

# Trauma during pregnancy : a situation pregnant with danger

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**Abstract :** Trauma in pregnancy is currently a leading cause of non-pregnancy-related maternal death, and maternal death remains the most common cause of fetal demise. The most common etiologies of trauma in pregnancy include transportation accidents, falls, violent assaults, and burn injuries. Head and neck injuries and hemorrhagic shock account for most maternal deaths secondary to trauma. Women of childbearing age are among the population at greatest risk for trauma. The pregnant trauma victim presents a unique spectrum of challenges to the health care team. Expeditious maternal resuscitation is the most effective method of fetal resuscitation. The management of pregnant trauma victims requires the anesthesiologist, the obstetrician and the trauma surgeon to consider and understand the unique changes in anatomy and physiology that take place during pregnancy. This article reviews the current considerations for the optimal perioperative management of pregnant trauma victims.

**Key words :** Pregnancy ; trauma ; abdominal trauma ; head injury ; cervical spine injury ; fetal injury ; gun shot wounds ; blunt trauma ; motor vehicle accidents ; falls ; violent assaults ; obstetric anesthesia.

## INTRODUCTION

Trauma is defined as a disease process that occurs with seasonal and geographic variation ; it is most prevalent during summer and in industrial (urban) areas (1). Common risk (trauma-predisposing) factors include environmental conditions such as heavy traffic and bad weather, and/or physical conditions such as intoxication, fatigue, or pregnancy. Trauma in pregnancy is currently a leading cause of non-pregnancy-related maternal death, and maternal death remains the most common cause of fetal demise (2-5). The most common etiologies of trauma in pregnancy include transportation accidents, falls, violent assaults, and burn injuries (6). Women of childbearing age are among the population at greatest risk for trauma. This article will review the current considerations for the optimal anesthetic, obstetric and surgical management of pregnant trauma victims.

## GENERAL CONSIDERATIONS

The recent literature documenting anesthetic, obstetric and surgical management of pregnant trauma victims is limited (4, 5, 7-9, 10-13). In general the difficulty in perioperative management of reproductive age female trauma victims increases from no pregnancy present preoperatively to pregnancy present preoperatively. The difficulty in perioperative management of pregnant trauma victims also increases from elective, to urgent, to emergent situations (4, 9). The anatomic and physiologic changes of pregnancy such as increased oxygen requirements, decreased functional residual lung capacity, and "full stomach" may increase the difficulty of perioperative management, while decreasing the time available and the margin of safety.

The pregnant trauma victim presents a unique spectrum of challenges to the trauma healthcare team. The surgical diagnosis may be unknown at the time of incision, as may be the nature and extent of the procedure being undertaken. The fact that pregnancy may not always be known to be present to the health care team (at the scene of transportation accidents, in the emergency room, or in the operating room) additionally complicates the situation. Pregnancy must always be suspected (until proven otherwise) in any female trauma patient of childbearing age (4).

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Table 1

Physiologic changes during pregnancy and their anesthetic implications

System involved	Change (“+” increase or “-” decrease)
<i>Central nervous system :</i>	
Minimal alveolar concentration (MAC) for general anesthetics	- 40%
<i>Cardiovascular system :</i>	
Peripheral vascular resistance	- 15%
Heart rate	+ 15%
Stroke volume	+ 30%
Blood volume	+ 35%
Cardiac output	+ 40%
Plasma volume	+ 45%
<i>Pulmonary system :</i>	
Functional residual capacity (FRC)	- 20%
HCO <sub>3</sub>	- 15%
PaCO <sub>2</sub>	- 15%
PaO <sub>2</sub>	+ 10%
Respiratory rate	+ 15%
Oxygen consumption	+ 20%
Tidal volume (VT)	+ 40%
Minute ventilation (MV)	+ 50%
<i>Hematologic system :</i>	
Hemoglobin	- 20%
Clotting factors	+ 50-200%
<i>Renal system :</i>	
Glomerular filtration rate (GFR)	+ 50%

#### ANATOMIC AND PHYSIOLOGIC CHANGES OF PREGNANCY

The perioperative management of pregnant trauma victims requires the anesthesiologist, the obstetrician, and the trauma surgeon to consider and understand the unique changes in anatomy and physiology that take place during pregnancy (Table 1). During the first trimester of pregnancy, the bony pelvis protects the uterus and the fetus from direct injury. During the second trimester, the gravid uterus ascends out of the bony pelvis and displaces abdominal viscera in the cephalad direction. During this time, the anatomic pattern of injury may be more variable, and the gravid uterus may shield other structures (mesentery, stomach) from direct traumatic injury.

