women, just as in the general population. For a pregnant woman, this means keeping the lap belt low, on the pelvic bones, and placing the shoulder strap between the breasts. **(See Figure 8.)** Emergency clinicians may provide a useful public health benefit by providing seat belt counseling to pregnant trauma patients in order to prevent future injuries.

Amniotic Fluid Embolism

Amniotic fluid embolism is a rare, but recognized, complication of pregnancy that is thought to occur when amniotic fluid enters the mother's circulation. The incidence is thought to be between 1 in

Figure 8. The Correct Way To Wear A Seat Belt When Pregnant

Reprinted with permission from the Saskatchewan Prevention Institute.

Risk Management Pitfalls For Pregnant Trauma Patients

1. **"She told me she wasn't pregnant."**
   Incidental finding of pregnancy occurs, and it can happen to your trauma patient as well. Any female of reproductive age involved in trauma should have a screening pregnancy test sent as part of the initial workup.

2. **"She wasn't complaining of abdominal pain, so I wasn't worried about the pregnancy."**
   Even relatively minor orthopedic injuries have been associated with adverse perinatal outcomes due to occult intrauterine trauma. All pregnant patients beyond 24 weeks—even those with relatively minor trauma—should have electronic fetal monitoring to assess for intrauterine pathology for a minimum of 4 to 6 hours.

3. **"She didn't look like she was that far along, so I wasn't worried about the fetus."**
   Gestational age can be assessed by fundal height, bedside ultrasound, or prior medical records, but it should be assessed and the emergency clinician should err on the side of fetal viability, especially with regard to major resuscitations.

4. **"I wasn't worried about bleeding, so I didn't order Rho(D) immune globulin."**
   Even minor trauma can result in fetal-maternal hemorrhage and complications in subsequent pregnancies in Rh-negative mothers. All pregnant patients with abdominal trauma or significant mechanism of injury should be Rh(D) typed and administered empiric Rho(D) immune globulin if they are Rh-negative.

5. **"She looked fine, so I just discharged her home."**
   The abdominal examination and laboratory tests can be deceptive, even with minor trauma. All pregnant trauma patients should have a minimum of 4 to 6 hours of electronic fetal monitoring and obstetric follow-up prior to discharge from the ED.

6. **"She was worried about radiation risks, so we didn't do the imaging studies I would have normally done."**
   The relative risk of radiation for most routine ED x-rays and CT scans is well below the recommended threshold of radiation exposure during pregnancy and shouldn't inhibit a thorough workup for trauma.

7. **"I wanted to give the mother 1 round of CPR and check for fetal heart activity before doing a perimortem cesarean section."**
   The indication for perimortem cesarean section is loss of vital signs, and in order to have the baby out in less than 5 minutes, no delay should be undertaken before performing this potentially life-saving maneuver.

8. **"I didn't ask about domestic violence."**
   Domestic violence is more common during pregnancy and, frequently, a victim's first contact with a medical provider is in the ED. Simple screening questions, asked in a private setting, can evaluate for further potential injuries.

9. **"I figured she was wearing her seat belt."**
   The number 1 source of mortality for pregnant women is motor vehicle trauma. Education regarding proper lap- and shoulder-belt placement can prevent life-threatening injuries.

10. **"We just laid her down, and she suddenly lost her vital signs."**
    The supine hypotensive syndrome is common in later pregnancy and can result in syncope and dramatically reduced cardiac output. It is easily avoided by keeping the patient in the left-lateral decubitus position or by tilting the spine board 15° to the left.

