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Trauma in Pregnancy

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The care of the pregnant trauma patient provides unique challenges and holds profound implications for both fetal and maternal outcomes. The incidence of trauma in pregnant patients is low, approximately 5% [1], but it is the leading cause of nonobstetric mortality, and the associated fetal morbidity and mortality increases with the severity of the maternal injuries.

The management of these patients is influenced by unique anatomic and physiologic changes, increased concern for deleterious radiation and medication exposures, and the need for multidisciplinary care. This article reviews the critical features necessary in the assessment, diagnosis, treatment, and disposition of pregnant trauma patients with a focus on recent developments reported in the literature pertinent to emergency management.

Incidence

As described previously, trauma represents a significant cause of maternal death despite its relatively low absolute incidence. In a review of 95 maternal deaths, Fildes and colleagues [2] reported 46.3% to be of traumatic etiology. This rate increases in younger women and those of certain ethnic and socioeconomic groups. The nature of these traumatic insults has been reported as 55% motor vehicle collisions, 22% falls, 22% assaults, and 1% burns [3]. Although sampling of certain patient populations yields higher rates of penetrating trauma and mortality associated with violent crimes [2], Weiss and colleagues [4] identified motor vehicle collisions as the leading traumatic cause of fetal death (82%). This study also notes

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that the causes of maternal and fetal mortality differ, with 11% of all fetal deaths being independent of maternal death.

Even minor maternal trauma may have immediate and long-term impacts on fetal well-being, highlighting the need for prevention, appropriate recognition, and multidisciplinary care.

General considerations

Typical prehospital and Advanced Trauma Life Support protocols must be modified in assessing the pregnant trauma patient because of alterations in anatomy and physiology. Additionally, the providers must consider the assessment and well being of the second patient—the fetus. These factors demand attention most immediately during the initial assessment and hold implications in the effective resuscitation, diagnosis, and treatment.

The uterus first becomes an intra-abdominal organ at 12 weeks, and as it enlarges it displaces abdominal contents upwards, reaching the costal margin between 34 and 38 weeks. The diaphragm may be elevated as much as 4 cm, with accompanying displacement of associated thoracoabdominal organs, altering interpretation of physical examination and radiographic findings. In a supine patient, the enlarged uterus compresses the inferior vena cava, decreasing venous return and potentially causing supine hypotension syndrome.

The maternal cardiopulmonary system displays significant alterations. By the second trimester, a mild increase in resting heart rate and decrease in systolic blood pressure are accompanied by moderate hypocapnia caused by increased minute ventilation. Multiple factors affect maternal hemodynamics. Increases in maternal blood volume (by 50%) and relatively smaller increases in red blood cell volume (by 30%) create a physiologic anemia of pregnancy with expected hematocrit values between 30% and 35% in the final trimester. These factors result in increased cardiac output, an increasing portion of which is shunted to the developing fetus and uterus.

Prehospital considerations

In the prehospital setting, information regarding the status of the pregnancy and the clinical condition of the patient should be obtained. In general, most pregnant patients following major trauma should be transported to a Level 1 trauma center with obstetric capabilities, particularly if there is hemodynamic compromise, loss of consciousness, or a third-trimester gestation [5]. Appropriate spine precautions should be observed, and a left lateral tilt position or manual displacement of the uterus may be used to avoid the supine hypotension syndrome. In late third-trimester patients, a supine position may be intolerable because of the associated respiratory distress, and the prehospital team may use up to 30° of reverse Trendelenberg positioning as allowed by hemodynamic parameters [6].

Appropriate emergency department management can proceed only if the patient is identified as pregnant. Emergency medical service personnel, family or friends, physical examination, and serum or urine pregnancy testing may provide this information, but not without the potential for delay or misinformation. In 2002 Bochicchio and colleagues [7] recommended that all female trauma patients of reproductive age receive a Focused Assessment with Sonography in Trauma with the secondary intent to screen for pregnancy. On retrospective review, these ultrasound examinations revealed a small number of newly diagnosed pregnancies with subsequent modification to the diagnostic evaluation of these patients. Once pregnancy is identified, the evaluation of a pregnant trauma patient should be multidisciplinary, including a combination of emergency physicians, trauma surgeons, and obstetricians.

