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REVIEW

The pathophysiology of trauma in pregnancy: A review

ADI Y. WEINTRAUB, ELAD LERON, & MOSHE MAZOR

Department of Obstetrics and Gynecology, Faculty of Health Sciences, Soroka University Medical Center, Ben-Gurion University of the Negev, Beer-Sheva, Israel

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Abstract

Emergency care of the pregnant patient with trauma presents a unique set of circumstances and challenges to physicians. Pregnancy causes anatomic and physiologic changes involving nearly every organ system in the body, making treatment of the pregnant trauma patient difficult. The other factors that make treatment complex are fear of harming the fetus, upsetting the patient, and/or lack of experience. The possibility of pregnancy should be considered in all women of reproductive age with trauma. A profound understanding of the pathophysiology of the pregnant trauma patient might aid in dealing with this complex problem.

Keywords: *Trauma in pregnancy, blunt abdominal trauma, placental abruption, motor vehicle accident*

Introduction

Traumatic injuries are a major cause of maternal and neonatal morbidity and mortality [1–7]. It has been estimated that 6–7% of pregnancies are complicated by trauma, and that 0.3–0.4% of pregnant women require hospitalization following trauma [5–7]. Maternal and perinatal mortality vary, some reported rates are as high as 10% and 60%, respectively [6].

In the past, most causes of maternal death were obstetric and due to a lack of prenatal care and inadequate assistance during delivery. Because of improved medical services, hospital deliveries, and reduced parity, a significant reduction in maternal mortality is noted. On the other hand, although there have been dramatic improvements in the management and treatment of medical and obstetric conditions, fetal mortality has not been reduced because of a rise in non-obstetric causes (mostly motor vehicle crashes) [8–10].

Emergency care of the pregnant trauma patient presents a unique set of circumstances and challenges for the physician. The anatomic and physiologic changes during pregnancy, fear of harming the fetus or upsetting the patient, and lack of experience are factors that make treatment of the pregnant trauma patient complex.

The management of pregnant trauma patients may be assisted if we stratify injured women into four groups [11]. The first is comprised of injured women who are unaware that they are pregnant. Since routine radiographic studies have the greatest teratogenic potential in early pregnancy, a pregnancy test should be obtained from all trauma patients of reproductive age. The second group is pregnant women of less than 24–25 weeks of gestation where the primary focus is aimed solely at the mother, since the fetus has not yet reached the border of viability. The third group consists of pregnant women at a gestational age beyond the border of viability. For this group, monitoring, support, and clinical consideration are aimed at two patients, the mother and fetus. The fourth group is comprised of severely injured women who present in a perimortem state. In these patients early cesarean section may facilitate maternal resuscitation and increases the chance of fetal survival.

The aim of this review is to better understand the physiology and pathophysiology of the pregnant trauma patient. To prepare this review we undertook a PubMed search of articles using the keywords:

Correspondence: Adi Y. Weintraub, Department of Obstetrics and Gynecology, Soroka University Medical Center, Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer-Sheva, Israel. E-mail: adiyehud@bgu.ac.il

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'trauma', 'pregnancy', 'injury', 'fetal loss/demise' and 'motor vehicle crash'.

Anatomic and physiologic changes in pregnancy that are relevant to trauma

The possibility of pregnancy should be considered in all female trauma patients of reproductive age. Pregnancy causes anatomic and physiologic changes involving nearly every organ system in the body, making the treatment of a pregnant trauma patient complex [12–15]. Some of the anatomic and physiologic changes in pregnancy that are relevant to trauma are presented in Table I. These changes, by altering the signs and symptoms of injury, may influence the interpretation of the physical examination as well as laboratory results of traumatized pregnant women. This may affect the approach and the response to resuscitation [6,13–15].

During the first trimester of pregnancy the uterus is confined and protected by the bony pelvis. It remains an intrapelvic organ until around the twelfth week of gestation, when it rises and becomes an abdominal one. In the second trimester the small fetus remains cushioned by a relatively large amount of amniotic fluid. By the third trimester the uterus is large and thin walled [11,14]. The uterus and its contents have increased susceptibility to injury (penetration, rupture, placental abruption, and premature rupture of membranes (PROM)). Some of the characteristics causing this increased susceptibility include the difference in elasticity between the uterus and placenta, which causes the uteroplacental interface to be subject to sheer forces, and may lead to placental abruption [16].

