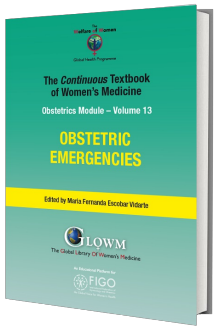
This chapter should be cited as follows:
Gallego JC, Gutiérrez KJ, *et al*, *Glob. libr. women's med.*,
ISSN: 1756-2228; DOI 10.3843/GLOWM.414923



The Continuous Textbook of Women's Medicine *Series* **– Obstetrics Module**
Volume 13
OBSTETRIC EMERGENCIES
Volume Editor: Dr María Fernanda Escobar Vidarte*, Fundación Valle del Lili, Cali, Colombia*

Chapter

Trauma in the Pregnant Patient: Which Concepts have Changed?

First published: February 2021

AUTHORS

Juan Carlos Gallego, MD
High Complexity Obstetric Unit, Department of Obstetrics and Gynecology, Fundación Valle del Lili, Cali; and Department of Obstetrics and Gynecology, Universidad Icesi, Cali, Colombia

Kelly Johana Gutiérrez, MD
Department of Obstetrics and Gynecology, Universidad del Valle, Cali, Colombia

Daniela Torres Hernández, MD
Department of Pediatrics, Universidad del Cauca, Popayan Colombia

Daniela Nasner
Clinical Research Center, Fundación Valle del Lili, Cali, Colombia

María Fernanda Escobar, MD
High Complexity Obstetric Unit, Department of Obstetrics and Gynecology, Fundación Valle del Lili, Cali; and Department of Obstetrics and Gynecology, Universidad Icesi, Cali, Colombia

INTRODUCTION

Trauma is defined as a "fatal injury at the organic level, result of an acute exposure to a type of mechanical, thermal, electrical, chemical, or radiant energy, in amounts that exceed the threshold of physiological tolerance".[1] This energy transfer takes place in three stages that condition the greater or lesser traumatic effect: pre-collision (prevention), collision (initial impact) and post-collision (medical care).[2,3]

Up to 20% of the world's public health problems are related to trauma: 5.8 million people die each year as a result of trauma, which represents 10% of all death registered in the world, 32% more than the amount of deaths caused by malaria, tuberculosis and HIV/AIDS. It is estimated that for every trauma death, between 10 and 50 people are left with some type of disability.[4] More than 90% of trauma deaths occur in low- and middle-income countries, where prevention measures are often not implemented and where health systems lack the strategies and resources to reduce the disease burden created by this event.[5]

Trauma in obstetric patients is a significant cause of maternal and perinatal morbidity and mortality. Prognosis and survival are affected by external factors such as trauma mechanism, type of trauma, consultation times, associated social factors, and comorbidities of the mother and the fetus. However, the determining factor of the outcome will depend on the approach and quality of the interdisciplinary team at the time of assistance.

This review of the literature of obstetric trauma, delineates the key factors for understanding the pathological impact in pregnant patients and the evidence-based management recommendations.

EPIDEMIOLOGY

Trauma is the main cause of maternal non-obstetric mortality among women of fertile age in the United States and complicates one in 12 pregnancies.[6] The trauma impact on perinatal mortality and morbidity is not established. In 2018, Deshpande and partners published a retrospective cohort study assessing the mortality risk among obstetric and non-obstetric patients with trauma, along with 1148 events in 1122 pregnant women and 43,608 traumatic events in 26,272 girls and women of reproductive age. In this study, pregnant women had almost twice as many violent trauma onsets 15.9% vs. 9.8% compared with non-pregnant women of reproductive age (p <0.001) and after adjusting for sociodemographic factors and trauma mechanisms, the pregnant women and girls had two times more risk of death (aRR 1.66; 95% CI, 1.30–2.12). Violent trauma during pregnancy is associated with 3.14 times more death risk than non-violent trauma.[7]

Although the literature regarding trauma in pregnancy is quite extensive, unbiased estimates of the overall impact in maternal and fetal results are scarce. One of the problems with ignorance of the real incidence and preventability of pregnancy trauma is that this cause of death is excluded from the epidemiological surveillance systems of maternal mortality around the world. Despite efforts to count the total number of such events in the analysis of pregnancy-related death, many deaths go unnoticed.[8] For example, in Washington DC, 43% of the women who died of homicide were pregnant and were not included in the pregnancy-related death category.[9] This type of information must alert and suggest possible changes regarding the assessment approach to maternal mortality by trauma in the world.

The systematic review of the Mendez group and partners has established more precisely, with 225 articles (only 17 with a prospective design) of pregnancy trauma, the prevalence rate according to trauma mechanism (Table 1).[10]

Table 1 Estimated incidence/prevalence of injury by type of trauma during pregnancy. Adapted from Mendez-Figueroa *et al.* 2013.[10]

Mechanism of injury	Estimated incidence/prevalence in pregnancy	Estimated incidence/prevalence outside of pregnancy
Motor vehicle crashes	207/100,000 live births	1104/100,000 women
Falls and slips	48.9/100,000 live births	3029/100,000 women
Burns	0.17/100,000 person-years	2.6/100,000 person-years
Domestic violence	8307/100,000 live births	5239/100,000 women
Suicide	2/100,000 live births	8.8/100,000 population
Homicide	2.9/100,000 live births	2.3/100,000 women
Penetrating trauma	3.27/100,000 live births	3.4/100,000 women
Toxic exposure	25.8/100,000 person-years	115.3/100,000 person-years

Perinatal results of pregnant women have shown an increased risk of spontaneous miscarriage, premature membrane

rupture, preterm delivery, uterine rupture, cesarean delivery, abruptio placenta (RR 9) and death of the fetus (RR 4.6) as a result of trauma.[10,11,12] The analysis study of fetal death certificates conducted in 16 states of the USA, reported a fetal death rate with maternal trauma of 2.3 per 10,000 live births, in which the leading cause of death was abruptio placentae.[13] One out of three pregnant women admitted because of trauma may give birth during hospitalization,[14] and the incidence will vary according to the criteria used for hospitalizing affected pregnant women.

