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Trauma in Pregnancy

A Review

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Trauma is one of the leading causes of morbidity and mortality during pregnancy. Although many aspects of trauma management are universal, the pregnant patient presents a unique clinical challenge. The approach to the pregnant patient with trauma necessitates understanding major physiological, endocrinological, and anatomical differences between pregnant patients and their non-pregnant counterparts, as well as simultaneous consideration for the well-being of the fetus.

Severe trauma during pregnancy is relatively rare, however minor and blunt injuries are common, complicating up to 6-7% of all pregnancies. Distribution of most types of trauma in each trimester is random, except for falls. The incidence of falls increases with advancing gestation, with up to 80% occurring after 32 weeks. This may be due to easy fatigability, more fainting spells and hyperventilation, increasing abdominal protuberance, and loosening pelvic joints that may contribute to unsteadiness.

Trauma can be classified into blunt and penetrating injuries. Blunt trauma accounts for the most frequent admissions. It includes falls, motor vehicle accidents, direct blows to the abdomen, and domestic abuse. Penetrating trauma includes stab and gunshot wounds, along with more severe motor vehicle accidents. For the purpose of guiding management protocols, trauma is further classified into minor and major trauma. Minor trauma includes the majority of cases, and major trauma includes most motor vehicle accidents and direct blows to the abdomen.

Maternal Physiology

Physiological changes of pregnancy are summarized in table 1. Maternal blood volume and plasma volume is increased by about 50% and increases steadily throughout pregnancy and plateaus by 34 weeks gestation. The red blood cell mass also increases but not to the same degree as plasma volume, resulting in a decreased hematocrit (31-35% is normal) in the latter half of the third trimester. This is often referred to as a physiologic anemia of pregnancy. In the trauma situation, where there may be significant hemorrhage, patients may lose up to 1200-1500ml of blood before exhibiting signs and symptoms of hypovolemia.

What's Inside…

Table 1 – Maternal Physiology

	Changes In Pregnancy	Significance In Trauma
Blood Volume	Increased	Marked blood loss occurs before clinical manifestations
Blood composition	Dilutional Anemia ↑ Leukocytes	Low Hb or High WBC may be misinterpreted
Cardiac Output	Increased	Requirements may be compromised by seemingly minor deficit
Heart Rate	Increased	Not a reliable clinical sign
Blood Pressure	Decreased in 1st Trimester Increasingly dependent on maternal position	Left Lateral decubitus position critical
Respiratory Rate	Increased	Not a reliable clinical sign
Blood Gases	Hypocapneic	Subtle increase in PaCO2 may represent significant acidosis
Oxygen Consumption	Increased	Requirements (fetal and maternal) may be compromised by seemingly minor deficit
Gastrointestinal Function	Hypomotility	Assume full stomach
Renal Function	Increased filtration and renal blood flow	Urine output is critical clinical parameter of volume status
Endocrine Function	↑ size of Pituitary Gland	Decreased perfusion can result in pituitary deficiency
Neurological Function	+/- Ecclampsia: hyperreflexic or seizures	Careful to distinguish neurologic manifestations of trauma vs ecclampsia

The composition of blood also changes during pregnancy. The leukocyte count increases where a value of 15x 10^9/L may be normal and can be up to 25 x 10^9/L during minimal stress or in labour. Levels of serum fibrinogen, plasma proteins and clotting factors are elevated, while serum albumin levels fall in pregnancy, causing a drop in total serum protein levels leading to a decrease in colloid oncotic pressure. Serum osmolarity remains at about 280 mOsm/L throughout pregnancy.

Cardiac output increases by 20-30% (~1.0 – 1.5 L/minute) after 10th week of pregnancy. This occurs along with the increase in plasma volume combined with the decrease in total peripheral vascular resistance. By the third trimester of pregnancy, the uteroplacental unit receives 20% of the total cardiac output. As the uterus increases in size, particularly in the second half of pregnancy, cardiac output becomes increasingly dependent on maternal position. In the supine position, vena caval compression may decrease cardiac output by 30% due to decreased venous return from the lower extremities.

Heart rate also increases gradually throughout pregnancy by 10 to 15 beats/min, reaching a maximum by third trimester. In trauma, an increased HR may be wrongly interpreted as physiological or mask response to hypovolemia until the hypovolemia becomes severe.

Blood pressure usually follows a pattern of decline in the first trimester. It then levels out in the second trimester and returns back to nonpregnant levels during the third trimester. Expected normal decline in systolic pressure is minimal (2-4mmHg), while diastolic pressure falls 5-15mmHg. Although low maternal BP may be physiological, it should not be misinterpreted in a trauma situation. Hypotension and tachycardia significant enough to cause clinical concern may be a late sign of severe hyovolemia and clinical deterioration.