The cardiovascular changes during pregnancy may complicate the evaluation of intravascular volume, the assessment of blood loss, and the diagnosis of hypovolemic shock (14). Maternal hemodynamic measurements may not accurately reflect the status of the uteroplacental circulation. Physicians providing care to pregnant trauma victims should remember that pregnancy maximally dilates the uterine vasculature, so that autoregulation is absent, and uterine blood flow is entirely dependent on maternal mean arterial blood pressure (MAP).

Pregnancy represents a state of accelerated but compensated intravascular coagulation, which has both advantages and disadvantages for the pregnant trauma victim (2, 14). Increased levels of coagulation factors may improve hemostasis following trauma, however, at the same time parturients remain at increased risk for thromboembolic complications during periods of immobilization. Because buffering capacity during pregnancy is diminished, pregnant trauma victims rapidly develop metabolic acidosis during periods of hypoperfusion and hypoxia.

#### THE OBSTETRIC AIRWAY : A CAUSE FOR CONCERN

The use of general anesthesia has been steadily declining in obstetric patients (15), however, in selected cases (such as an emergent abdominal delivery in a pregnant trauma victim), it may still be necessary. Since difficult intubation is frequently unexpected, careful preanesthetic evaluation of all parturients (including pregnant trauma victims) should identify the majority of patients with difficult airway and subsequently avoid unexpected difficult airway management (16).

Anatomic and physiologic factors that place the pregnant patient at increased risk for airway management complications and difficult intubation include pregnancy induced generalized weight gain and particularly increase in breast size, respiratory tract mucosal edema, decreased functional residual capacity (FRC) and increased oxygen consumption.

It is not uncommon for the parturient to gain 20 kg or more during pregnancy. A high body mass index (BMI) has been associated with an increased risk of airway management problems including difficult intubation. Weight gain and uterine enlargement leads to a decreased FRC, which hastens the onset of hypoxemia during periods of hypoventilation or apnea. Pregnancy results in significant increase in breast size. In the supine position the enlarged breasts tend to fall back against the neck, which can interfere with insertion of the laryngoscope and intubation. Therefore use of a short-handled laryngoscope has been widely recommended in obstetric patients (16). In addition, placing the patient in the sniffing position helps keep the laryngoscope handle away from the breasts.

Vascular engorgement of the respiratory tract during pregnancy leads to edema of the nasal and oral pharynx, larynx and trachea (16). These changes in the nasal mucosa may result in bleeding

at the time of airway manipulation or nasogastric tube placement. Laryngeal edema may inhibit the passage of standard size endotracheal tube, despite adequate vocal cord visualization at laryngoscopy and require a smaller internal diameter tube size. Furthermore tongue enlargement may make it difficult to retract the tongue into the mandibular space during direct laryngoscopy.

Increased maternal metabolic requirements combined with fetal metabolic needs and increased maternal respiratory requirements result in increased maternal oxygen consumption. In approximately 12-15% of parturients at term, the gravid uterus may compress the vena cava and aorta in the supine position causing decreased venous return, decreased cardiac output, blood pressure and uterine blood flow. Therefore, pregnant women should not be allowed to assume the supine position.

Pregnant patients have an elevated gastric acid content, with decreased pH, and reduced function of the gastro-esophageal sphincter secondary to the mechanical and hormonal effects of pregnancy. Consequently, all parturients should be assumed to have full stomachs and are at increased risk for aspiration of gastric contents (16). General anesthesia should always be induced with cricoid pressure in order to decrease the risk of regurgitation of gastric contents in the pharynx. Lung denitrogenation with the administration of 100% oxygen is mandatory before rapid sequence induction of general anesthesia.