Initial evaluation of the pregnant trauma patient

The primary survey is performed according to standard Advanced Trauma Life Support protocols, but special consideration must be paid to the cardiopulmonary alterations described earlier. Rapid-sequence induction is accepted as safe and is the preferred method for intubation. Appropriate techniques, such as Sellick's maneuver and adequate preoxygenation, are necessary to avoid complications, because pregnant patients are prone to aspiration and desaturation. Disturbances of respiration (eg, pneumothorax) may be more challenging to detect and may be associated with an accelerated decompensation because of alterations in respiratory mechanics. If tube thoracostomy is performed, a higher intercostal space should be used to avoid the elevated diaphragm. When evaluating the patient's circulatory status, the physiologic changes present in later pregnancy must be taken into account. The 50% increase in maternal blood volume and increased cardiac output may mask significant blood loss; fetal distress may be the earliest indicator of impending hemodynamic instability. Resuscitation with crystalloid should be initiated as appropriate, and, if needed before the availability of type-specific blood, O negative packed red blood cells should be used. Because of the susceptibility of the uterine blood supply, the use of vasopressors should be avoided.

After the primary survey is completed, a secondary survey should be performed with several important modifications. As early as possible in the resuscitation, fetal monitoring should be initiated for all viable gestations ($>$ 23 weeks) and continued for at least 4 to 6 hours [8]. The decision to cease fetal monitoring should be made by the consulting obstetrician and should take into account documented uterine contractions, fetal well-being, and any plans for operative intervention. A vaginal examination should be completed to assess for the presence of blood or amniotic fluid and cervical effacement and dilation. Vaginal fluid may be examined for the presence of

ferning and an elevated pH near 7, which would be consistent with traumatic rupture of membranes.

The standard Focused Abdominal Sonography for Trauma examination should be performed during the secondary survey, providing a screening examination for intraperitoneal hemorrhage with sensitivities of 80% to 83% and specificities of 98% to 100% for intraperitoneal fluid [9–11]. Bedside ultrasound also can be used to assess the fetal heart rate rapidly. With the advent of bedside ultrasound and rapid CT scans, diagnostic peritoneal lavage (DPL) has largely fallen out of routine use in the evaluation of trauma patients. The limited data on DPL in pregnancy report that it is accurate in pregnant patients and can be performed safely with no increases in fetal loss [12,13]. If performed during pregnancy, a DPL should be done by the supraumbilical approach using an open technique.

Diagnostic evaluation

Many trauma centers evaluate patients with a standardized laboratory panel. Alterations in pregnancy that should be considered in interpreting laboratory results include a physiologic anemia, slight elevation of the white blood cell count, mildly decreased serum bicarbonate, and an increased fibrinogen. Arterial blood gas analysis may reveal a slightly elevated pH and mild hyperventilation with pCO_2s near 30 mm Hg.

Kleihauer-Betke (KB) testing identifies fetal red blood cells within a maternal blood sample, indicating fetomaternal hemorrhage of at least 5 mL using current methods, although the development of flow cytometry techniques may lower this threshold [14]. The Rh-positive fetus possesses this antigen after 6 weeks' gestation, and transplacental hemorrhage of as little as 0.0001 mL of fetal blood can cause maternal sensitization. Consequently, the American College of Emergency Physicians recommends administration of immune globulin after even minor trauma [15]. Similarly, the American College of Obstetrics and Gynecology recommends administering Rh immune globulin to all Rh-negative trauma patients who have a positive KB test [16]. Further dosing to account for larger transplacental hemorrhage may be administered according to the dosing schedule of 300 μg of immune globulin per 30 cm^3 of estimated fetomaternal hemorrhage.

In 2004 Muench and colleagues [17] recommended routine KB testing in all cases of maternal trauma, regardless of maternal Rh status. In a retrospective review of 71 trauma patients, they report a positive KB test holding a sensitivity of 100% in the prediction of uterine contractions and labor with a specificity of 96% and 54% for the prediction of contractions and preterm labor, respectively. Dhanraj and Lambers [18], however, comparing low-risk third-trimester volunteers with pregnant trauma historical controls, revealed no significant difference in the incidence of a positive KB test. The authors concluded that an isolated positive result therefore is not indicative of

pathologic transplacental hemorrhage. Although this retrospective review has obvious limitations, it questions the potential utility of the negative predictive value of the KB test.