Table I. Anatomic and physiologic changes in pregnancy that are relevant to trauma.

Organ system	Changes relevant to trauma
Uterus	• First trimester: Intrapelvic organ protected by the bony pelvis. • Second trimester: Becomes an abdominal organ; the fetus is cushioned by a relatively large amount of amniotic fluid. • Third trimester: The uterus is large and thin walled.
Blood	• Increase in plasma volume greater than in RBC results in a decreased HCT.
Cardiovascular system	• Increase in plasma volume and decrease in vascular resistance of the uterus and placenta cause an increase in cardiac output. • Increase in the cardiac rate. • In the second trimester there is a decrease in both systolic and diastolic blood pressure.
Respiratory system	• Increased tidal volume and minute ventilation. • Hypocapnea in late pregnancy. • Decreased residual volume.
GI system	• Gastric emptying time is prolonged. • In the third trimester the bowel is pushed upwards and lies mostly in the upper abdomen.
Other systems	• Dilatation of the renal calyces, pelvis, and ureters. • The pituitary gland increases in size. • The symphysis pubis and the sacroiliac joints widen.

RBC, red blood cell; HCT, hematocrit; GI, gastrointestinal.

Plasma volume increases throughout pregnancy and plateaus (peaks at the 34th week) at about 34 weeks of gestation. A smaller increase in the number of red blood cells results in a decreased hematocrit [11,14,15]. The placental vasculature is maximally dilated, yet it is very sensitive to catecholamine stimulation [9,11,14–16]. An acute decrease in the intravascular volume may result in a significant increase in the uterine vascular resistance. This could cause a reduction in fetal oxygenation, even though the maternal vital signs can stay within normal range [6,7,9,14–17].

There are hemodynamic changes that are noted during pregnancy and that are relevant when dealing with injured pregnant patients. An increase in cardiac output is noted after ten weeks of gestation that is due to the increase in plasma volume and the decrease in vascular resistance of the uterus and placenta. During the third trimester the uterus and placenta receive 20% of cardiac output. A gradual increase in the cardiac rate, maximizing in the third trimester, must be considered when evaluating the tachycardic response to hypovolemia. In the second trimester there is a decrease in both systolic and diastolic blood pressure. Turning the patient to the left lateral decubitus position may, in some women, prevent hypotension [11,14,15,18].

Increased levels of progesterone in pregnancy are thought to increase tidal volume and minute ventilation. Hypocapnea is common in late pregnancy. The diaphragm elevates causing decreased residual volume. Maintaining adequate arterial oxygenation is important in the resuscitation of injured pregnant patients because of increased oxygen consumption during pregnancy [14,15].

Gastric emptying time is prolonged in pregnancy, therefore, in the emergency setting, early gastric tube decompression is important in order to avoid aspirations. In the third trimester, as the uterus enlarges, the bowel is pushed upwards and lies mostly in the upper abdomen [11]. Therefore, in blunt trauma the bowel is relatively protected while the uterus and its contents (fetus, placenta) are more vulnerable. However, penetrating trauma to the upper abdomen can cause complex intestinal injury [14,15].

Other changes in pregnancy involving nearly every organ system in the body are important when treating a patient suffering a trauma. Physiologic dilatation of the renal calyces, pelvis, and ureters are noted and should be taken into account when dealing with cases of pelvic and abdominal trauma [14]. During pregnancy the pituitary gland increases in size. Shock can cause necrosis of the anterior pituitary gland, resulting in pituitary insufficiency [14]. The symphysis pubis and the sacroiliac joints widen and should be considered when interpreting pelvic X-rays. In the vertex presentation, the fetal head is usually located in the pelvis and the rest of the body, above the pelvic brim. Pelvic fractures in late gestation may result in fetal head injury (skull fractures, intracranial injuries) [11,14,19–21]. Differentiating between head trauma with convulsions and eclampsia (hypertension, proteinuria, and peripheral edema) as a cause for seizures is important [11,14].