#### OBSTETRIC COMPLICATIONS

Trauma to the abdomen and the gravid uterus threatens both the mother and the fetus (2, 4, 5, 11, 13). Because the fetus is dependent on its mother for its oxygen requirements, an uninterrupted supply of oxygenated blood must be provided to the fetus at all times. Although it occurs infrequently, trauma-related uterine rupture may be life threatening; maternal mortality rates approach 10%, while fetal mortality rates may approach 100%. Placental abruption complicates 1-5% of minor injuries and 20-50% of major injuries. Except for maternal death, placental abruption is the most frequent cause of maternal death after trauma. Fetal death, resulting from injuries to the obstetric patient is most commonly associated with placental abruption (2, 10).

Compression of the vena cava by the uterus reduces venous return to the heart thereby decreas-

ing cardiac output and exacerbating preexisting shock. Unless a spinal injury is suspected, the pregnant patient should be transported and evaluated on her left side. Although diagnostic irradiation poses a risk to the fetus, necessary radiographic studies should be obtained (17, 18). If the mother's condition is stable, the status of the fetus and the extent of uterine injury determine further management. A potentially viable fetus that shows no signs of distress should be monitored by external ultrasonography. Since premature labor is always a possibility in these patients, an external tocotransducer should be used to detect the onset of uterine contractions. If premature labor ensues, tocolytic therapy may be initiated. When a viable fetus shows signs of distress, despite successful resuscitative measures, a cesarean delivery must be performed expeditiously. A nonviable fetus may be managed conservatively in utero to optimize maternal oxygenation and circulation. Primary repair of all maternal wounds should be attempted in a critically injured mother carrying a viable gestation, even at the expense of fetal well-being.

#### TRAUMA TO THE GRAVID UTERUS

Trauma to the abdomen and the gravid uterus may result from MVAs, falls and violent assaults. The prevalence of violence against pregnant women has been reported to range from 0.9 to 20.1% (13, 19). GAZAMARIAN *et al.* concluded that violence against pregnant women might be more prevalent than pregnancy specific disorders such as preeclampsia, gestational diabetes, and abnormal placentation (19). Violent assaults may include blunt trauma or penetrating trauma, or both, to the pregnant women's abdomen. Falls may result from an unstable gait often associated with pregnancy. The incidence of trauma increases with each pregnancy trimester (Table 2); 8% of injuries occur during the first trimester, 40% during the second trimester, and 52% during the third trimester (2). The incidence of splenic injuries and retroperitoneal hemorrhage is greater in pregnancy

Table 2

Incidence of trauma during pregnancy

Pregnancy trimester	Incidence of traumatic injury
First	8%
Second	40%
Third	52%

due to the pregnancy-induced increased tissue vascularity.

Penetrating abdominal trauma usually results from gunshot wounds (GSW) and/or stab wounds to the gravid uterus, or it may be sustained during a MVA. CROSBY *et al.* in a retrospective study of pregnant women involved in MVAs found that maternal death was the most frequent cause of fetal demise (20). After penetrating abdominal trauma fetal death rates often exceed maternal death rates with maternal death rate of 5% of cases and fetal death rate of 59-80% of cases.

#### THE HEAD-INJURED PREGNANT TRAUMA VICTIM

Head and neck injuries, respiratory failure and hypovolemic shock constitute the most frequent causes of trauma-related maternal death in pregnancy (2). The most common etiologies of head injuries include transportation accidents and falls (21).

In the head-injured reproductive-age-female trauma victims there appears to be a number of conflicting constraints pertinent to the anesthetic management, and particularly to the management of the airway. These usually include : 1) an uncertain intracranial pressure (possibly elevated), 2) an uncertain cervical spine (possibly fractured), 3) an uncertain airway (possibly difficult), 4) an uncertain volume status (possibly decreased), 5) an uncertain level of consciousness (possibly comatose or combative), 6) an "uncertain stomach" (almost always full), 7) an uncertain oxygenation (possibly decreased), and finally 8) an uncertain obstetrical status (possibly pregnant).