Diagnostic imaging in pregnancy

As mentioned previously, ultrasound is an ideal tool for imaging the pregnant trauma patient, because it provides valuable information about both the fetus and mother and has no associated radiation exposure. Often, however, additional diagnostic imaging is required. In general, clinically necessary imaging studies should not be deferred because of concern about radiation, and the uterus should be shielded as much as feasible given the intended study [19]. The cumulative radiation dose associated with an increased risk of fetal malformation is 5 to 10 rads, significantly higher than many studies commonly used in trauma patients [20]. A pelvic CT alone (with mandated absence of shielding) will administer between 3 to 9 rads to the fetus and should be be undertaken only in critical patients, as the clinical situation requires [19,21]. Although the literature suggests radiographic studies should not be deferred in the pregnant trauma patient, the increased use of CT in blunt trauma patients results in radiation doses that often exceed previously described thresholds [22]. Clinicians are encouraged to consider these factors in the choosing appropriate imaging studies [23].

Injury severity scores and outcome in pregnant trauma patients

Much literature has been devoted to the description of factors associated with adverse maternal and fetal outcomes in trauma [2,4,13,24–32]. As described previously, trauma is one of the leading causes of maternal death and accounts for at least 5% of fetal deaths [2,4]. Pregnancy, however, does not influence morbidity or mortality independently from trauma; overall rates are similar to those in nonpregnant patients and are consistent with markers of injury severity [33,34]. Shah and colleagues [33] reported a mortality rate of 3.5% in a retrospective case-control analysis of 114 patients, which did not differ significantly from controls. The authors, however, did identify a trend in the pattern of injury toward more severe abdominal injuries and less severe head injuries.

Several factors have been investigated to identify predictors of fetal injury and loss. It is well documented that the maternal Injury Severity Score (ISS) correlates well with adverse fetal outcomes [13,26,29–31,33–35]. Rogers and colleagues [35] reported a 50% fetal mortality rate with an ISS greater than 25, whereas Kissinger and colleagues [30] identified a significant difference in mean ISS when comparing trauma with (ISS 21.6) and without (ISS 6.2) associated fetal mortality. This scoring system provides little assistance in the acute management of these patients, however, and may not be useful in

prospectively identifying those at risk for adverse fetal outcomes [31]. The assessment of a Revised Trauma Score in the initial resuscitation has been investigated as a potential marker of clinical course. A small retrospective analysis failed to identify a predictive value in assigning a Revised Trauma Score when examining for untoward outcomes or the need for prolonged monitoring [27]. In a retrospective analysis of 20 patients who had an ISS higher than 12, Ali and colleagues [26] identified the presence of disseminated intravascular coagulation (DIC) as a major predictor of fetal mortality. DIC was identified with equal incidence in patients with and without evidence of placental abruption but was present only in the group with associated fetal mortality. Laboratory values consistent with DIC were found in 61.5% of these patients. Despite a small study size and previous reports with contradictory data [36], the authors recommend that patients who have DIC be considered for imminent delivery of a fetus of viable gestational age. Additional criteria that have been associated with fetal mortality include decreased Glascow Coma Scale, maternal acidosis, decreased serum bicarbonate, maternal hypoxia, and a single documented fetal heart rate below 110 beats per minute [13,29,30,33,35]. Although various analyses differ in the statistical significance of each of these features, markers of maternal malperfusion and hypoxia, direct uteroplacental injury, and severe maternal head injury are associated consistently with adverse fetal outcome. Sperry and colleagues [32] noted that even women discharged after minor traumatic injury with a viable pregnancy have increased risk of a preterm delivery and a low birth weight infant and identified trauma as an independent risk factor for these outcomes.