MATERNAL PHYSIOLOGICAL CHANGES WITH IMPACT ON THE MANAGEMENT OF THE TRAUMATIZED PATIENT

Pregnancy physiology meets the increasing maternal metabolic demands and the needs of the growing fetus to allow both components of the maternal–fetal unit to survive the birth requirements. Some of these changes modify the assessment or treatment in patients with trauma during pregnancy.

Cardiovascular changes in pregnancy

During pregnancy, the blood volume increases progressively with a maximum volume exceeding 50% of the volume of a non-pregnant adult.[15] This increase protects the mother from possible blood loss related to birth.

Heart rate increases from 15 to 20 beats/minute; the systolic volume increases by 20–30% during pregnancy and the cardiac output increases by 30–50% above average.[16] Blood flow towards the uterus and placenta constitutes up to 25% of cardiac output at the end of pregnancy.[17]

Systemic vascular resistance decreases during pregnancy to around 20 weeks of gestation, followed by a gradual increase until the end of pregnancy to allow a high-flow and low-resistance system at a uteroplacental level. This state is the result of the direct vasodilator effect through the endothelium and placental hormones, added to the increase in the renin-angiotensin-aldosterone system's activity with a low density of receptors for angiotensin II and resistance to vasopressive effects of angiotensin II.[15,18,19] In this way, vasodilated placental vasculature during pregnancy is very sensitive to catecholamine stimulation and an abrupt reduction in maternal blood flow could lead to uterine vasoconstriction, reducing the fetal oxygenation, even in the presence of vital signs.

Systemic and diastolic blood pressure decreases during the second and third term by approximately 10–12 mmHg compared to standard blood pressure before pregnancy. These changes return to the baseline gradually by the end of pregnancy.[19]

In the supine decubitus position, the pregnant uterus compresses the inferior vena cava, blocking the venous return to the heart, decreasing preload, the cardiac expenditure by 30% and the uterine and fetal perfusion.[20] These maternal hemodynamic changes can alter the early recognition of shock and predispose, especially in pelvic lesions, to an increased risk of massive bleeding.

Respiratory changes in pregnancy

The increase in estrogens enlarges the vascularization of the upper airway area and stimulates the production of secretions. Also, secondary capillary congestion and the decrease of plasma oncotic pressure, generates an inflammation of the mucous membranes of the respiratory tract, which can complicate orotracheal intubation. The parallel increase in progesterone levels produces a decrease of the esophagus sphincter activity and a higher risk of bronchoaspiration during airway manipulation.[15] Finally, breast growth can make it more difficult to perform a laryngoscopy for intubation.

At the thorax level, secondary to the uterus growth, there is an increase in the anterior-posterior diameter of about 2 cm and a diaphragm elevation of up to 4 cm, which should be taken into account in the trauma that requires the use of thorax tubes.

Functional residual capacity decreases by 20%, due to the elevation of the diaphragm. In contrast, inspiratory capacity increases due to the elasticity of the rib cage mediated by relaxins and, thus, vital lung capacity remains practically unchanged.[21]

The increasing metabolic demand during pregnancy increases the fetus oxygen consumption by about 20%, which is why the ventilation per minute is higher. The respiratory center is directly stimulated by progesterone to improve respiratory

frequency in a compensatory way, with increased sensitivity to detect hypoxic states. This hyperventilation in pregnancy creates a respiratory alkalosis, with a partial pressure of carbon dioxide ($PaCO_2$) between 27 and 38 mmHg. In turn, this chronic alkalosis stimulates the production of 2,3-diphosphoglycerate (2–3 DPG) and the transfer of oxygen into the placenta. Despite reduced functional pulmonary capacity, there is an increase of maternal oxygen blood pressure (PaO_2) of more than 10 mmHg. Nevertheless, the mother and fetus are very susceptible to hypoxia. At the fetal level, the umbilical vein and artery have a much lower oxygen partial pressure than the maternal circulatory system. Fetal oxygenation remains constant, until maternal PaO_2 drops below 60 mmHg; the decrease gives the fetus approximately 2 minutes of oxygen supply. When there is a 30% reduction of uterine blood flow, the result is that the fetus is further compromised.

Hematological changes in pregnancy

During pregnancy, the total body water content increases by about 6.5–8 liters due to the renin-angiotensin-aldosterone system activation, with increased sodium reabsorption from the kidneys and water retention.[22] Red blood cell production is also stimulated by the increase in erythropoietin secretion at the renal level. However, the increase is about 18–25% of the red blood cells, related to the increase in plasma volume, leading to dilutional anemia.[23] Hemoglobin levels and the hematocrit decrease to produce less blood viscosity and increase the blood flow in the organs.[23]

During pregnancy, there is leukocytosis, which is adrenocorticoid hormone-mediated and a level of 14.000/mm^3 leukocytes is considered normal. Pregnancy is a prothrombotic state that increases the risk of developing venous thromboembolic events four-fold due to the increase in the coagulation factors VII, VIII, IX, X and XII levels and in fibrinogen levels, with a decrease in fibrinolysis, mediated by an increase of the inhibitors of the plasminogen activator 1 and 2.[24]

Gastrointestinal changes in pregnancy

As gestation progresses, the uterus grows and cephalically shifts the stomach and intestines. This position may protect the intestines in closed trauma but makes the uterus and the mother-fetus unit components more vulnerable in direct abdominal trauma, allowing the injury of the uterus itself (uterine rupture), the adjacent organs (bladder rupture), or the uterus contents (premature placenta abruption or direct fetal injury). The peritoneum is gradually stretched which leads to desensitization and makes abdominal examination for detecting peritoneal irritation signs, difficult and potentially inaccurate.[25]

TRAUMA MECHANISM AND IMPACT DURING PREGNANCY

The trauma mechanism determines different maternal and fetal results, and are summarized below.