After 20 weeks, the uterus rises to the level of the inferior vena cava, which causes compression when supine. By term, it can be

expected that the inferior vena cava may be completely occluded when supine, thereby reducing systolic BP up to 30mmHg due to decreased preload. Venous hypertension is also common in the lower extremities during the third trimester. Adequate venous return through collateral channels to the azygous vein determines extent of drop in blood pressure. Left lateral decubitus position may relieve hypotension that is attributable to supine position. Keep in mind that in the trauma situation, normal blood pressure upon presentation does not rule out internal bleeding. Maternal physiology allows for extra reserve so that up to 35% of blood volume may be lost before clinical signs of maternal hypovolemia are observed.

Respiratory changes during pregnancy may also complicate the interpretation of vital parameters in trauma. Hypocapnea, for instance, may be normal in late pregnancy. Expected arterial pCO2 in pregnant patients is approximately 30mm Hg from second trimester to term. Thus PaCO2 of 35-40 mmHg may be associated with impending respiratory failure during pregnancy. Also, pregnant women have a decreased buffering capacity due to low HCO3 levels. These adaptations in respiratory physiology are primarily a result of the unique maternal hormonal status. Placental progesterone stimulates the respiratory center in the medulla causing increased minute ventilation and increased tidal volume. Another contributing factor is the elevated diaphragm, which occurs due to the enlarging uterus and can cause a 20% decrease in residual volume. Consequently, there is greater gas exchange of O2 for CO2 in a chronic compensated respiratory alkalosis and reduced blood buffering capacity (low HCO3).
Despite the decreased maternal oxygen reserve, oxygen consumption is increased by approximately 15% due to demands of maternal organs, the growing fetus, and placenta. Therefore, a higher pCO2 in the latter half of pregnancy may reflect inadequate ventilation and potential respiratory acidosis that may precipitate fetal distress.

Gastrointestinal adjustments during pregnancy involve hypomotility of all smooth muscle. As a result, pregnant women have prolonged gastric emptying time. Thus it is safest to always assume a full stomach in pregnancy. Early gastric tube decompression is particularly important to avoid aspiration.

Renal blood, and plasma flow and glomerular filtration rate are markedly increased in pregnancy. Levels of creatinine and blood urea nitrogen fall to approximately half of prepregnancy levels. Glycosuria is common because of increased filtration. In a trauma situation, urinary output monitoring to assess perfusion is one of the most reliable parameters of volume status.

The pituitary gland increases in size by 30-50% during pregnancy. This becomes significant in a trauma situation as shock-like states may cause necrosis of the anterior pituitary gland, resulting in pituitary insufficiency.

Neurological function is unchanged in pregnancy. However, some pregnancy associated complications, such as ecclampsia, present with neurological symptoms. It is critical to be able to distinguish these neurological signs from those secondary to other causes. Seizures that occur with hypertension, hyperreflexia, and/or proteinuria should strongly suggest ecclampsia.

Maternal Anatomy

Anatomic changes that accompany pregnancy and their significance in trauma are summarized in Table 2. The most obvious anatomic changes primarily encompass the pregnant abdomen. The uterus grows from a 7cm, 70g organ at conception to a 36cm, 1000g organ at term. In the first trimester, the uterus remains an intrapelvic organ, protected by the bony pelvis. During this period, the uterus is a small, thick- walled structure. In the second trimester, the uterus becomes an abdominal organ, vulnerable to direct injury. The fetus, however, remains mobile and cushioned by a relatively generous amount of amniotic fluid throughout this time. In the third trimester, the uterus is large and thin walled. Its contents become more susceptible to injury, including penetration, rupture, abruption, and premature rupture of membranes. Also, pelvic fractures in late gestation may result in fetal skull fracture or

serious fetal intracranial injury if vertex presentation. In addition, amniotic fluid may itself become a source of embolism and cause disseminated intravascular coagulation following trauma if it gains access to the intravascular space.

peritoneal irritation is altered by the stretching abdominal wall. Expected muscle guarding and rebound is blunted despite significant intraabdominal organ injury. Physical exams are thus unreliable in pregnant patients, and potentially more misleading with advancing pregnancy.

Table 2 – Maternal Anatomy

	In Pregnancy	In Trauma
Uterus --1st Trimester	Uterus intrapelvic organ	Uterus protected by pelvis
--2nd Trimester	Uterus abdominal organ	Uterus vulnerable organ Fetus cushioned by generous amniotic fluid
--3rd Trimester	Uterus large and thin walled	Uterus and contents more susceptible to injury/ penetration
Pelvis	Contains fetal presenting part	Pelvic fractures may injure fetal skull if vertex
Bladder	Hyperemic and Displaced into abdominal cavity after 12 weeks GA	Injury can cause significant blood loss
Abdominal Viscera	Shielded by uterus early in pregnancy, then gradually displaced cephalad	Can result in more complex injury with upper abdominal trauma
Peritoneum	Shifted contents and abdominal wall stretching thus altered pain location patterns and compartmentalization	Peritoneal irritation response altered Physical exam may be misleading in advanced pregnancy
Pubis Symphisis	Loosens, widens as approach term pregnancy	May alter interpretation of pelvic x-rays
Amniotic Fluid	Functions to cushion intrauterine contents	May be a source of embolism or DIC following trauma

In association with uterine growth, other abdominal organs undergo adjustments. The bladder is displaced into the abdominal cavity beyond 12 wks and becomes hyperemic. Thus bladder injury may lead to marked blood loss compared to similar injury in nonpregnant patients. Other abdominal viscera, bowel in particular, are pushed upward/cephalad by the enlarging uterus. These organs may be shielded by the uterus in blunt abdominal trauma. In penetrating trauma, however, particularly to the upper abdomen, this shifting may result in a more complex intestinal injury.