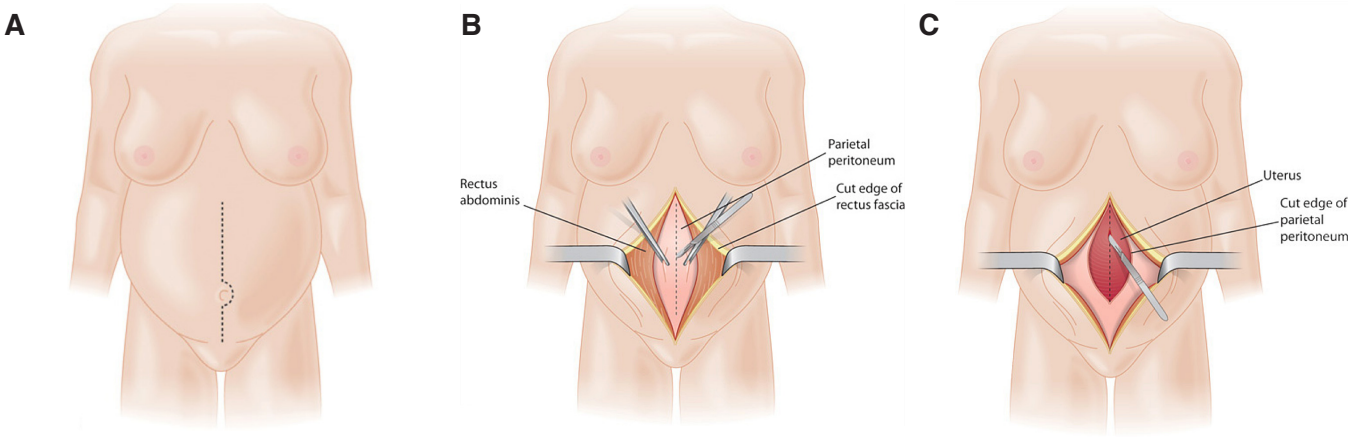
15,000 and 1 in 54,000 pregnancies, and it portends a relatively grave prognosis, with mortality ranging from 30% to 86%.[52] A small number of case studies have identified patients in whom amniotic fluid embolism resulted from traumatic injury, and these have usually occurred in the setting of blunt trauma from motor vehicle collisions. In 1 small series of 3 patients, despite minimal (if any) external evidence of trauma, the patients experienced rapid decline in clinical status following the insult.[52] All 3 patients were identified to be critically ill out of proportion to their external injuries upon emergency medical services arrival to the accident scenes. Two of these patients died within the hour, despite resuscitation, while the other patient initially survived but ultimately succumbed to complications 3 weeks later. [52] Importantly, disseminated intravascular coagulation can result from amniotic fluid embolism, which can worsen traumatic bleeding. While this complication is rare, it should be considered in the differential of any unstable patient. Unfortunately, there is no silver bullet for treating amniotic fluid embolism, and resuscitation efforts should focus on stabilizing maternal hemodynamics and providing adequate oxygenation to the fetus. Innovative treatments for amniotic fluid that show promise include pulmonary vasodilators, including inhaled nitric oxide, sildenafil, and prostacyclin. Consider discussion with a pulmonologist if you feel that these interventions may be indicated.[53]

Perimortem Cesarean Section

Perimortem cesarean section is indicated when the fetus is at (or near) the age of viability and the mother loses vital signs. It is likely increasing in incidence as education regarding the procedure has become widespread.[54] Multiple case reports have shown that the procedure is often unnecessarily delayed, yet outcomes are directly linked to timing of the intervention.[27,54] Because brain damage begins to occur after 4 to 5 minutes of hypoxia, perimortem cesarean section is ideally performed at the 4-minute mark following onset of maternal cardiac arrest so that the baby can be delivered by minute 5. Case studies support the 5-minute standard, which may increase both fetal (and possibly maternal) survival.[55] Viable infants have been delivered up to 25 minutes after the onset of maternal cardiac arrest, so the procedure should generally be attempted even if a period of time longer than 5 minutes has passed.[56]

Once the mother is determined to be moribund, there should be no delay in proceeding with perimortem cesarean. The procedure is shown in **Figure 9**. In practice, it requires little more than a scalpel and shears. The initial incision should be midline, extending from approximately 4 cm inferior to the xiphoid process down to the pubic symphysis. **(See View A.)** The muscles should be dissected through and the peritoneum entered. **(See View B.)** A vertical uterine incision should then be made. **(See View C.)** If an anterior placenta is present, it should be cut through, and the infant should then be delivered. **(See View D.)** The placenta should be removed from the uterus following delivery of the infant. **(See View E.)** It is important to continue maternal CPR throughout the procedure and afterwards to monitor whether the cesarean section (and resultant relief of the physiologic aortocaval obstruction) will allow for return of spontaneous maternal circulation. Closure of the uterus, fascia, peritoneum, and skin should eventually be performed, but this may be delayed until return of circulation occurs. In fact, delaying closure may be preferable in order to allow for view of the uterus, since significant blood loss can occur from the uterus following perimortem cesarean section.