If there is an uncertainty about the integrity of the cervical spine, direct laryngoscopy should be avoided, and fiberoptic (awake fiberoptic) intubation of the trachea, if feasible (time constraints, and/or equipment availability), should be considered (8). If direct laryngoscopy is deemed necessary, an "in line stabilization" of the head and neck by an assistant to prevent extension and rotation of the cervical spine is indicated. If awake fiberoptic intubation of the trachea is selected it is essential to titrate analgesic and sedative drugs carefully to maintain continual meaningful verbal communication between the anesthesiologist and the patient. Respiratory depression and aspiration of stomach contents during the application of a local anesthetic agent is much less likely to occur if the patient remains awake and alert. In addition, a rational alert mother minimizes the risk of neonatal depres-

sion. Midazolam is the benzodiazepine recommended for these purposes, however, it is highly unionized and very lipophilic, and its fetal/maternal ratio is 0.76 at 15-20 minutes after maternal administration. However, unlike other benzodiazepines, the ratio falls rapidly. No adverse fetal effects have been reported (16).

It has been empirically established that trauma victims with a GCS of 8 or less usually require intubation and mechanical ventilation for both, the airway control and control of the intracranial pressure. However, trauma victims with "good" GCS's can "talk and deteriorate/die" following traumatic head injury, particularly an injury associated with loss of consciousness, and delayed deterioration has been observed up to 48 hours after the initial insult.

The succinylcholine-induced ICP increase has been a concern in the past, nevertheless ; recent analysis of the problem has shown that the magnitude and clinical importance of this increase have been grossly exaggerated. It is currently believed that when there is an urgent need to secure an airway in the head-injured pregnant trauma victim, succinylcholine is an appropriate and safe drug, and it should be used. All of the intravenous anesthetic agents (except ketamine) cause some degree of vasoconstriction, and therefore decrease in cerebral blood flow (CBF). All of the inhaled agents have some cerebral vasodilatory effect, however, their administration is usually consistent with acceptable ICP levels (22, 23).

There seems to be no ideal "best" way of perioperative anesthetic management of the head-injured pregnant trauma victim. The best approach should incorporate all the various factors listed above, and should be determined by the relative weight of these factors. Nevertheless, the A.B.C or resuscitation should always be an initial higher priority than ICP of neuroanesthesia, and aggressive maternal resuscitation should always be the initial highest priority, which often proves lifesaving for both the parturient and her fetus.

#### THERMAL INJURY IN PREGNANCY

The incidence of pregnancy in women admitted to hospital with thermal injuries has been estimated at 6.8 to 7.8% (24, 25). The maternal and fetal outcome is related to the extent, presence or absence of complications of thermal trauma and to the gestational age of the fetus. In parturients with 25-50% of the total body surface area (TBSA)

burned the mortality rates reach 63% for both the mother and the fetus (26). Urgent delivery has been considered the treatment of choice in term or near term pregnant women with extended burn injury (27). As true for any trauma victim, initial treatment of the parturient with thermal injury should involve attention to the airway, breathing, and circulation. Pulmonary function can be directly or indirectly affected by thermal injury. Direct inhalational injury is usually manifested as upper airway edema, which can lead to life-threatening airway obstruction. However, lower airways can also be subjected to direct thermal injury or can be injured by exposure to smoke and/or toxic products of combustion.

Indications of inhalational injury include facial burns, singed nasal hair or eyebrows, stridor, hoarseness, soot in sputum, respiratory distress, or history of combustion in a close space. Many patients with inhalational injury, however, do not demonstrate any signs until several hours post-exposure. Major burns can alter pulmonary function even in the absence of direct lung injury. For example, vascular permeability can be increased throughout the entire microcirculation system and may contribute to the development of pulmonary edema and acute respiratory distress syndrome (ARDS). Within hours after a burn the patient becomes hypermetabolic. The manifestations usually include hyperthermia, increased oxygen consumption, tachypnea, tachycardia, and increased serum catecholamine levels (28).