Motor vehicle collision

The most common form of unintentional trauma in pregnant women is car accidents.[26] The estimated incidence if 207 cases per 100,000 pregnancies, with a maternal mortality of 1.4 per 100,000 and a fetal mortality rate of 3.7 per 100,000 pregnancies.[27] Importantly, these statistics can be underreported. In a cross-sectional study with self-reported data, conducted in 22 states of USA by the Centers for Disease Control and Prevention (CDC), it was found that 92,500 pregnant women are victims of car accidents, and most of them, have not reported being counseled about seat beat use.[28]

The principal risk factor for adverse outcomes during car accidents is the improper use of the seatbelt: in front or rear crashes, the impact of the steering wheel could be avoided by proper use of the seatbelt. Less than 50% of pregnant women have received advice on the use of the seatbelt by their prenatal care provider.[29] The use of toxic substances and alcohol have been reported in up to 19% of car accidents, and 45% of the assessed patients after the accidents, turning into event risk factors.[30,31]

The highest obstetric risk during car accidents is the tension applied to the uterus, which can lead to placental detachment. The impact during a car accident leads to a forward uterus displacement and to an increase in negative pressure and the "backlash" effect. These mechanisms, increase intra-abdominal pressure and lead to forces that could cause shearing and, later, placenta detachment.[31] In pregnant women with severe injuries due to a car accident, placental abruption occurs up to 40% of cases.[32]

After the accident nearly 80% of affected pregnant women may require medical care,[33] and have an increased risk of cesarean section[34] and the preterm birth. The risk of perinatal death seems only to increase if birth occurs immediately after the accident with an estimated rate of 3.5%, from 20 weeks onwards.[35] Perinatal death risk in cesarean sections reflects the trauma severity, and the surgery should not be delayed if clinically justified in hope for better results.[10]

Closed trauma in the abdomen

Because the pregnant uterus changes its location in the abdomen, blunt trauma impact on the fetus is directly related to gestational age. Direct fetal injuries, such as skull fractures, are less than 1%. Before week 13 of gestation, the uterus is protected by the pelvic bones, which decreases the probability of fetal damage. Direct bruised trauma to the uterus, especially after 35 weeks, can be an independent risk factor for the development of perinatal complications, and perinatal mortality varies from 3.5% to 38%, usually resulting from a placental abruption, hypovolemic shock or maternal death.[36] Placental detachment occurs in 40% of women who suffer from severe closed abdominal trauma and in 3% of patients who experience mild abdominal trauma.[37] The presentation spectrum is broad and includes patients with minimal symptoms to those with severe manifestations such as uterine hypertonia, rutilating red vaginal bleeding and non-satisfactory fetal status.

Uterine rupture occurs in less than 1% of closed trauma victims, but has a severe prognosis for the fetus and the mother. Approximately 75% of the cases endanger the uterine fundus due to high-impact direct trauma.[13,38] The diagnosis is complicated because other abdominal injuries can hide the signs and symptoms. The characteristic findings are abdominal pain, disproportionate uterine sensitivity to the degree of damage and non-satisfactory fetal status. The patient can be hemodynamically stable at the beginning of the evaluation and then collapse suddenly.[13] Due to vascular congestion associated with pregnancy, there is a higher incidence of splenic and retroperitoneal hemorrhage with blunt trauma, primarily if it is associated with pelvic fracture.[36,13]

An amniotic fluid embolism is a rare event after trauma, with resultant maternal mortality ranging from 30% to 50%. Signs and symptoms of presentation include respiratory distress, distributive shock, coma, seizures, disseminated intravascular coagulation and heart failure.[39]

Abdomen penetrating trauma

Penetrating trauma includes gunshot wounds and sharp weapons. Maternal mortality rates from penetrating injuries during pregnancy are lower than in non-pregnant women, and injury to the abdominal organs is less likely to occur as the pregnancy progresses. This phenomenon occurs due to the displacement of the abdominal viscera through the uterus, which together with the amniotic fluid and the fetus receive a significant impact from the second trimester of pregnancy. Fetal mortality rates range from 40% to 70%, secondary to preterm delivery, or direct fetal injury by the missile.[13]

When damage occurs, the most common injuries are those of the gastrointestinal tract. The impact of gunshot wounds depends on numerous variables including size, bullet speed, firing distance, the anatomical region of penetration, entrance angle, projectile trajectory and fetal gestational age. Indications for surgery should not be delayed evaluating fetal viability.

As reported by Mendez *et al.* in 2013,[10] there are no prospective studies or randomized controlled tests that assess the penetrating trauma during pregnancy. A retrospective study that included 321 patients, reported that this type of trauma accounted for 9% of all trauma-admitted pregnant women, with fetal mortality of 73%. Of these cases, 73% were single-load firearm, 23% by sharp weapon (knife), and 4% by multiple-load firearm.

Burn

Information on burns in pregnancy comes from reports and case series. The impact depends for the most part on the depth of the burn, and the total area of corporal surface affected; when the area exceeds the 40%, the mortality rate for the mother and the fetus is close to 100%.[40,41] This mortality increases significantly in cases where smoke has been inhaled.[42] It seems that the mother's age and the trimester do not affect the outcome or survival after severe burns.[43] However, there are insufficient data in the literature to develop specific guidelines for the management of burns in the pregnant patient. Most recommendations are based on small case series or are extrapolated from nonpregnant patients. With that in mind, several recommendations can be made with regard to airway management and fluid resuscitation.[44]

Victims of severe burns and those who burn in a closed space must be evaluated for the high possibility of carbon monoxide (CO) poisoning. CO crosses the placenta freely and fetal hemoglobin binds avidly to it, with an even higher affinity than to maternal hemoglobin. Therefore, it is recommended to administer oxygen to all symptomatic patients and non-symptomatic patients with a CO venous level above 15%.

Burns that occur during the first trimester of pregnancy have been associated with miscarriages, especially in patients who develop sepsis. Most of these losses occur within 10 days after the burn.[41] Thermal injury seems to increase the preterm delivery risk.