Perimortem cesarean section

A perimortem cesarean section should be performed in the pregnant patient in traumatic arrest if the fetus is potentially viable. This procedure originally was proposed by Katz and colleagues [37] in 1986 in light of data suggesting the inefficacy of cardiopulmonary resuscitation in the third trimester. Emptying the uterus relieves uterocaval compression and improves venous return and, consequently, cardiac output. The initial recommendation was to perform the procedure within 4 minutes of maternal arrest to minimize the potential for adverse maternal neurologic outcome in reversible causes of cardiac arrest. Subsequent studies have reported fetal and maternal survival rates of 45% and 72%, respectively [38]. Recently, a review of 38 case reports provided tentative evidence that maternal and fetal outcomes are improved by initiation of perimortem cesarean section within 4 minutes of maternal cardiac arrest. Eight of these cases were traumatic, although no subgroup analysis was provided. Both return of spontaneous circulation and delivery of normal infants was reported in several cases despite delay of the procedure for more than 15 minutes after arrest. Despite an acknowledged reporting bias affecting the review, the authors recommend

a caesarean delivery be performed if pulses cannot be obtained in the case of maternal arrest [39].

Injuries unique to the pregnant trauma patient

Placental abruption

Placental abruption can occur even after minor abdominal trauma. It is the second most common cause of fetal mortality in this patient population [40]; the incidence ranges between 1% and 60% [5,24,41]. In minor trauma the rate of placental abruption is between 1% and 5% with significant mechanisms associated with rates of 20% to 60% [5,33,36].

Placental abruption results from the placenta shearing away from the uterus with bleeding into this space and clot formation. The elasticity of the uterus, matched against the relative stiffness of the placenta, creates a vulnerable interface. A placental abruption can result in the patient experiencing abdominal pain, cramping, and vaginal bleeding. The clinician may detect uterine tenderness on physical examination. Unfortunately, the absence of these features does not exclude the diagnosis of placental abruption reliably.

Several diagnostic modalities may be used in the evaluation of placental abruption. Ultrasound may detect a placental abruption, has the benefit of the absence of ionizing radiation, and provides additional information about fetal well-being. Its sensitivity for placental abruption, however, is poor—around 50%—so a negative ultrasound does not rule out a placental abruption [36,42]. Use of the KB test as an indicator of the fetomaternal hemorrhage likely to accompany abruption is not of great clinical utility because of its low specificity, particularly in light of the data presented earlier from Dhanraj and Lambers [18], and currently is not recommended for this application by the American College of Obstetrics and Gynecology [16]. Continuous fetal monitoring is the preferred test and should be initiated as early in the evaluation as possible. In the absence of symptoms consistent with placental abruption, an observation period of 4 to 6 hours is adequate [24,42]. Because of the potential for delayed manifestation (24–48 hours) of significant placental abruption, the Eastern Association for the Surgery of Trauma recommends continuation of fetal monitoring in the presence of uterine contractions, a nonreassuring fetal heart rate pattern, vaginal bleeding, significant uterine tenderness or irritability, or serious maternal injury [8]. This recommendation applies to even minor trauma, because these patients are particularly prone to delayed recognition of placental abruption.

Uterine rupture

Uterine rupture is a rare consequence of maternal trauma, one that carries a grave outcome for the fetus. This diagnosis is present in less than 1% of blunt trauma and is found typically in patients who have had a previous

cesarean section. Associated fetal mortality is nearly universal, with an associated 10% maternal mortality rate [42]. Presenting features may include uterine tenderness and variable shape, hemodynamic instability, and the ability to palpate fetal parts on abdominal examination. In patients without a previous cesarean section, the uterus is more likely to rupture posteriorly, making detection of these physical examination findings more difficult [43].

Pelvic fracture

As expected from proximity alone, injuries to the bony pelvis are complicated to manage in pregnancy. Leggon and colleagues [44] described maternal and fetal mortality rates of 9% and 35%, respectively, in a retrospective review of 101 pelvic and acetabular fractures sustained during pregnancy. The major causes of fetal deaths were direct injury to the uterus, placenta, or fetus (52%) and maternal hemorrhage (36%). Fatal insults to the fetus were identified in all three trimesters, with no significant difference in the distribution of fetal mortality by gestational age. In subanalysis of this population according to injury severity, a fetal mortality rate of 10% was discovered in patients who had injuries of minor severity. These results are significantly higher than the generally accepted fetal mortality rates of 1% in this subset of pregnant trauma patients [5]. Although the research methodology has inherent limitations, this finding suggests that pelvic fractures may be an independent predictor of adverse fetal outcome.