Indications for early intubation include the presence of copious secretions, hypoxia and/or upper airway edema that may subsequently progress to airway obstruction. If in doubt, the trachea should be intubated before edema develops and intubation becomes technically difficult. Timely and aggressive anesthetic (including early control of the airway) and obstetric (including early delivery) management of the pregnant thermal trauma victim is vital for optimal maternal and fetal outcome.

#### CARDIOPULMONARY RESUSCITATION IN PREGNANCY

When cardiac arrest occurs in a parturient, standard cardiopulmonary resuscitation guidelines apply without modification (2, 29, 30). However, placing the pregnant woman supine on a firm, flat surface, which provide optimal resuscitation conditions in non-pregnant subjects may (and most likely will) exacerbate aortocaval compression in the

parturient. Although manual left uterine displacement or left lateral tilt may relieve aortocaval compression, it may also interfere with effective chest compression and resuscitation efforts. Cardiopulmonary resuscitation should be initiated as soon as possible after cardiac arrest. Cesarean delivery may facilitate maternal resuscitation by relieving aortocaval compression, increasing venous return and cardiac output during cardiopulmonary resuscitation efforts (2). KATZ *et al.* have advocated that if a pregnant woman suffers a cardiopulmonary arrest from any cause during the third trimester, a perimortem Cesarean section should be performed (31). The authors recommended so called the "4-minute rule", which states that perimortem cesarean delivery should begin within 4 minutes of the cardiac arrest, and the fetus should be delivered within 5 minutes of maternal cardiac arrest (31).

#### CONCLUSION

The first priority in resuscitation of a pregnant trauma victim is stabilization of the mother, and only then should attention be directed to the fetus. In general the initial resuscitation of the pregnant trauma victim should follow advanced trauma life support (ATLS) principles. Electronic fetal heart rate (FHR) monitoring helps guide obstetric, surgical and anesthetic management during maternal resuscitation, surgery and postoperative management in the intensive care unit.

Provision of care for the trauma patients (including pregnant trauma victims) is perhaps the highest challenge of the practice of anesthesiology. It requires simultaneous provision of anesthesia and intensive care (volume resuscitation) to patients with injuries, which may not be fully assessed, and co-existing diseases, which may not be fully known perioperatively. At the same time, provision of care to the trauma victims exposes the trauma health care provider to professional hazards such as hepatitis and the human immunodeficiency virus (HIV) as well as to medicolegal liability. Accidental injury, unplanned surgery, pregnancy loss, and the lack of established physician-patient relationship all may contribute to the risk of litigation.