In the treatment of the mother with a burn, aggressive resuscitation with liquids, respiratory support and primary wound care become priorities because uterus-placental hypoperfusion is more probable in the first 12 hours. Infused liquid volume can be calculated using Parkland formula (4 ml × kg × % burnt body surface).[45]

Falls

Approximately 1 out of 4 pregnant women will fall at least once during pregnancy, [46] 79% of the events occur in the third trimester and inferior limb fracture is the most common fracture.[47] Vladutiu *et al.* evaluated prospectively 1400 pregnant women through a structured questionnaire applied from gestational weeks 17 to 22, and from weeks 27 to 30; a global incidence of injuries of 4.1 cases per 1000 exercise hours was found, most due to falls.[48] The follow-up of hospitalized pregnant patients admitted after falling demonstrated an increase in preterm birth risk of 4.4 times (95% CI 3.4–5.7), 8 times placenta abruptio risk (95% CI 4.3–15.0), 2.1 times risk of non-satisfactory fetal status (95% CI 1.6–2.8) and 2.9 times of fetal hypoxia (95% CI 1.3–6.5).[47]

Intimate partner violence

The most common form of intentional trauma in pregnancy is domestic violence (DV) or intimate partner violence (IPV). The prevalence of DV/IPV has been evaluated in more than 60 studies and 20 countries with reports during pregnancy from 1 to 57% of pregnant women,[49,50,51] compared to the 22% reported in the general female population. According to national reports of vital statistics, it is estimated that up to 159, 109 to 318, 219 pregnant women were affected by partner violence.[52] This type of abuse includes physical, sexual, psychological and sexual coercion violence. Physical violence patterns include 42% face and neck injuries, 21% torso and 25% of the patients have superficial bruises and wounds.[53]

Risk factors associated with domestic violence during pregnancy include being a single mother, substance abuse by the pregnant woman or intimate partner, the mother's low educational level, low socioeconomic status, unwanted pregnancy, domestic violence history before pregnancy and witnessed violence record.[54,55] Adverse associated pregnancy outcomes include the increase in maternal death frequency (19–95%, CI 2.7–14), uterine rupture (46–95%, CI 6.5–338), fetus death (8–95%), pre-term birth (2.4–95%, CI 1.8–3.3), membrane premature rupture (7.6–95%, CI 3.9–14) and low birth weight (5.3%, 95% CI 3.9–7.3).[56,57,58,59,60]

Suicide and opioid consumption

Palladino *et al.* calculated suicide and homicide rates during pregnancy in a multi-state sample of the National

notification system of death by violence in US from 2003 to 2007, finding rates of 2.0 per 100,000 and 2.9 per 100,000 live births, respectively.[61] Failed suicide attempts have been associated with adverse pregnancy outcomes. In a review of 2132 suicide attempts in California, women who attempted suicide but did not succeed had a higher risk of premature birth, cesarean section delivery, need for transfusion, increased respiratory distress syndrome and low birth weight.[62]

CDC reported that almost 2 million Americans are addicted to opioids[62] and their use during pregnancy increases every year. Maternal mortality by overdose is starting to be a significant cause of death. For example, the Texas Department of Health and Human Services (DSHS) reported in 2017 that 63 of 382 maternal deaths were due to this cause.[63] How many of these deaths are associated with suicide attempts and the highly probable association is yet to be identified.

CARE PROTOCOL

As in non-pregnant patients, a primary assessment must be conducted according to the vital support of trauma protocols, following the ABCDE pattern: A. management of airway with cervical spine control, B respiratory assessment with emphasis on the detection and treatment of life-threatening injuries, C evaluation of circulation, external hemorrhage control, and internal hemorrhage detection, D neurological deficit and E patient's exposure with environmental monitoring.[64,65] All women should be considered pregnant until proven otherwise because up to 3% of assessed women in a trauma center are pregnant. In 11% of cases, the diagnosis is incidental.[66]

Initial maternal and fetal resuscitation

1. According to the National Center for Injury Prevention and Control, women who are >20 weeks pregnant must be transported to a center that can fulfill a convenient and exhaustive trauma assessment and that has an integral team for life-threatening injuries management.[67]
2. All obstetric patients with trauma who are more than 20 weeks pregnant must be observed for at least 6 hours after the event.[68]
3. All pregnant patients with trauma must be treated in a health center with interdisciplinary teams that include obstetrics services.
4. Lateral detaching of the uterus should be performed to decrease aortocaval compression, especially after 20 weeks of pregnancy (see Circulation and hemorrhage section below).
5. Abdominal evaluation is essential to determine the degree of maternal and fetal involvement secondary to trauma.
6. Auscultation with fetal Doppler can be used to ensure embryo and fetal viability from 10 to 24 weeks of pregnancy. From 24 weeks onwards, continuous fetal monitoring is recommended for patients at high risk of fetal loss for at least 24 hours. Without risk factors, monitoring can be done every 6 hours.
7. The duration of fetal monitoring is controversial since no predictive factors of poor perinatal outcome have been found. The Society of Obstetricians and Gynecologists of Canada recommend a 4 hour-monitoring if the initial results are normal, and 24 hours if there is abdominal pain, bleeding, uterine activity, premature membrane rupture, non-reactive fetal monitoring, fibrinogen levels lower than 200 g/dl and trauma mechanism of high risk.[69]

Airway and cervical spine control

Owing to the complexity of maternal airways, it must be patent when the patient is unconscious by means of traction or mandibular subluxation maneuvers, preventing associated iatrogenic cervical injuries.

The incidence of failed intubation in obstetric anesthesia is 4 times higher than in the non-obstetric surgical population,[38] and the advanced management of airway with orotracheal intubation is an independent maternal mortality risk factor in pregnant trauma patients, with an RR of 6.0.[66] The decision to intubate should be taken as soon as possible, since prolonged ventilation with bad valve mark (BVM), significantly increases the risk of broncho aspiration.[70] The continued use of pressure on the cricoids (sellick maneuver) in ventilation with BVM on the unconscious mother has been suggested to reduce the risk.