Shifting within the abdomen also results in altered pain location patterns and compartmentalization. Normal response to

Other anatomical changes include dilatation of renal calyces, pelves, and ureters outside of the pelvis. Also musculoskeletal adjustments occur, such as widening and softening of the symphysis pubis by the 7th month (4-8mm). Sacroiliac joint spaces also increase. These anatomic differences should be considered when interpreting x-rays of pelvis. Furthermore, when interpreting maternal chest x-rays, keep in mind that increased lung markings and prominence of pulmonary vessels may be a normal finding.

Approach To Trauma

The general approach to trauma is universal to any trauma patient. It should always be systematic so as not to miss critical details in the midst of rapidly changing clinical conditions and the need for quick decisions. The unique challenge is further complicated by the consideration of the welfare of two patients. For optimal outcome, initial assessment and resuscitation is geared toward the mother. The fetus is assessed once maternal condition is relatively stable with respect to vital signs and primary survey. Fetal health surveillance may occur simultaneously, or just prior to the maternal secondary survey.

Approach to Trauma in Pregnancy (Flowchart) – Fig 1

Primary Survey and Resuscitation

As in any trauma, approach involves the ABC's first; airway, breathing, and circulation. The initial goal is to assure patent airway and adequate ventilation. Supplemental oxygen is particularly important to pregnant mothers because of increased requirements. Since fetal blood functions on a left shifted oxygen dissociation curve, this oxygen is also beneficial to the fetus. Indications for ventilatory support are unchanged for the pregnant woman. Successful intubation may require hyperoxygenating prior to intubation to account for the decreased reserve. Also, expect full stomachs due to delayed gastric emptying, which increases the risk of aspiration.

If chest tube insertion is required, proceed as with nonpregnant patients, keeping in mind that the diaphragm rises up to 4cm in pregnancy with compensatory flaring of ribs. It is thus suggested to place the tube one or two interspaces higher than the usual fifth interspace. Beware that tension pneumothorax may develop more rapidly because of diaphragm elevation and hyperventilation.

Circulatory support includes early resuscitation with generous IV fluids, preferably crystalloid. Distinguish hypotension from physiologic causes by obtaining ideal maternal position. Tilt pelvis to the left or roll to left side maintaining c-spine precautions when indicated. Placental vasculature is maximally dilated throughout gestation, yet it is exquisitely sensitive to catecholamine stimulation. Abrupt decrease in intravascular volume may result in profound increase in uterine vascular resistance resulting in marked decrease in utero-placental blood flow. Physiological vasoconstriction response occurs because the uterus is not considered a vital maternal organ. Blood flow to the placenta may be decreased by 10-20% and accompanied by decreased fetal oxygenation, before maternal blood pressure is affected resulting in catastrophic fetal compromise. Vasopressors should be avoided because they further decrease uterine blood flow and may produce fetal distress.

Military Anti-Shock Trousers are best reserved for pelvic fracture stabilization in the first trimester or to tamponade bleeding leg injuries. Theoretically, inflating the abdominal compartment after 20 wks gestation could compress uterus against IVC, decrease preload, and reduce cardiac output.

Secondary Survey

Fetal health evaluation begins with assessment of fetal viability and knowledge of gestational age. At most tertiary care centres, active fetal management is indicated at approximately 24 weeks gestational age or more. Initial fetal heart tones can be auscultated with a Doppler (after 10 weeks), then repeated frequently. Continuous FHR monitoring is preferred, and is most useful beyond 20-24 weeks gestation. Abnormal baseline fetal heart rate, repetitive decelerations, absence of accelerations, loss of beat to beat variability, and frequent uterine activity may all be signs of impending fetal decompensation. Continuous fetal heart rate monitoring may be done while maternal condition is being reassessed and the secondary survey begins. Biophysical profiles may also be used to assess fetal health at this time.

Secondary survey of the mother is similar to all patients, including a full physical exam. It is important to pay particular attention to a formal pelvic examination. Look for presence of amniotic fluid in the vagina, cervical dilatation and effacement, fetal presentation,

and station. Indications for Diagnostic Peritoneal Lavage (DPL) or abdominal ultrasound are also the same. It is possible to safely detect maternal intraperitoneal injury in any trimester by open technique above the uterus. As shown in previous studies, DPL is 92-100% sensitive and specific in recognizing intraperitoneal bleeding caused by blunt trauma.