The mechanism of injury

The cause of traumatic injury in pregnancy is thought to parallel roughly with that of the general population, with blunt trauma being more common. Penetrating trauma accounts for a greater proportion of injuries in inner-city centers [10]. In a retrospective review of pregnant patients hospitalized at a level-1 trauma center, Baerga-Varela et al. found that over 90% of the patients were there due to blunt trauma (including: motor vehicle crashes, falls, pedestrian injuries, assaults, and drowning) [6]. Motor vehicle crashes account for the majority of severe blunt trauma cases, and are the leading cause of non-obstetric maternal and perinatal mortality [6–14].

Blunt abdominal trauma

Different mechanisms of maternal injury occur in pregnant women with blunt abdominal trauma compared with their non-pregnant counterparts. Because the gravid uterus changes the relative location of abdominal contents, transmission of force may be altered in the pregnant abdomen [16–22].

The rate of perinatal mortality after maternal blunt trauma is 3.5–38% [4,6,7,10,14,23,24] typically from placental abruption, maternal shock, and maternal death [10,16,22,23]. Among pregnant trauma victims, head injury and hemorrhagic shock account for most deaths [25,26]. Serious injuries do not result in a higher mortality rate in pregnant women compared with non-pregnant women. However, splenic and retroperitoneal injuries and hematomas are more frequent in pregnant victims of blunt abdominal trauma due to increased vascularity during pregnancy. Conversely, bowel injury is less frequent [22,25].

Placental abruption

Over 70% of fetal losses following blunt abdominal trauma result from placental abruption [11,16,22, 27,28]. The uterus consists of a significant proportion of elastic fibers, whereas, the placenta is largely devoid of elastic fibers. The mechanism of placental abruption resulting from trauma is based on the forces placed on the placental–uterine interface coupled with the relative inelasticity of that interface. Two alternative possibilities should be considered: The fetus within the amniotic fluid can either strike the placenta and create a potential shear, or alternatively pull the placenta from the umbilical cord. The second, a traumatic deformation may set a fluid wave within the uterus, and because of the fundamental tissue differences between the uterus and placenta, a shearing effect to this interface could occur [16,22].

Preterm labor

The true incidence of preterm labor following trauma during pregnancy is not known. It appears to be under 5% [16,29]. Traumatic injury to the uterus may result in destabilization of lysosomal enzymes that can initiate prostaglandin production. This is the mechanism presumed to cause preterm labor associated with trauma. Another possibility is that trauma may cause preterm premature rupture of membranes (PROM) and preterm birth. Administration of slow-released progesterone should be considered in all women with contractions after trauma in pregnancy to decrease the rate of preterm birth and the risks of prematurity [30].

Direct fetal injury

Direct fetal injuries and fractures complicate less than 1% of severe blunt abdominal trauma in pregnant women, since the maternal soft tissue, uterus, and amniotic fluid absorb energy and diminish the force delivered to the fetus. Most cases, with severe injuries, occur during late pregnancy [22,25]. Cranial injuries are the most frequently reported category of direct fetal injury after blunt abdominal trauma. Fetal brain and skull injuries may be more common in cases with fetal head engagement in which maternal pelvic fractures occur. Deceleration injury to the unengaged fetal head may also occur [19–22,25].

Uterine rupture

Uterine rupture is a rare complication of blunt abdominal trauma, complicating about 0.6% of traumatic events during pregnancy. Uterine rupture tends to occur only in the most serious accidents involving

direct abdominal trauma. This event can be catastrophic for both the mother and her unborn fetus, especially when there is a delay in the diagnosis, since initial symptoms may be variable. With traumatic rupture, fetal mortality approaches 100% and maternal mortality close to 10%. Maternal deaths involving uterine rupture are due to concurrent injuries. Most reported cases involve the uterine fundus, although other locations and degrees of uterine rupture from other causes have also been reported [22,25,31].

Fetal–maternal hemorrhage

Fetal–maternal hemorrhage (FMH) occurs four to five times more frequently in injured pregnant women than in uninjured controls, and the volume of transfused blood is also greater in injured women [22]. A direct correlation between the incidence of FMH and the severity of maternal injury has not been demonstrated [16,25]. Pearlman et al. [29] found that neither the severity of injury nor the presence of uterine activity was predictive of FMH. However, an anteriorly positioned placenta and the presence of uterine tenderness did correlate with FMH. Complications of FMH include Rhesus (Rh) sensitization in the mother, neonatal anemia, cardiac arrhythmias in the fetus, and fetal death from exsanguination [25]. The Kleihauer–Betke acid elution assay is one method used to detect FMH, and should be considered in every woman, in order to determine the Rh immune globulin dose necessary to be administered to women who are Rh negative and suffered a massive transfusion [11,16,25,29].