Dealing with the airway of a mother with trauma should be undertaken by experts and should ideally include:

1. Use of laryngoscope to enhance success in the first intubation attempt;[66]
2. Equipment of difficult airways, including laryngeal masks and supraglottic devices;
3. Gum elastic bougie;
4. Short handle laryngoscope;
5. Endotracheal tube with an internal diameter of 0.5–1 mm, shorter than the one who would be used if not pregnant (e.g. 6, 6.5 or 7 French).

Once orotracheal intubation has been checked, a stomach decompression is performed with a nasogastric tube to minimize the risk of broncho aspiration.

The transport of the obstetric patient must be carried out with all available restraint measures including manual maneuvers, rigid collars, lateral head immobilizer and rigid stretcher associated with fixing tapes, always taking into account the possible cervical spine injury.[37]

Ventilation

Due to increased oxygen consumption, supplementary oxygen should be used freely with devices that allow FiO_2 supply as close to 100%. Decrease of 20–30% in the capacity of functional reserve and expiratory reserve volume leads to a less effective preoxygenation and desaturation can be produced much faster than in the non-pregnant patient. Therefore, a pre-oxygenation period of 3–5 minutes is recommended.[71] When using ventilatory support with BVM, one must be careful not to hyperventilate because the CO_2 blood pressure drop leads to vasoconstriction of the uterine vessels, followed by the decrease in perfusion pressure of the fetus-placental unit.

Once basic support maneuvers have been performed, if the patient continues with increased respiratory effort, it is necessary to rule out five injuries that threaten her life: unstable thorax, tensioned pneumothorax, open pneumothorax, cardiac tamponade, mass hemothorax, and once the injuries are identified, proceed to their appropriate handling.[72]

Circulation and hemorrhage control

The supine position in pregnant women decreases the cardiac expenditure by 30%, thus compromising the hemodynamic state of the obstetric patient.[73,74] Therefore, it is vital to position the patient on the left lateral side or to perform manual lateralization of the uterus to decrease the aorto-cava compression effect after week 20 of gestation or before in multiple pregnancies.[73]

The heart rate and maternal blood pressure are not reliable markers for the shock state assessment since a blood loss between 30 and 35% is required to show signs of hypovolemia. This condition must always be suspected.

Maintenance of blood volume is essential because the decrease of blood flow in the placenta increases the fetal mortality up to 85%. All patients must have two venous lines of good caliber (14 or 16)[75] to perform initial resuscitation with isotonic crystalloids at 39°C, using systolic blood pressure greater than 90 mmHg as an objective. Norepinephrine can be used as a vasopressor in accordance with the trauma equipment concept, with the consideration that fetal monitoring is a good maternal perfusion indicator.

Whenever blood transfusion is necessary, Rh-negative blood should be given if the patient's Rh factor is unknown. This is to prevent maternal sensitivity and decrease the risk of fetal isoimmunization in future pregnancies. In cases of mass bleeding secondary to pregnancy trauma, strategies of mass transfusion and hemostatic resuscitation should be used, in relation to the trauma's severity. The fresh frozen plasma (FFC) transfusion, packed red blood cells and platelets (transfusion package) must be performed in 1 : 1 : 1 ratio to avoid trauma-associated coagulopathy.[76,77]

In hemodynamically unstable pregnant women, the FAST (Focused Assessment sonography for trauma) abdominal ultrasound should be performed as part of the initial assessment of possible bleeding sources.

Neurological deficit

The primary assessment of the neurological deficit does not differ significantly from the general population. The level of consciousness should be evaluated using Glasgow Coma Scale, motor and sensitive function of each limb, and signs of focalization must be sought by assessing the size and pupil reflex.[65] If imminent brain herniation signs are found, this is

the only indication to hyperventilate the patient.

Exposure and temperature control

It is of vital importance to ensure the patient's exposure and examination to visualize possible injuries, to assess if the uterus is hypertonic, painful and to observe for the presence of vaginal bleeding or amniorrhea. Given the possibility of domestic violence during pregnancy, it is essential to expose hidden areas, especially the back, because abusers often cause injuries in hidden places to minimize the possibility of being discovered. The patient should be dried and covered with thermal blankets to reduce the hypothermia. Hypothermia, coagulopathy, plus acidosis resulting from tissue hypoperfusion can be devastating.[75]

The main goal of this kind of management is stabilization, since the fetal results are directly correlated to early and aggressive maternal resuscitation.[78] The patient will require immediate stabilization and advanced life support of trauma if they present with a cardiac arrest, a non-permeable airway, blood pressure <80/40 mmHg, pulse <50 or >140LPM, respiratory rate <10 or >24 min, FCF <110 or >160 LPM.

Because of the complexity of the approximations to this approach, the recommendation for its management among interdisciplinary teams must include intervention boxes, the creation of trauma equipment, protocol supported by flow charts, checklists, debriefing for human resources feedback right after medical care. The great conceptional change is to implement protocols and rapid response teams, which in other scenarios such as postpartum hemorrhage has had a significant impact. For example, a standardized checklist has been made for fetal trauma that integrates into the Advance Trauma Life Support process (ATLS; American College of Surgeons, Chicago, IL), and in 2019 was made public in order to establish its effectiveness.[79]

DIAGNOSTIC IMAGES

The diagnostic images in traumatized pregnant women should be re-aligned if clinically indicated and must not be delayed due to fears of fetal effects. The three most studied methods include ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI). In acute trauma, the use of MRI is not recommended.[80] Ultrasound is often of easier access in an emergency room and can provide crucial information such as gestational age, placental location, fetal presentation, and viability.