Admission to hospital is mandatory in presence of vaginal bleeding, uterine irritability, contractions, abdominal tenderness, pain or cramping, evidence of hypovolemia, changes in or absence of fetal heart tones, or leakage of amniotic fluid. Also, if the mechanism of injury is severe, regardless of obvious sustained injuries, close maternofetal monitoring is mandated for at least 24 hours. This is to protect the fetus that may be in jeopardy or at high risk for injury with apparently minor maternal injury.

Investigations

Maternal monitoring should include frequent vitals, routine bloodwork (Complete Blood Count, ABO blood grouping and Rh status, electrolytes, Blood Urea Nitrogen, Creatinine, coagulation profile), pulse oximetry, arterial blood gases, +/- lactate, Kleihauer Betke test (if > 24 wks GA), and accurate urinary output measurement. Maintenance of urinary output of at least 1.5cc/kg/hr may be a valuable goal in maintaining the relative hypervolemia reqired in pregnancy. Central lines and vasive monitoring may prove useful in these patients during resuscitation. Resting central venous pressure is variable with pregnancy but response to volume is same as nonpregnant state.

When interpreting electrocardiograms, note that some changes may be present in normal pregnancy. That is, axis may shift leftward by approximately 15 degrees, while T waves may be flattened or inverted in leads III, AVF, and the precordial leads. Ectopic beats are also increased during pregnancy.

Further investigations include ultrasound as a valuable tool for maternal and fetal assessement. Sonography can provide some information regarding maternal organs, including injuries to the spleen, liver, and kidneys. Ultrasound may also help to identify intra-abdominal fluid and increase the index of suspicion for intraperitoneal hemorrhage. Real time ultrasound is partiiclarly useful in the setting of pregnancy and trauma for establishing gestational age, locating placenta, estimating amniotic fluid volume, determining fetal well being, fetal injury, and fetal demise. However, sonography is not as sensitive as cardiotocography for detection of placental abruption. Studies show that ultrasound may have an accuracy of 86% in detecting injuries Fubut <50% detection of abruptions.

Table 3 – Investigations

Maternal	Fetal
Complete Blood Count, Electrolytes, BUN, Creatinine	Non-Stress Test
Kleihauer Betke Test Apts Test	Continuous Fetal Heart Rate Monitoring
Arterial Blood Gases	Real Time Scan
Coagulation Studies	Biophysical Profile
Ultrasound	
Radiographs, CT Scans, MRI	
Diagnostic Peritoneal Lavage	
Electrocardiogram	

Radiographic studies should be performed with due regard for fetal protection when indicated. Necessary diagnostic studies should not be withheld out of concern for fetal radiation alone. Whenever possible, fetal irradiation should be minimized by limiting the scope of the examination and using technical means like shielding and colimation. In the first week of gestation, the embryo is very sensitive to lethal effects of radiation. During the major organogenesis period of the second to seventh week, the fetus is sensitive to the teratogenic, growth restricting, lethal, and neoplastic effects of radiation. Organs are less sensitive to radiation teratogenesis in the subsequent weeks of gestation up to term, but growth restriction, central nervous system dysfunction, and postnatal neoplastic effects may occur.

Exposure to less than 5-10 rad (5000 – 10 000 mrad) is not associated with any significant increase in the risk of congenital malformations, intrauterine growth restriction, or miscarriage. X-ray beams aimed more than 10 cm away from fetus are not dangerous. Naturally occurring radiation that a fetus receives during gestation is up to ~50 to 100 mrad. Those that receive 15 rads or more may develop severe mental retardation (~6%), childhood cancer (< 3%), or small head size (~15%), which may not necessarily affect mental function.

Computerized tomography and magnetic resonance imaging should be used as a complement to diagnostic peritoneal lavage and ultrasound in evaluating abdominal trauma in pregnancy. With careful attention to shielding of the maternal abdomen, exposure from head and chest scans can be kept below an acceptable one rad limit. CT scans of the abdomen above the uterus can be done with a less than three rad dose to the fetus. Pelvic CT scans, centered over the fetus, produce a more prohibitive 3-9 rad dose. MRI creates images using a large static magnetic field and an electromagnetic field produced by radiofrequency waves to generate signals from hydrogen nuclei within a patient. As opposed to ionizing radiation, magnetic field energies generated in clinical applications seem to have no detrimental effect on mother or fetus. However, testing has been limited.

One of the major drawbacks of CT and MRI is the lack of portability, which necessitates patient removal from the environment of close monitoring. Also, long examination times and larger radiation doses imparted to the fetus during abdominal scans are disadvantages. There are limited reports of trauma cases where abdominal CT and MRI studies are used in pregnancies that carry live normal fetuses.

Fetal health surveillance primarily involves continuous FHR monitoring. Recommendations for the duration of monitoring are not consistent. Minimum time of monitoring varies from 2-6 hours in various studies. However, these monitoring guidelines have not been validated in large prospective trials where electronic fetal monitoring and uterine activity monitoring may be predictive of uterine/fetal injury, primarily placental abruption. Gestational age, severity/mechanism of trauma, and clinical suspicion of injury have all been used as criteria in the obstetrical evaluation of trauma in pregnancy.