Penetrating abdominal trauma

Gunshot and stab wounds are the most common cause of penetrating injury during pregnancy. The maternal mortality rate from gunshot and stab injuries to the abdomen is less than that of non-pregnant women, due to the protective effect of the uterus [22,32–35].

As the uterus enlarges it is more vulnerable to injury. The musculature of the pregnant uterus is relatively dense and most of the traumatic force is transmitted to the muscle. Hence, injury to other organs is relatively rare [32]. However, in both gunshot and stab wounds, the fetal death rate is appreciable. As pregnancy progresses, the fetus presents a larger target and is more likely to sustain injury [22,32–35]. According to some reports, fetal injuries are between 60% and 90% with perinatal mortality reaching levels as high as 70% [22,32]. Apart from fetal injury, the membranes, the cord, and the placenta may also be injured.

Traditionally the presence of penetrating abdominal trauma necessitates surgical exploration. Accumulating data suggests a more selective approach [22,32–34]. A distinction is made between upper and lower abdominal penetrating wounds. In general, explorative laparotomy for all upper abdominal wounds is advocated. A major reason is that compression of bowel into the upper abdomen increases the likelihood of extrauterine visceral injury. Another reason is that diaphragmatic lacerations must be ruled out [33]. Awwad et al. [34] suggested conservative management of anterior abdominal entry wounds below the level of the uterine fundus. Diagnostic peritoneal lavage, fistulogram, and ultrasound, may all be used in the conservative management of stable lower abdominal penetrating injury during pregnancy [22,33,36].

Surgical exploration for an abdominal penetrating wound is not an absolute indication for the removal of the fetus from an uninjured uterus. The performance of a cesarean section significantly increases blood loss and operative time. The risk of precipitating labor after explorative laparotomy is negligible, if proper care is taken [32]. Emptying an uninjured uterus is justified only if the uterine size limits either adequate abdominal exploration or repair of extrauterine injuries or in the presence of non-reassuring fetal status. In patients with fetal death, it is advisable to afford delivery by induction of labor rather than uterine evacuation at the time of laparotomy [22,32,33]. In the rare occurrence of patients who present in the perimortem state with a viable fetus, cesarean section should be considered. The timing of delivery is crucial, with best outcomes obtained when delivery is managed within 5 minutes of maternal circulatory arrest. It has been suggested that perimortem cesarean sections may have beneficial effects on maternal resuscitation due to elimination of the low-resistance uteroplacental circulation [11,36].

Clinical recommendations

1. A multidisciplinary approach should be employed in the management of pregnant trauma patients (obs/gyn, surgeons, anesthesiologists, neonatalogists, and trauma and critical care experts).
2. A pregnancy test should be obtained from all trauma patients of reproductive age.
3. A minimum of four to six hours of cardiotocographic monitoring is required for women beyond 22 weeks of gestation, when immediate adverse outcomes are excluded (abdominal pain, uterine tenderness, premature labor, and vaginal bleeding).
4. The Kleihauer–Betke test should be performed on all pregnant trauma patients. Administration of immune globulin within 72 hours of injury should be considered for all Rhesus negative patients.

5. Administration of slow-released progesterone should be considered in all pregnant women with contractions after trauma, to decrease the rate of preterm birth and complications of prematurity.
6. Conservative management should be considered for anterior abdominal entry wounds below the level of the uterine fundus.

Summary

The causes of traumatic injury in pregnancy are thought to parallel roughly with those of the general population, with blunt trauma being the most common. The major reasons for perinatal mortality due to blunt trauma in pregnancy are placental abruption, maternal shock, and/or maternal death. Other causes include preterm labor, direct fetal injuries, uterine rupture, and fetal–maternal hemorrhage. Gunshot and stab wounds are the most common causes of penetrating injury during pregnancy. Traditionally, the presence of penetrating abdominal trauma necessitates surgical exploration. Recent studies suggest a more selective approach. Conservative management of anterior abdominal entry wounds below the level of the uterine fundus has been proposed. A profound understanding of the pathophysiology of the pregnant trauma patient might aid us in dealing with this complex problem.

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