Figure 9. Perimortem Cesarean Section (Continued on page 15)



Controversies And Cutting Edge

The entire management of pregnant trauma patients could be considered controversial due to the lack of hard evidence or large case series regarding treatment and management. MRI has loomed on the horizon for decades, promising advanced imaging potential for trauma patients with minimal risk, but it still lacks widespread availability, and sequence times are too long to make imaging practical in sick patients. The perimortem cesarean section is a de facto standard of care and is taught in most emergency medicine curricula. While it is dreaded, it does no harm to an already moribund mother and has the potential to be life-saving. Fetal tococardiographic monitoring remains somewhat controversial in the obstetric literature during routine labor, but in the acute-care setting, there is no question that monitoring for contractions and fetal distress, while not perfect, is the only monitoring available that can identify occult abruption or other fetal pathology that would prompt delivery or other definitive management in the otherwise stable pregnant patient.

Disposition

Pregnant trauma patients with a potentially viable fetus should be monitored for a minimum of 4 to 6 hours on electronic fetal monitoring to determine any evidence of premature labor or fetal distress. Ideally, a pregnant trauma patient is stabilized in the ED, her life-threatening conditions are addressed, and then she is admitted to the obstetric unit for further monitoring and observation. In cases where the mother is monitored in the ED, monitoring should show no evidence of fetal distress and no evidence of premature labor throughout the period of observation in order to safely discharge.[15] Due to delayed complications from seemingly minor trauma, some groups advocate for longer monitoring periods to avoid any possibility of adverse outcomes.

At discharge, patients should be counseled on reasons to return to the ED, including vaginal bleeding, abdominal pain or contractions, back pain, or loss of sensation of fetal movement. Patients in the first trimester of pregnancy should be counseled that, with normal fetal cardiac activity seen prior to discharge, the relative risk of adverse outcomes is relatively minor for the rest of their pregnancy. Attempts should be made to coordinate follow-up care with the patient's obstetrician for repeat evaluation within 2 weeks to make sure that the pregnancy continues to progress. Injury-prevention education, including proper use of seat belts during pregnancy, should be encouraged.

Summary

The care of a pregnant patient with trauma requires a broad understanding of the underlying maternal physiology that may affect vital signs and laboratory values and mask underlying pathophysiology. Initial resuscitation and evaluation focus on the mother, as maternal well being is the only way to protect the fetus from hypoxia. Once the mother is stabilized, the fetus can be assessed for evidence of distress, which is best addressed via prompt obstetric consultation. Workup should include awareness of the risks of radiation during pregnancy, with adherence to doing as little harm as possible while still ordering the definitive studies to evaluate for occult injury, including radiography and CT scans, where appropriate. When maternal shock turns to cardiac arrest with a viable fetus, perimortem cesarean section is indicated and may add the benefit of improved maternal outcomes when performed within 5 minutes

Figure 9. Perimortem Cesarean Section (Continued from page 14)

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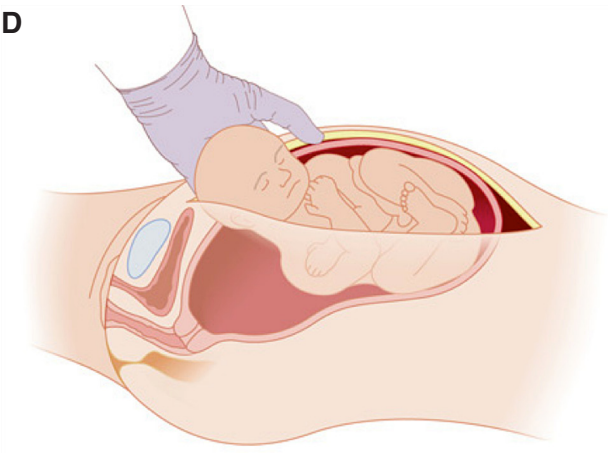