Abdominal helical CT allows the evaluation of several organ systems in stable patients. A known drawback of CT is fetal radiation exposure of up to 3.5 rads (0.035 Gy) per a study. However, the risk/benefit must ne assessed against the possibility of injury identification that could threaten the life offered by these powerful image techniques. It is important to note that radiation doses (0.05 Gy) are not associated with a high risk of anomalies, loss of a pregnancy or growth restriction.[81]

Kleihauer-Betke (KB) test is used as a routine trauma assessment component. However, the KB tests if insensitive and poorly predictive of perinatal adverse results, preterm childbirth, placental abruption, or fetal distress, in minor trauma or trauma with absent maternal injury.[82,83]

PERIMORTEM CESAREAN

Perimortem cesarean section is defined as a cesarean performed as an emergency when the pregnant woman is going into brain-cardio-respiratory failure. In a multicenter retrospective cohort study of 114,952 trauma admissions, including 441 pregnant women, 32 emergency cesarean sections were performed with a survival rate of 45% for the fetus and 75% for the mother.[84] However, these results depend on multiple factors, including the interval between maternal heart failure and childbirth, the heart failure etiology and the mother care team's experience. Based on the evidence database, the perimortem cesarean delivery can be appropriate in an imminent maternal death context or in the fourth minute after cardiopulmonary resuscitation, since both child and mother survival increases when the cesarean is performed 4 minutes after maternal heart failure.[85,86]

CONCLUSIONS

Trauma in pregnant patients is a pressing situation for the patient and medical staff because it represents a clinical scenario where organized interdisciplinary management is necessary, supported by protocols and adapted to physiological changes typical of pregnancy. The future of all teams faced with this impact reality in public health is the improvement of technical and non-technical skills permanently for the challenge of maternal and fetal survival.

PRACTICE RECOMMENDATIONS

GRADE system

1. Moderate: To ensure adequate maternal and fetal oxygenation oxygen supplementation to maintain maternal oxygen saturation >95%.

2. Moderate: All patients must have two venous lines of 14 or 16 caliber to perform initial resuscitation.

3. Moderate: Lateral detaching of the uterus should be performed to decrease aortocaval compression, especially after 20 weeks of pregnancy, to increase venous return and improve cardiac output.

4. Moderate: In hemodynamically unstable pregnant women, FAST (Focused Assessment sonography for trauma) abdominal ultrasound should be performed as part of the initial assessment of possible bleeding sources.

5. Moderate: Radiographic studies indicated for maternal evaluation should not be deferred or delayed due to concerns regarding fetal exposure to radiation.

6. Moderate: Cesarean section should be performed for viable pregnancies (≥23 weeks) no later than 4 minutes (when possible) following maternal cardiac arrest to aid with maternal resuscitation and fetal salvage.

7. High: Whenever blood transfusion is necessary, Rh-negative blood should be given if the patient's Rh factor is unknown to prevent maternal sensitivity and decrease the risk of fetal isoimmunization in the next pregnancies.

8. Moderate: Anti-D immunoglobulin should be given to all rhesus D-negative pregnant trauma patients.

CONFLICTS OF INTEREST

Author statement awaited.

