A situation pregnant with danger: **Trauma in pregnancy**

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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 foetal demise. The most common aetiologies of trauma in pregnancy include transportation accidents, falls, violent assaults and burn injuries. Head and neck injuries and haemorrhagic 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 healthcare team. Expeditious maternal resuscitation is the most effective method of foetal resuscitation. The management of pregnant trauma victims requires the anaesthesiologist, 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.

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 foetal demise.[2-5] The most common aetiologies 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 of trauma. This article will review the current considerations for the optimal anaesthetic, obstetric and surgical management of pregnant trauma victims.

General considerations

The recent literature documenting anaesthetic, obstetric and surgical management of pregnant trauma victims is limited.[4,5,7–9,10–13] In general the difficulty in perioperative management of female trauma victims of reproductive age 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 anatomical and physiological 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 healthcare 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]

Anatomical and physiological changes of pregnancy

The perioperative management of pregnant trauma victims requires the anaesthesiologist, the obstetrician and the trauma surgeon to consider and understand the unique changes in anatomy and physiology that take place during pregnancy (see Table I).

Table I: Physiological changes during pregnancy and their aesthetic implications

System involved	Change ("+" increase or "-" "decrease)
Central nervous system:	
Minimal alveolar concentration (MAC) for general anaesthetics	-40%
Cardiovascular system:	
Peripheral vascular resistance	-15%
Heart rate	+15%
Stroke volume	+30%
Blood volume	+35%
Cardiac output	+40%
Plasma volume	+45%
Pulmonary system:	
Functional residual capacity (FRC)	-20%
HCO_3	-15%
$PaCO_2$	-15%
PaO_2	+10%
Respiratory rate	+15%
Oxygen consumption	+20%
Tidal volume (VT)	+40%
Minute ventilation (MV)	+50%
Haematological system:	
Haemoglobin	-20%
Clotting factors	+50–200%
Renal system:	
Glomerular filtration rate (GFR)	+50%

During the first trimester of pregnancy, the bony pelvis protects the uterus and the foetus 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 hypovolaemic shock.[14] Maternal haemodynamic 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 haemostasis following trauma; however, at the same time parturients remain at increased risk of thromboembolic complications during periods of immobilisation. Because buffering capacity during pregnancy is diminished, pregnant trauma victims rapidly develop metabolic acidosis during periods or hypoperfusion and hypoxia.

The obstetric airway: a cause for concern

The use of general anaesthesia 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 pre-anaesthetic 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]

Anatomical and physiological factors that place the pregnant patient at increased risk of airway management complications and difficult intubation include pregnancy-induced generalised weight gain and particularly increase in breast size, respiratory tract mucosal oedema, 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 hypoxaemia during periods of hypoventilation or apnoea. 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 oedema 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 oedema may inhibit the passage of standard size endotracheal tube, despite adequate vocal cord visualisation 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 foetal 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-oesophageal 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 of aspiration of gastric contents.[16] General anaesthesia 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 anaesthesia.

Obstetric complications

Trauma to the abdomen and the gravid uterus threatens both the mother and the foetus.[2,4,5,11,13] Because the foetus is dependent on its mother for its oxygen requirements, an uninterrupted supply of oxygenated blood must be provided to the foetus at all times. Although it occurs infrequently, trauma-related uterine rupture may be life threatening; maternal mortality rates approach 10%, while foetal 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. Foetal 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 decreasing cardiac output and exacerbating pre-existing 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 foetus, necessary radiographic studies should be obtained.[17,18] If the mother's condition is stable, the status of the foetus and the extent of uterine injury determine further management. A potentially viable foetus that shows no signs of distress should be monitored by external ultrasonography. Since premature labour is always a possibility in these patients, an external tocotransducer should be used to detect the onset of uterine contractions. If premature labour ensues, tocolytic therapy may be initiated. When a viable foetus shows signs of distress, despite successful resuscitative measures, a caesarean delivery must be performed expeditiously. A non-viable foetus may be managed conservatively in utero to optimise 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 foetal 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. conclude that violence against pregnant women might be more prevalent than pregnancy-specific disorders such as pre-eclampsia, gestational diabetes and abnormal placentation.[19] Violent assaults may include blunt trauma or penetrating trauma, or both, to the pregnant woman's abdomen. Falls may result from an unstable gait often associated with pregnancy. The incidence of trauma increases with each pregnancy trimester (see Table II); 8% of injuries occur during the first trimester, 40% of injuries during the second trimester and 52% during the third trimester.[2] The incidence of splenic injuries and retroperitoneal haemorrhage is greater in pregnancy due to the pregnancy-induced increased tissue vascularity.