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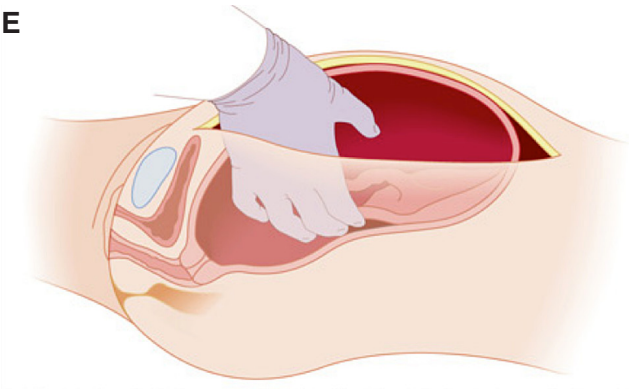

Time- And Cost-Effective Strategies

- Consider obstetric consultation early. Even in the best of circumstances, a pregnant patient beyond 24 weeks' gestation is going to require a minimum of 4 to 6 hours of monitoring, which is best done in an area of the hospital where personnel are trained to perform such monitoring and can deal with complications if monitoring shows evidence of fetal distress. Odds are that this is not going to be optimally done in the ED. Get your obstetrician on board early, do your workup for trauma, and then get the patient to an area where she can be better assessed and you can move on to caring for other patients.
- Domestic violence screening can be best carried out during initial triage by the nursing staff. During triage, it is usually easier to isolate the patient and, by making domestic violence screening questions part of the standard triage script, you can screen every patient effectively.
  Risk management caveat: If there are signs of domestic violence or abuse, make a concerted effort to get the details yourself, document thoroughly, and involve a social worker.
- Every female patient who presents with trauma should have a pregnancy test. It is cheap, quick, and informs you of the potential for intrauterine complications. It also influences treatment choices due to medications that are contraindicated in pregnancy. Bedside urine pregnancy tests can be used with whole blood samples to rule out pregnancy if urine is not available.
- Don't hesitate to utilize radiography in a pregnant trauma patient. National recommendations recognize the need for appropriate ionizing radiation during pregnancy, and most single imaging studies are well below the recommended dose threshold for the fetus. Education for the patient about the low risk and efforts to minimize exposure to ionizing radiation should be included in the discussion as well as the benefits to the mother and the fetus of a thorough trauma evaluation.
  Risk management caveat: Make sure that any alternative forms of imaging that might be available (such as ultrasound or MRI) are considered, and, whenever feasible, have a discussion with the patient and obtain consent for extensive radiographic procedures

of arrest. A minimum of 4 to 6 hours of monitoring is required in all pregnant patients beyond 24 weeks, as even relatively minor injuries can result in dramatic fetal injuries.

Case Conclusions

The first patient you saw who was 30 weeks pregnant with the ankle injury was immediately assessed, and fetal heart tones were reassuring. After a brief discussion regarding the relatively minimal risk of plain films, she was sent for x-rays of the cervical spine and ankle, which showed a small avulsion fracture of her lateral malleolus, for which she was placed in a splint. She was started on electronic fetal monitoring in the ED, which showed normal fetal heart rate and no evidence of contractions. You discussed with the obstetric team having her admitted to the labor and delivery unit for 6 hours of monitoring, after which she was discharged home without event.

The second patient, who fell while jogging, was placed on electronic fetal monitoring, and a FAST exam was performed. Although the FAST exam was negative, she had several contractions while downstairs and was admitted to the obstetric unit for further monitoring. While there, she was found to have evidence of mild abruption. It was treated with conservative management over the next few days, and she was eventually released.