Any viable fetus of 24 or more weeks gestation requires monitoring after a trauma event. Before 24 wks, concern for maternal health is the main indication for hospitalization and/or further testing.

FHR monitoring protocols guided by severity of injury suggest that minor trauma usually requires 6 hours of continuous monitoring, serial non stress tests or a biophysical profile in order to detect intrauterine pathology and adequately assess the fetus. Major trauma or minor trauma associated with any non-reassuring signs requires continuous inpatient monitoring for a longer period, usually 24 hours. Signs and symptoms that indicate longer fetal monitoring include more than one uterine contraction every 15 minutes, uterine tenderness/irritability, nonreassuring FHR monitoring strip, vaginal bleeding, or rupture of membranes. Maternal injury also demands extended monitoring. It has been shown that 80% of females admitted to hospital in hemorrhagic shock who survive have an unsuccessful fetal outcome. Most fetal deaths in which the mother survives are caused by placental abruption resulting from maternal shock or damage to the uterus or placenta. When the fetus is alive on presentation, fetal distress is present in 60% of cases of placental abruptions. However, in the remainder of cases, placental disruptions are small enough to be compatible with fetal survival. At 10-20 weeks gestational age, 86% of pregnancies with subchorionic hematomas less than 60 ml will reach term versus 81% of those with greater than 60mls will not.

Consequences Of Trauma

Table 4 – Obstetrical Consequences

UTERINE CONTRACTIONS
UTERINE RUPTURE
PLACENTAL ABRUPTION
PLACENTAL TEAR
PLACENTAL CONTUSION
FETOMATERNAL HEMORRHAGE
FETAL INJURY/ DEMISE
MATERNAL INJURY/ DEMISE

Uterine Contractions

Contractions are the most common obstetrical problem caused by trauma. Myometrial and decidual cells damaged by contusion or placental separation release prostaglandins that stimulate uterine contractions. Progression to labor depends upon size of uterine damage, amount of prostaglandins released, and gestational age of pregnancy. Routine use of tocolytics for premature labour is controversial. One study found that 90% of contractions stop spontaneously. Those contractions that are not self-limited are often pathology induced (ie. underlying abruption in 20%) and are a contraindication to tocolytic therapy.

Uterine Rupture

Uterine rupture is suggested by findings of abdominal tenderness, guarding, rigiditiy, rebound tenderness, or abnormal fetal lie (often oblique or transverse). Easy palpation of fetal parts due to extrauterine location and inability to readily palpate the uterine fundus can also be associated with uterine rupture. Frequently peritoneal signs are difficult to appreciate due to expansion and attenuation of abdominal wall musculature. X-ray evidence includes extended fetal extremities, abnormal fetal positon, and free intraperitoneal air. Suspicion of rupture mandates surgical exploration.

Placental Abruption

The placenta, unlike myometrium, has little elasticity. This leaves it predisposed to shear forces at the uteroplacental interface during sudden deformation of the uterus. Deceleration forces can have as damaging an effect on placenta as direct uterine trauma. Placental abruption can occur with little or no external signs of injury to the abdominal wall. After blunt trauma, abruption occurs in 2-4% of minor accidents and 6-66% of major injuries. Maternal mortality associated with placental abruption is less than 1% in tertiary centers, but fetal death ranges from 20-35%. Inhibited flow of oxygen in utero causes carbon dioxide accumulation, which then leads to fetal distress from hypoxia and acidosis.

The best indications of abruption are based on close clinical observation. Typical findings include vaginal bleeding, abdominal cramps, uterine tenderness or rigidity, amniotic fluid leakage, and/or maternal hypovolemia out of proportion to visible bleeding. Up to two litres of blood can accumulate in the uterus. Concealed hemorrhage can pose a greater maternal hazard because the extent of bleeding may not be clinically appreciated. Other suspicious signs may be an expanding fundal height, uterus larger than normal for GA, or a change in FHR. However, signs may often be minimal or not present at all.

Cardiotocographic monitoring is an important adjunct in the obstetrical assessment of the pregnant patient. Tachycardia or late decelerations are seen frequently in cases of abruption, and are more sensitive in picking up abruption or associated fetal distress than visualization by ultrasound. Frequent uterine activity is also a sensitive indicator. Magnetic Resonance Imaging can be used as a second line investigation. MRI has been found to be nearly 100% sensitive and specific for identification of pathologically significant intrauterine bleeds. The main advantage is better tissue differentiation and the ability to identify flowing blood, which helps to distinguish blood from other fluid collections.

Disseminated Intravascular Coagulation may develop with extensive placental separation or amniotic fluid embolization. This consumptive coagulopathy may develop rapidly, so uterine evacuation should be accomplished on an

urgent basis. Replacement of platelets, fibrinogen, and other clotting factors is also an important aspect of treatment.