The management of pelvic fractures in pregnant trauma patients has several critical modifications. Because of the increased risk of fetal morbidity and mortality, a thorough evaluation of the uterus and of fetal well-being must be undertaken. Recent reports, however, suggest that both percutaneous and open fixation may be performed with good fetal and maternal outcomes [45–47]. In addition to stabilization of unstable pelvic fractures, current management of hemodynamically unstable polytrauma victims often includes the use of angiography to coil or embolize bleeding pelvic or retroperitoneal vessels. The feasibility of this procedure in pregnant patients is not established.

In a large retrospective analysis of 3992 hospitalized pregnant patients who had fractures of any type, El Kady and colleagues [25] found lower extremity fractures were the most common, but pelvic fractures were associated with the highest risk of placental abruption and maternal and fetal death. Women who had pelvic fractures and who were discharged without delivering carried an increased risk of fetal, neonatal, and infant death, mostly attributed to abruption and low birth weight.

Injury prevention

Given the dramatic impact on fetal well-being and the prevalence of traumatic injuries in women of childbearing age, there are great potential

benefits in the prevention of traumatic injuries in pregnant patients. Although there is discrepancy in the literature regarding the etiology, most authors identify motor vehicle collisions as the primary source of traumatic injuries. Even though the use of seatbelts is recommended, many pregnant patients do not use them. Approximately one third of pregnant patients do not use safety restraints properly, and a minority of women report physician counseling on this topic [48,49]. Previous literature suggests as few as 46% of pregnant women involved in motor vehicle collisions were properly restrained, with as few of half of all pregnant women reporting routine proper use of restraints [33,50–52]. Therefore a large emphasis has been placed on appropriate positioning of the lap and shoulder belts. Recently, the role of airbag deployment in obstetric complications has been investigated in case reports and series. Fusco and colleagues [53] reported the first case of uterine rupture associated with airbag deployment in 2001. Subsequently, a retrospective review by Metz and Abbott [54] of 30 cases involving airbag deployment failed to demonstrate a high rate of abruption or fetal compromise. Although preliminary experimental data suggest airbags may impart dangerous force to the uterus with improper use, the risk of airbags in late-trimester patients remains to be defined [55,56]. In 1997 the National Highway Traffic Safety Administration issued guidelines that describe the benefits of airbags as outweighing potential risks and recommended positioning the sternum and/or uterine fundus at least 10 inches away from the airbag cover [57]. At this time there remains great opportunity to impact pregnancy outcomes with both effective public health initiatives and patient education during interactions between pregnant patients and independent health care practitioners.

The prevalence of violence in pregnancy is estimated to be 10% to 15%, with some series identifying up to 31.5% of traumatic injuries as attributable to interpersonal violence [58–60]. Most of these assaults (70%–85%) are attributable to boyfriends or spouses [47]. The frequency and/or nature of abuse may escalate during pregnancy and is associated with late entry into prenatal care, prematurity, and low birth weight in addition to any immediate implications of the traumatic insult. In a large retrospective analysis of severely injured, hospitalized assault victims, El Kady and colleagues [28] identified increased rates of maternal mortality and uterine rupture. Furthermore, they reported adverse long-term effects on fetal outcome (eg, low birth weight) that persisted when controlling for socioeconomic factors previously viewed as confounding variables. The available structure of routine prenatal visits and the potential for increased use of emergency departments by this patient population may provide opportunities to detect patients subjected to domestic violence. Several methods for detection have been described, and guidelines for screening are available from the American College of Obstetrics and Gynecology [61–63].

Summary

Trauma in pregnancy presents unique challenges to the emergency physician. Knowledge of the anatomic and physiologic alterations in pregnancy, a thorough evaluation of both the mother and fetus, and careful consideration of conditions specific to pregnancy are essential to manage these cases expertly and ensure the best possible outcomes for both the mother and the fetus.

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