The third patient who was involved in the motor vehicle collision arrived to the ED with a barely palpable pulse and a fundus that was well above the umbilicus. Because she was nonresponsive to pain upon arrival, you placed a wedge under the spine board, which improved her pulse, but you decided to intubate for airway protection. This went uneventfully, and you began rapid infusion of crystalloid and called for O-negative blood. As you performed a FAST exam, you anticipated the worst and had a knife and chlorhexidine at the bedside "just in case." With volume, her vitals improved, and she was stabilized and placed on electronic fetal monitoring, with some variable decelerations. In consultation with the surgeons, she was taken to the CT scanner, where several intra-abdominal injuries were noted, including a splenic laceration and left kidney laceration, but no evidence of placental abruption or uterine trauma was seen. She was taken to the surgical ICU, where over the next 3 weeks she had a rocky course, but ultimately she underwent a cesarean section and delivery of a healthy baby girl.

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study

will be included in bold type following the reference, where available. In addition, the most informative references cited in this paper, as determined by the authors, are noted by an asterisk (*) next to the number of the reference.

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CME Questions

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1. Most major studies on outcomes after trauma in pregnant patients have shown:
   a. Penetrating trauma is more common than blunt trauma.
   b. Serious complications can occur with even minor trauma.
   c. Injury severity scores are indicative of neonatal outcomes.
   d. Trauma in pregnancy is rare.

2. Which of the following is TRUE of the pregnant female anatomy?
   a. Lower location of abdominal organs
   b. Increased lung volumes
   c. Increasing abdominal sensitivity to painful stimuli
   d. Lower center of gravity

3. What causes maternal supine hypotension syndrome?
   a. Increased plasma volume with relative anemia
   b. Diminished respiratory drive due to relatively low pCO_2
   c. Decreased overall cardiac output during late pregnancy
   d. Obstruction of venous return due to the gravid uterus on the vena cava

4. **At approximately how many weeks' gestation does the uterine fundus lie at the umbilicus?**
   a. 12 weeks b. 20 weeks
   c. 24 weeks d. 36 weeks

5. **Kleihauer-Betke testing is utilized for:**
   a. Quantifying the amount of fetal blood in the maternal bloodstream
   b. Determining the Rh status of the fetus
   c. Determining the Rh status of the mother
   d. Quantifying maternal anti-Rh antibodies in the mother

6. **Electronic fetal monitoring (fetal cardiotocography) should be initiated:**
   a. Prior to arrival in the ED
   b. Immediately upon arrival in the ED
   c. As soon as possible after the mother has been stabilized
   d. Only after admission to an obstetric service

7. **The recommended maximum fetal ionizing radiation dose in pregnancy is:**
   a. 5 mGy (0.5 rad) b. 25 mGy (2.5 rad)
   c. 50 mGy (5 rad) d. 500 mGy (50 rad)

8. **Regarding contrast agents in pregnancy, which of the following is TRUE?**
   a. Iodine-based and gadolinium contrast agents are both contraindicated.
   b. Iodine-based contrast agents are contraindicated; gadolinium is relatively safe.
   c. Iodine-based contrast agents are relatively safe; gadolinium is contraindicated.
   d. Iodine-based and gadolinium contrast agents are both relatively safe.

9. **Domestic violence screening performed in the ED:**
   a. Is useful because this may be the patient's first encounter with a healthcare practitioner
   b. Should be done in private with every pregnant patient presenting to the ED for trauma
   c. Provides potential to prevent further harm to the mother and the fetus
   d. All of the above

10. **What is the proper method for a pregnant woman to wear a seat belt?**
    a. Lap belt only, without shoulder restraint
    b. Lap belt below the belly with shoulder restraint off to one side
    c. Lap belt over belly with shoulder restraint between the breasts
    d. Lap belt below the belly with shoulder restraint between the breasts

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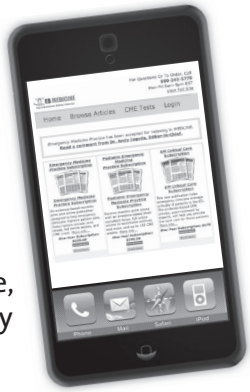

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