Management of placental abruptions may depend on the particular clinical case. Expectant management can be an option for partial placental abruptions when mother and fetus are stable, especially if the fetus is less than 32 weeks GA. Morbidity and mortality associated with prematurity make aggressive management risky. Yet, further placental separation is possible at any time, which can compromise or potentially cause demise of the fetus. Thus close maternal and fetal monitoring along with the ability to perform immediate caesarean section is important, as there may be little time between appearance of distress and fetal demise.

Aggressive intervention is indicated when mother and fetus are unstable or in jeopardy regardless of fetal age (>24 weeks). Some recommend rapid intervention if >32 weeks gestational age because the risk of further placental separation outweighs benefit of further fetal maturation. Reports of fetal death from abruption as late as five days after trauma confirm that accurate diagnosis and timely intervention is critical.

Maternal Injury

Generally maternal injury from blunt trauma is related to the large, engorged pelvic vessels that surround the gravid uterus. Damage to this vasculature can contribute to massive retroperitoneal bleeding with associated pelvic fractures. Maternal injury associated with penetrating trauma depends on location and nature of the insult. Gunshot wounds with peritoneal penetration need operative exploration because of a high visceral injury rate. Stab wounds to the upper abdomen may necessitate Diagnostic Peritoneal Lavage to detect visceral damage or intraperitoneal hemorrhage.

TABLE 5 – MATERNAL CONSEQUENCES

Maternal Injury	Consequences
General Injury	Specific to mechanism Similar to Nonpregnant state
Abdominal -- Blunt	Caution Retroperitoneal Bleeding
-- Penetrating - Above Uterus - Uterus	High risk of visceral injury High risk of fetal injury
Cardiac Arrest	Consider Perimortem Cesaerean Section
Demise	

Direct injury to the uterus is associated with relatively less damage to other viscera because the uterine musculature, amniotic fluid and conceptus can absorb energy from penetrating missiles. This mechanism accounts for the generally excellent maternal outcome. Any viable fetus in distress is grounds for immediate C-section and exploration with penetrating injuries. Yet, there is some controversy on the management of these cases where the fetus appears stable. Nonoperative treatment advocates suggest that if the entry wound is below the fundus and the bullet is radiographically demonstrated to be in the uterus, with stable maternal vital signs and absence of blood in GI or GU tracts, the patient may be managed conservatively.

On the other hand, operative treatment advocates show that gunshot wounds to the uterus may be associated with a 59-89% incidence of fetal injury and a 41-71% fetal mortality rate. Stab wounds to uterus may be associated with up to 93% morbidity and 50% mortality rates. Without exploration, it is impossible to know the size or depth of uterine penetration. No guidelines exist to indicate if a uterine wound can be left unsutured without incurring a risk of infection or future uterine rupture. Exploratory laparotomy is generally viewed as the safest management option because of possible missed injuries.

Fetal injury in trauma can also be divided into direct and indirect injuries. Direct fetal injuries usually tend to occur in late pregnancy and are typically associated with serious maternal trauma. Signs of fetal

distress include decreased variability of the heart rate, late fetal decelerations, tachycardia above 160 beats/min, or bradycardia below 110 beats/min. The most common causes of fetal death in blunt trauma are maternal death, maternal shock, and placental abruption. When there is penetrating injury to the uterus the fetus generally fares poorly.

Indirect injury to the fetus may occur from rapid compression, deceleration, contrecoup effect, or a shearing force on the placenta, causing abruption. Proper use of seatbelts is important in decreasing the incidence of indirect injury to the fetus in motor vehicle accidents. The use of lap belt alone allows forward flexion and uterine compression with possible uterine rupture or abruption. Lap belts worn too high over the uterus can also produce rupture because of direct force transmission to the uterus on impact along with anterior abdominal wall bruising. Minor maternal injury can be associated with potentially significant fetal injury. Up to 6.7% of minor trauma had adverse fetal outcomes.

Fetomaternal Hemorrhage (FMH)

Transplacental hemorrhage of fetal blood into the maternal circulation after trauma occurs in 8-30% (ranges 2.5 – 115 ml) of cases compared to 2-8% (range 0.1 – 8 ml) for controls. Anterior placental location and uterine tenderness have been associated with increased risk of FMH, rather than severity of blunt trauma or GA of fetus. Complications of fetomaternal hemorrhage include Rh sensitization in the mother, fetal anemia, fetal paroxysmal atrial tachycardia, or fetal death from exsanguination.

Fetomaternal hemorrhage is detected by the Kleihauer-Betke acid elution technique on maternal blood. The ratio of fetal cells to maternal cells is recorded using a screen of 1000 red blood cells from the mother. Thus one fetal cell per 1000 cells counted corresponds to a FMH of 5 mls. Only 1 ml of RH pos blood can sensitize 70% of RH negative women, so a negative Kleihauer Betke test does not exclude minor degrees of fetomaternal hemorrhage. Therefore, all RH negative mothers with a history of trauma should receive one 300ug prophylactic dose of RH immune globulin within 72 hours, unless the injury is remote.