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## References

- Martinez R., *Injury control : A primer for physicians*, ANN. EMERG. MED., **19**, 97-101, 1990.
- Baker B. W., *Trauma*. In : Chestnut D. H., ed. *Obstetric Anesthesia : Principles and Practice*. Mosby, St. Louis, 1041-1050, 1999.
- Aitokallio-Tallberg A., Halmesmaki E., *Motor vehicle accident during the second or third trimester of pregnancy*, ACTA OBSTET. GYNECOL. SCAND., **76**, 313-317, 1997.
- Kuczowski K. M., Ispirescu J. S., Benumof J. L., *Trauma in pregnancy : anesthetic management of the parturient with multiple gun shot wounds to the gravid uterus and fetal injury*, J. TRAUMA, **54**, 420, 2003.
- Daponte A., Khan N., Smith M. D., Gegiannis E., *Trauma in pregnancy*, S. AFR. J. SURG., **41**, 51-54, 2003. An excellent and comprehensive review of surgical management of the pregnant trauma patient.
- Shah A. J., Kilcline B. A., *Trauma in pregnancy*, EMERG. MED. CLIN. NORTH AM., **21**, 615-629, 2003.
- Wong S. Y., Wong K. M., Chao A. S., et al., *Awake fiberoptic intubation for cesarean section in a parturient with odontoid fracture and atlantoaxial subluxation*, CHANG GUNG MED. J., **26**, 352-356, 2003.
- KUCZKOWSKI K. M., *Peripartum anaesthetic management of a parturient with spinal cord injury and autonomic hyperreflexia*, ANAESTHESIA, **58**, 823-824, 2003.
- Kuczowski K. M., Fouhy S. A., Greenberg M., Benumof J. L., *Trauma in pregnancy : anaesthetic management of the pregnant trauma victim with unstable cervical spine*, ANAESTHESIA, **58**, 822, 2003.
- Schiff M. A., Holt V. L., *The injury severity score in pregnant trauma patients : predicting placental abruption and fetal death*, J. TRAUMA, **53**, 946-949, 2002.
- Hyde L. K., Cook L. J., Olson L. M., et al., *Effect of motor vehicle crashes on adverse fetal outcomes*, OBSTET. GYNECOL., **102**, 279-286, 2003.
- Weiss H. B., Strotmeyer S., *Characteristics of pregnant women in motor vehicle crashes*, INJ. PREV., **8**, 207-210, 2002.
- Rachana C., Suraiya K., Hisham A. S., et al., *Prevalence and complications of physical violence during pregnancy*, EUR. J. OBSTET. GYNECOL. REP. BIOL., **103**, 26-29, 2002.
- Chulu A., Kuczowski K. M., *Anaesthetic management of the parturient with massive peripartum haemorrhage and fetal demise*, ANAESTHESIA, **58**, 933-934, 2003.
- Hawkins J. L., Koonin L. M., Palmer S. K., et al., *Anesthesia-related deaths during obstetric delivery in the United States 1979-1990*, ANESTHESIOLOGY, **86**, 277-283, 1997.
- Kuczowski K. M., Reisner L. S., Benumof J. L., *Airway Problems and New Solutions for the Obstetric Patient*, JOURNAL OF CLINICAL ANESTHESIA, **15**, 552-563, 2003.
- Falimirski M. E., Gonzalez R., Rodriguez A., Wilberger J., *The need for head computed tomography in patients sustaining loss of consciousness after mild head injury*, J. TRAUMA, **55**, 1-6, 2003.
- Ardill W., Gidado S., *Penetrating head wound, a remarkable case*, J. TRAUMA, **60**, 120-123, 2003.
- Gazamarian J. A., Lazorick S., Spitz A. M., et al., *Prevalence of violence against pregnant women*, JAMA, **275**, 1915-1920, 1996.
- Crosby W. M., Costiloe J. P., *Safety of lap-belt restraint for pregnant victims of automobile collisions*, N. ENGL. J. MED., **284**, 632-636, 1971.
- Kleiven S., Peloso P. M., von Holst H., *The epidemiology of head injuries in Sweden from 1987 to 2000*, INJ. CONTROL SAF. PROMOT., **10**, 173-180, 2003.
- Barker S. J., *Anesthesia for trauma*, ANESTH. ANALG., Suppl., **96**, 1-6, 2003.
- Warner D. S., *Neuroanesthesia 2000*, ANESTH. ANALG., **90**, 1238-1240, 2000.
- Fildes J., Reed L., Jones N., et al., *J. Trauma : the leading cause of maternal death*, J. TRAUMA, **32**, 643-645, 1992.
- Cheah S. H., Sivanesaratnam V., *Burns in pregnancy - maternal and fetal prognosis*, AUST. N. Z. J. OBSTET. GYNAECOL., **29**, 143-145, 1989.
- Mabrouk A. R., el-Feky A. E., *Burns during pregnancy : a gloomy outcome*, BURNS, **23**, 596-600, 1997.
- Ullmann Y., Blumenfeld Z., Hakim M., et al., *Urgent delivery, the treatment of choice in term pregnant women with extended burn injury*, BURNS, **23**, 157-159, 1997.
- Kuczowski K. M., Fernandez C. L., *Thermal injury in pregnancy : anesthetic considerations*, ANAESTHESIA, **58**, 931-932, 2003.
- Morris S., Stacey M., *ABC of Resuscitation : Resuscitation in pregnancy*, BMJ, **327**, 1277-1279, 2004.
- Kuczowski K. M., *Trauma in reproductive-age women*, S. AFR. J. SURG., **42**, 32, 2004.
- Katz V. L., Dotters D. J., Droegemuller W., *Perimortem cesarean delivery*, OBSTET. GYNECOL., **68**, 771-776, 1986.