REFERENCES

1 Baker SP, O'Neill B, Haddon W, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974;14:187–96.
2 Haddon W. A logical framework for categorizing highway safety phenomena and activity*J Trauma – Inj Infect Crit Care* 1972;12:193–207.
3 Haddon, W. Energy damage and the ten countermeasures strategies.*J Trauma* 1973;13:321–331.
4 Disease control priorities in developing countries.*Choice Rev Online* 2006;44.
5 Lopez AD, Mathers CD, Ezzati M, *et al*. Global burden of disease and risk factors.*Int Bank Reconstr Dev/World Bank* 2006.
6 Talley CL, Edwards A, Wallace P, *et al.* Epidemiology of Trauma in Pregnancy.*Curr Trauma* 2018;205–210.
7 Deshpande NA, Kucirka LM, Smith RN, *et al*. Pregnant trauma victims experience nearly 2-fold higher mortality compared to their nonpregnant counterparts. *Am J Obstet Gynecol* 2017;217:590.e1–9.
8 Kilpatrick SJ. Trauma in pregnancy: an underappreciated cause of maternal death.*Am J Obstet Gynecol* 2017;217:499–500.
9 Schiff MA, Holt VL. Pregnancy outcomes following hospitalization for motor vehicle crashes in Washington state from 1989 to 2001*Am J Epidemiol* 2005;161:503–10.
10 Mendez-Figueroa H, Dahlke JD, Vrees RA, *et al*. Trauma in Pregnancy: an updated systematic review.*Am J Obstet Gynecol* 2013;209:1.
11 Weiss HB, Songer TJ, Fabio A. Fetal deaths related to maternal injury.*JAMA* 2001;286:1863–8.
12 Schiff MA, Holt VL, Daling JR. Maternal and infant outcomes after injury during pregnancy in Washington state from 1989 to 1997*J. Trauma* 2002;53:939–45.
13 Foroutan J, Ashmead GG. Trauma in pregnancy.*Postgraduate Obstetrics & Gynecology* 2014;34(14):1–6.
14 Kuo C, Jamieson DJ, McPheeters ML, *et al*. Injury hospitalizations of pregnant women in the United States, 2002.*Am J Obstet Gynecol* 2007;196:161.e1–6.
15 Oliveira KD, Abdel-Razeq SS. Physiology of Pregnancy. *Curr Trauma Rep* 2018;4:211.
16 San-Frutos L, Engels V, Zapardiel I, *et al*. Hemodynamic changes during pregnancy and postpartum: A prospective study using thoracic electrical bioimpedance. *J Matern Neonatal Med* 2011;24:1333–40.
17 Thornburg KL, Jacobson SL, Giraud GD, *et al*. Hemodynamic changes in pregnancy. *Semin Perinatol* 2000;24:11–4.
18 Melchiorre K, Sharma R, Khalil A, *et al*. Maternal cardiovascular function in normal pregnancy: Evidence of maladaptation to chronic volume overload. *Hypertension* 2016;754–62.
19 Carbillon L, Uzan M, Uzan S. Pregnancy, vascular tone, and maternal hemodynamics: A crucial adaptation.*Obstetrical and Gynecological Survey* 2000;574–81.
20 Lee SWY, Khaw KS, Ngan Kee WD, Leung TY, Critchley LAH. Haemodynamic effects from aortocaval compression at different angles of lateral tilt in non-labouring term pregnant women. *Br J Anaesth* 2012;109:950–5.
21 Hegewald MJ, Crapo RO. Respiratory physiology in pregnancy. *Clin Chest Med* 2011;32:1–13.
22 Irani RA, Xia Y. The functional role of the renin-angiotensin system in pregnancy and preeclampsia.*Placenta* 2008;29:763–71.
23 Hytten F. Blood volume changes in normal pregnancy. *Clin Haematol* 1985;14:601–12.
24 Brenner B. Haemostatic changes in pregnancy. *Thromb Res* 2004;114:409–14.
25 Conklin KA. Maternal physiological adaptations during gestation, labor and the puerperium. *Semin Anesth* 1991;10:221–234.
26 Pearlman MD, Tintinallli JE, Lorenz RP. A prospective controlled study of outcome after trauma during pregnancy*Am J Obstet Gynecol* 1990;162:1502–7.
27 Kvarnstrand L, Milsom I, Lekander T, *et al*. Maternal fatalities, fetal and neonatal deaths related to motor vehicle crashes during pregnancy: a national population based study. *Acta Obstet Gynecol Scand* 2008;87:946–52.
28 Sirin H, Weiss HB, Sauber-Schatz E, *et al*. Seat belt use, counseling and motor vehicle injury during pregnancy: results from a multi-state population-based survey. *Matern Child Health J* 2007;11:505–510.
29 Motozawa Y, Hitosugi M, Abe T, *et al*. Effects of seat belts worn by pregnant drivers during low-impact collisions*Am J Obstet Gynecol* 2010;203:62.e1–8.
30 Patteson SK, Snider CC, Meyer DS, *et al*. The consequences of high-risk behaviors: trauma during pregnancy.*J Trauma* 2007;62:1015–20.
31 Ikossi DG, Lazar AA, Morabito D, *et al*. Profile of mothers at risk: an analysis of injury and pregnancy loss in 1,195 trauma patients*J Am Coll Surg* 2005;200(1):49–56.
32 Reis PM, Sander CM, Pearlman MD. Abruptio placentae after auto accidents: a casecontrol study.*J Reprod Med* 2000;45:6–10.
33 Vivian-Taylor J, Roberts CL, Chen JS,*et al*. Motor vehicle accidents during pregnancy: a population based study. *BJOG* 2012;119:499–503.
34 Ali J, Yeo A, Gana TJ, *et al*. Predictors of fetal mortality in pregnant trauma patients.*J Trauma* 1997;42:782–5.
35 El-Kady D, Gilbert WM, Anderson J, *et al*. Trauma during pregnancy: an analysis of maternal and fetal outcomes in a large population. *Am J Obstet Gynecol* 2004;190:1661–8.
36 Wyant AR. Trauma in pregnancy: Diagnosis and Management of two patients in one*JAAPA* 2013;26(5):24–30.
37 Oxford C, Ludmir J. Trauma in pregnancy. *Clinical Obstetrics And Gynecology* 2009;52:611–629.
38 Einav S, Sela HY, Weineger CF. Management and Outcomes of Trauma During Pregnancy*Anesthesiology Clin* 2013;31:141–156.
39 Smith KA, Bryce CE. Trauma in the pregnant patient: an evidence-based approach to management.*Emerg Med Pract* 2013;15:1–18;quiz 18–9.
40 Maghsoudi H, Samnia R, Garadaghi A, *et al*. Burns in pregnancy. *Burns* 2006;32:246–50.
41 Chama CM, Na'aya HU. Severe burn injury in pregnancy in northern Nigeria*J Obstet Gynaecol* 2002;22:20–2.
42 Karimi H, Momeni M, Rahbar H. Burn injuries during pregnancy in Iran.*Int J Gynaecol Obstet* 2009;104:132–4.
43 Akhtar MA, Mulawkar PM, Kulkarni HR. Burns in pregnancy: effect on maternal and fetal outcomes.*Burns* 1994;20:351–5.
44 Clark A, Bloch R y Gibbs M. Trauma in pregnancy. *Trauma Reports* 2011;12:1–16.
45 Huls CK, Detlefs C. Trauma in pregnancy. *Seminar Perinatol* 2018;42:13–20.
46 Dunning K, Lemasters G, Bhattacharya A. A major public health issue: the high incidence of falls during pregnancy*Matern Child Health J* 2010;14:720–5.
47 Schiff MA. Pregnancy outcomes following hospitalization for a fall in Washington state from 1987 to 2004*BJOG* 2008;115:1648–54.
48 Vladutiu CJ, Evenson KR, Marshall SW. Physical activity and injuries during pregnancy.*J Phys Act Health* 2010;7:761–9.