The Kleihauer Betke test is most useful for RH negative women at risk for massive FMH that will exceed the efficacy of one dose of Rhogam (i.e. >30 ml). These trauma patients have been identified as those presenting with major injuries or obstetrical findings. For documented FMH, some recommend repeat Kleihauer Betke testing in 24 hours to check for increased bleeding. It is suspected that FMH's usually stabilize in 24-48 hours. It is unknown if serial testing is useful in patients who do not show FMH on first screen.

Some Obstetricians question whether RH immune globulin is needed at all for trauma. Silent bleeds in the normal population are effectively treated with Rhogam at 28 weeks and delivery. Thus trauma patients who have no obvious clinical bleeding may also be effectively covered by this standard therapy. Despite support from some retrospective studies, it seems more prudent to treat RH negative women at time of each trauma event.

Perimortem Caesarean Section

Extended and exclusive attention to the mother in cardiopulmonary arrest may prevent recovery of a potentially viable fetus. If there is no response to advanced cardiac life support within 4-5 minutes, perimortem caesarean section must be considered. Maternal CPR should be continued. Thoracotomy with open chest massage but without aortic cross-clamping should also be considered. Emergency caesarean sections for viable fetuses may be performed. Maternal revival after delivery has been reported.

There is little data to support perimortem caesarean section in patients suffering from hypovolemic cardiac arrest. Progressive maternal hypovolemic instability compromises fetal survival, as the fetus has already suffered prolonged hypoxia. Fetal survival with perimortem caesarean section depends on fetal maturity and time interval without maternal circulation.

Review of 250 years of literature reveals 120

successful perimortem C/S: 70% were delivered in less than 5 minutes, 13% in 6-10 minutes, 12% in 11-15 minutes, 1.7% in 16-20 minutes, 3.3% after 20 minutes. There is no record of fetal survival after more than 25 minutes of CPR. Neurologic sequelae are increased with longer delivery times. Classic midline vertical skin incision with vertical uterine incision from fundus to bladder reflection is the most common surgical approach.

Conclusion

Patients may be discharged home when maternal and fetal condition is reassuring. Mothers should be instructed to record fetal movements and return for reevaluation. Usually this involves an NST within next 48 hours, or advise to return for assessment if any signs of decreased fetal movement, contractions, vaginal bleeding, or uterine pain are noted. Serial non-stress tests or biophysical profiles periodically throughout remaining pregnancy may be indicated.

Management of trauma in pregnancy requires the recognition of unique maternal physiology and anatomy. This is critical in the interpretation of vital signs and clinical parameters in the acute trauma scenario. Familiarity with the approach to assessment, monitoring, and treatment guidelines in trauma may prove critical to decision making in the emergent situation. High clinical suspicion for silent or impending maternal and fetal injuries is the key to safe management of these patients. Ideally, with proper management and attention to key principles of trauma management of the pregnant patient, it may be possible to minimize injury and protect both mother and fetus from potentially detrimental outcomes.

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For Your Information ...

The following is the most recent protocol approved by the Southwestern Ontario Rh Service (SWORhS).

Southwestern Ontario Rh Service Guidelines for Antenatal Antibody Screening and Rh Sensitization Prophylaxis

First Trimester

Option 1
If the blood group of the woman is not known, or if the woman is Rh positive: blood group and antibody screening test should be performed at one of the following laboratories:
- blood bank at the hospital where the woman will likely give birth
- the Canadian Blood Service
- a private laboratory

Option 2
If the woman is know to be Rh Negative: Woman should be referred at 16 weeks gestation to a women's clinic that manages an Rh Prophylaxis Program. An appointment will be made to return at 28 weeks gestation for repeat antibody screen and antenatal Rh Immune globulin injection.
If the Rh status of the infant's father is unknown, a blood group must be determined. If the father types as Rh negative on current or previous testing a Du test must be performed to determine if his cells carry a weak expression of the D antigen.

Chorionic Villus Sampling
- blood group and antibody screening test
- Rh negative women to receive 300 ug of Rh immune globulin ★
- additional injections of 300 ug of Rh Immune globulin should be given every 12 weeks until birth

Threatened Abortion
Before 10 weeks gestation:
- not necessary to give Rh immune globulin

After 10 weeks gestation:
- Rh negative women should receive 300 ug of Rh ★immune globulin should the physician request
- additional injections of 300 ug of Rh immune globulin should be given every 12 weeks until birth

Woman is Rh negative or Rh positive with a positive antibody screening test

Woman Rh negative with a negative antibody screening test

Spontaneous or Inducted Abortion: ★
- blood group and antibody screening test

Before 16 weeks gestation:
- Rh negative women should receive 120 ug of Rh immune globulin

After 16 weeks gestation:
- Rh negative women should receive 300 ug of Rh immune globulin

Second and Third Trimesters

Refer patient to a physician experienced in antibody-sensitized pregnancies

At 28 weeks gestation:
- repeat antibody screening test
- inject 300 ug of Rh immune globulin
- patient sign consent/refusal form