Table II: Incidence of trauma during pregnancy

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

Penetrating abdominal trauma usually results from gunshot wounds (GSWs) 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 foetal demise.[20] After penetrating abdominal trauma, foetal death rates often exceed maternal death rates, with maternal death rate of 5% of cases and foetal death rate of 59–80% of cases.

The head-injured pregnant trauma victim

Head and neck injuries, respiratory failure and hypovolaemic shock constitute the most frequent causes of trauma-related maternal death in pregnancy.[2] The most common aetiologies of head injuries include transportation accidents and falls.[21]
In female trauma victims of reproductive age with head injuries there appears to be a number of conflicting constraints pertinent to anaesthetic 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 fibreoptic (awake fibreoptic) intubation of the trachea, if feasible (time constraints, and/or equipment availability), should be considered.[8] If direct laryngoscopy is deemed necessary, an "inline stabilisation" of the head and neck by an assistant to prevent extension and rotation of the cervical spine is indicated. If awake fibreoptic intubation of the trachea is selected, it is essential to titrate analgesic and sedative drugs carefully to maintain continual meaningful verbal communication between the anaesthesiologist and the patient. Respiratory depression and aspiration of stomach contents during the application of a local anaesthetic agent is much less likely to occur if the patient remains awake and alert. In addition, a rational, alert mother minimises the risk of neonatal depression. Midazolam is the benzodiazepine recommended for these purposes; however, it is highly unionised and very lipophilic, and its foetal/maternal ratio is 0.76 at 15 to 20 minutes after maternal administration. However, unlike other benzodiazepines, the ratio falls rapidly. No adverse foetal effects have been reported.[16]

It has been empirically established that trauma victims with a Glascow Coma Scale (GCS) of 8 or less usually require intubation and mechanical ventilation for both airway control and control of intracranial pressure (ICP). However, trauma victims with 'good' GCSs 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 anaesthetic agents (except ketamine) cause some degree of vasoconstriction, and therefore a 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 perioperative anaesthetic 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 ABC or resuscitation should always be an initial higher priority than ICP of neuroanaesthesia, and aggressive maternal resuscitation should always be the initial highest priority, which often proves lifesaving for both the parturient and her foetus.

Thermal injury in pregnancy

The incidence of pregnancy in women admitted to hospital with thermal injuries has been estimated at 6.8-7.8%.[24,25] The maternal and foetal outcome is related to the extent, presence or absence of complications of thermal trauma and to the gestational age of the foetus. In parturients with 25–50% of the total body surface area (TBSA) burned, the mortality rates reach 63% for both the mother and the foetus.[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 oedema, 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 oedema and acute respiratory distress syndrome (ARDS). Within hours after a burn, the patient becomes hypermetabolic. The manifestations usually include hyperthermia, increased oxygen consumption, tachypnoea, tachycardia and increased serum catecholamine levels.[28]

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

Conclusion

The first priority in resuscitation of a pregnant trauma victim is stabilisation of the mother, and only then should attention be directed to the foetus. In general the initial resuscitation of the pregnant trauma victim should follow advanced trauma life support (ATLS) principles. Electronic foetal heart rate (FHR) monitoring helps guide obstetric, surgical and anaesthetic 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 anaesthesiology. It requires simultaneous provision of anaesthesia 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 healthcare provider to professional hazards such as hepatitis and the human immunodeficiency virus (HIV) as well as to medico-legal liability. Accidental injury, unplanned surgery, pregnancy loss and the lack of established physician-patient relationship all may contribute to the risk of litigation. SAJAA

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