49 Beydoun HA, Tamim H, Lincoln AM, *et al*. Association of physical violence by an intimate partner around the time of pregnancy with inadequate gestational weight gain. *Soc Sci Med* 2011;72:867–73.
50 Stockl H, Hertlein L, Himsl I, *et al*. Intimate partner violence and its association with pregnancy loss and pregnancy planning.*Acta Obstet Gynecol Scand* 2012;91:128–33.
51 Silva EP, Ludermir AB, De Araujo TV, Valongueiro SA. Frequency and pattern of intimate partner violence before, during and after pregnancy. *Rev Saude Publica* 2011;45:1044–53.
52 Martin JA, Hamilton BE, Osterman MJK, *et al*. Births: Final Data for 2015.*Natl Vital Stat Rep* 2017;66:1–70.
53 Nannini A, Lazar J, Berg C, *et al*. Physical injuries reported on hospital visits for assault during pregnancy-associated period.*Nurs Res* 2008;57:144–149.
54 Umeora OU, Dimejesi BI, Ejikeme BN, *et al*. Pattern and determinants of domestic violence among prenatal clinic attendees in a referral center, south-east Nigeria. *J Obstet Gynaecol* 2008;28:769–74.
55 Meuleners LB, Lee AH, Janssen PA, *et al*. Maternal and foetal outcomes among pregnant women hospitalized due to interpersonal violence: a population-based study in western Australia, 2002–2008. *BMC Pregnancy Childbirth* 2011;11:70.
56 Fanslow J, Silva M, Whitehead A, *et al*. Pregnancy outcomes and intimate partner violence in New Zealand.*Aust N Z J Obstet Gynaecol* 2008;48:391–7.
57 Rodrigues T, Rocha L, Barros H. Physical abuse during pregnancy and preterm delivery.*Am J Obstet Gynecol* 2008;198:171.e1–6.
58 Yost NP, Bloom SL, McIntire DD, *et al*. A prospective observational study of domestic violence during pregnancy.*Obstet Gynecol* 2005;106:61–5.
59 Wiencrot A, Nannini A, Manning SE, *et al*. Neonatal outcomes and mental illness, substance abuse, and intentional injury during pregnancy. *Matern Child Health J* 2012;16:979–88.
60 El Kady D, Gilbert W, Guibo X, Smith LH. Maternal and neonatal outcomes of assaults during pregnancy.*Obstet Gynecol* 2005;105:357–363.
61 Palladino CL, Singh V, Campbell J, *et al*. Homicide and suicide during the perinatal period: findings from the national violent death reporting system. *Obstet Gynecol* 2011;118:1056–63.
62 Gandhi SG, Gilbert WM, Mcelvy SS, *et al*. Maternal and neonatal outcomes after attempted suicide. *Obstet Gynecol* 2006;107:984–90.
63 CDC. Prevent Opioid Use Disorder. https://www.cdc.gov/drugoverdose/prevention/opioid-use-disorder.html Accessed 1/18/2018.
64 Texas Health and Human Services, Texas Department of State Health Services. The Role of Opioid Overdoses in Confirmed Maternal Deaths, 2012–2015. www.dshs.texas.gov/mch/pdf/Role-of-Opioid-Overdoses-in-Confirmed-Maternal-Deaths_Dec2017_FINAL.pdf.
65 Advanced Trauma Life Support® Student Course Manual. Library of Congress Control Number: 2017907997. ISBN 78-0-9968262-3-5.
66 Sakamoto J, Michels C, Eisfelder B, *et al*. Trauma in pregnancy. *Emerg Med Clin N Am* 2019, 37:17–338.
67 CDC. Guidelines for field triage of injured patients. 2011. Available at: http://www.cdc.gov/fieldtriage/pdf/decisionscheme_poster_a.pdf.
68 Barraco RD, Chiu WC, Clancy TV, *et al*. Practice management guidelines for the diagnosis and management of injury in the pregnant patient: the EAST practice management guidelines work group. *J Trauma* 2010;69(1):211–4.
69 Jain V, Chari R, Maslovitz S, *et al*. Guidelines for the management of a pregnant trauma patient.*J Obstet Gynaecol Can* 2015;37:553–71.
70 Raja A. Trauma in pregnancy. *Emerg Med Clin N Am* 2012;30:937–948.
71 Heidemann B, McClure J. Changes in maternal physiology during pregnancy. *Br J Anaesth* 2003;3:65–68.
72 Shah AJ, Kilcline BA. Trauma in pregnancy. *Emerg Med Clin N Am* 2003;21:615–629.
73 Archer TL, Shapiro AE, Suresh PJ. Maximisation of maternal cardiac output during labour might help to prevent not only foetal hypoxaemia but also myometrial ischaemia, dysfunctional labour, uterine atony and postpartum endometritis. *Anaesth Intensive Care* 2011;39:774–5.
74 Brown S y Mozurkewich E. Trauma During Pregnancy. *Obstet Gynecol Clin N Am* 2013;40:47–57.
75 National Association of Emergency Medical Technicians, Basic and Advanced Prehospital Trauma Life Support, Ed 7. Mosby 2012.
76 Pacheco L, Saade G, Constantine M, *et al*. The Role of Massive Transfusion Protocols in Obstetrics.*Am J Perinatol* 2013;30:1–4.
77 Devika S, Lal y Beth H, Shaz. Massive transfusion blood component ratios.*Curr Opin Hematol* 2013, 20:521–525.
78 Brown HL. Trauma in pregnancy. *Obstet Gynecol* 2009;114:147–60.
79 MacArthur B, Foley M, Gray K, *et al*. Trauma in Pregnancy: A Comprehensive Approach to the Mother and Fetus.*Am J Obstet Gynecol* 2019;220:465–468.e1.
80 Puri A, Khadem P, Ahmed S, *et al*. Imaging of trauma in a pregnant patient.*Semin Ultrasound CT MR* 2012;33:37–45.
81 Committee on Obstetric Practice. ACOG committee opinion no. 299, September 2004 (replaces no. 158, September 1995): guidelines for diagnostic imaging during pregnancy. *Obstet Gynecol* 2004;104:647–51.
82 Dhanraj D, Lambers D. The incidences of positive Kleihauer-Betke test in low-risk pregnancies and maternal trauma patients.*Am J Obstet Gynecol* 2004;190:1461–3.
83 Trivedi N, Ylagan M, Moore TR, *et al*. Predicting adverse outcomes following trauma in pregnancy.*J Reprod Med* 2012;57:3–8.
84 Morris JA Jr, Rosenbower TJ, Jurkovich GJ, *et al.* Infant survival after cesarean section for trauma.*Ann Surg* 1996;223:481–8.
85 Thomas R, Sotheran W. Postmortem and perimortem cesarean section.*J R Soc Med* 2000;93:215–6.
86 Katz V, Balderston K, Defreest M. Perimortem cesarean delivery: were our assumptions correct?*Am J Obstet Gynecol* 2005;192:1916–20.
87 Chames MC, Pearlman MD. Trauma during pregnancy: outcomes and clinical management. *Clin Obstet Gynecol* 2008;51:398–408.
88 Petrone P, Talving P, Browder T, *et al*. Abdominal injuries in pregnancy: a 155-month study at two level 1 trauma centers.*Injury* 2011;42:47–9.
89 Awwad JT, Azar GB, Seoud MA, *et al*. High-velocity penetrating wounds of the gravid uterus: review of 16 years of civil war.*Obstet Gynecol* 1994;83:259–64.
90 Kuczkowski KM, Reisner LS, Benumof JL Airway Problems and New Solutions for the Obstetric Patient.*J Clin Anesth* 2003;15:552–563.