Amniocentesis, Miscarriage or Stillbirth:
- Rh negative women should be given 300 ug of Rh immune globulin following termination of pregnancy or amniocentesis
- a test for fetal red cells (i.e. Kleihauer test) should be done in case of stillborn

Third Trimester
Repeat antibody screening test is not necessary

External Version
Trauma During Pregnancy
- Rh negative women should be given 300 ug of Rh immune globulin
- additional 300 ug injections of Rh immune globulin should be given every 12 weeks until birth

At Birth and/or Post Partum

Determine Rh group of the infant
If infant is Rh positive or weak D (Du positive):
1. a test for fetal red cells (i.e. Kleihauer test) should be done to determine if additional Rh immune globulin is indicated prior to injection
2. woman to receive a minimum of 120 ug of Rh immune globulin
3. if woman received Rh immune globulin 3 weeks prior to birth AND no fetal cells detected postpartum AND residual prenatal Rh immune globulin is detected on post-partum specimen, physician may opt not to administer postpartum Rh immune globulin

Prophylactic Rh Immune Dose Missed?
If antenatal Rh immune globulin prophylaxis has not been given at 28 weeks gestation, 300 ug should be given at any time before the birth

NOTES:
1. Administer within 72 hours of event to ensure effectiveness (if omitted, give ASAP).
2. Administer INTRAVENOUS or DEEP INTRAMUSCULAR route, to ensure adequate absorption. Injection into gluteal region may only reach subcutaneous tissue, therefore decreasing effectiveness. If necessary use alternate muscle or IV route.
3. Informed consent is recommended (Krevor report). ★
4. Antibody screen results must be obtained within 4 weeks of any injection of Rh immune globulin

★ The Southwestern Ontario Region Rh Service has developed an Information Letter and Consent for Rh (D) Immune Globulin. This consent and the pamphlet titled "RH Factor and Your Pregnancy" have been developed to address the issue of "informed consent is advised" as recommended by the Krevor Report. The reverse side of the consent has directions on how to arrange an outpatient injection of Rh. (D) Immune Globulin and information about the Role of Rh. (D) Immune Globulin in preventing Rh Disease. It will be available on the Internet **www.sjhc.london.on.ca** When using the Internet please print two copies of the consent one for the patient and one for the chart.

For Your Information ...

For Neonatal Transfers to London

Call: St. Joseph's Health Care, London (SJHC)
Neonatal Intensive Care Unit (NICU)
(519) 646-6100 x 64427

*Ask for the Neonatologist on call

For Paediatric Transfers to London

Call: Children's Hospital of Western Ontario (CHWO)
Paediatric Critical Care Unit (PCCU)
(519) 685-8500 x 52824

*Ask for PCCU attending Physician or Fellow

Alarm Courses - 2002

Regina, SK	Feb. 9-10, 2002
Vancouver, BC	Apr. 5-6, 2002
Instructors Course	Apr. 7, 2002
Montreal, QC	Apr. 20-21, 2002
Toronto, ON	May 3-4, 2002
Winnipeg, MB	Jun 19-20, 2002
Edmonton, AB	Sep 28-29, 2002
Toronto, ON	Nov 17-18, 2002
Toronto, ON	Dec 1-2, 2002

Contact: SOGC
780 Promenade Echo Drive
Ottawa, ON K1S 5R7
Tel: 1-800-561-2416
www.sogc.org

Have a Safe and Happy Holiday Season
Renato, Jill, Nancy, Gwen & Sheila
Regional Perinatal Outreach team

Upcoming Events:

Mark Your Calendar!

Conferences –
Mood and Anxiety Disorders in the Perinatal Period

Keynote speaker:
Jeanne Watson Driscoll, MS, RN, CS
April 26, 2002
Four Points Sheraton Hotel
1150 Wellington Road South, London
Contact:
Nancy Dodman
Regional Perinatal Outreach Program of Southwestern Ontario
(519) 646-6100 x 65900
Fax: (519) 646-6172

Nancy.dodman@sjhc.london.on.ca

16th Annual Regional Perinatal Outreach Conference
Friday, September 26, 2002
Topics: To Be Announcedl
Contact: Perinatal Outreach Office
(519) 646-6100, ext. 65859

Maternal Newborn Nurse Educator Course 2002
London:
Tuesdays: April 2 – May 21, 2002
St. Joseph's Health Care, London
Contact:
Gwen Peterek
Perinatal Outreach Program of Southwestern Ontario
Phone: (519) 646-6100 ext 65901
Fax: (519) 646-6172

Gwen.peterek@sjhc.london.on.ca

Chatham:
Mondays: May 13 – June 24, 2002
(excluding Mon. May 20, 2002, Tuesday, May 21, instead)
Contact:
Brenda Foster
Program Director, Women & Children's Health
Public General Hospital - Chatham
Phone: (519) 436-2534

This newsletter is a publication of the Perinatal Outreach Program of Southwestern Ontario.

Letters, queries and comments may be addressed to:

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