CHAPTER 80

Acute Abdomen and Trauma during Pregnancy

SCOTT ALEXANDER HARVEY

INTRODUCTION

Pregnancy induces different physiologic and anatomic factors that make evaluation and treatment of a pregnant woman different than that of the nonpregnant individual. The clinician has the opportunity to care for two (or more) patients, as the survival of the fetus will be dependent on instituting normal maternal physiology or delivering the fetus, depending on the gestational age. This chapter summarizes the approach to evaluate, diagnose, and treat the gravid patient with a surgical or traumatic process within the abdomen, highlighting the key differences owing to maternal physiology.

Of women aged 12 to 44 years old, 102.1 per 1,000 women are pregnant at any given time, with the highest rate of pregnancy in ages 20s to 30s (1). The incidence of a pregnant woman developing a disease requiring nonobstetric surgery is approximately 0.2% to 0.75% (2). The American College of Obstetricians and Gynecologists (ACOG) has released multiple guidelines to help guide surgical and obstetrical management with recommendations for disease conditions as they relate to the pregnant woman. Some foundational facts regarding surgery during pregnancy are found in Table 80.1, with the knowledge that no woman should be declined indicated surgery based on pregnancy status or gestational age (3).

In addition to acute surgical conditions, trauma affects 5% to 8% of pregnant women and is the leading cause of nonobstetric death in the United States (4–7). The scope of trauma could be as minor as bumping the abdomen into a table to a pregnant woman falling, as pregnant women are more prone to falls (8), to a motor vehicle passenger ejection, victim of domestic violence, or other major traumatic event. Clinical knowledge that the patient is pregnant is an integral part of the trauma assessment, either in the primary survey (based on history or physical examination), or the secondary survey as an incidental finding from an ultrasound examination or pregnancy test. In one trauma center, “incidental pregnancy” found on routine screening during the trauma assessment in 11% of women of reproductive age, where 8% of those patients were unaware of their gravid state (9); this warrants routine pregnancy screening during trauma assessment of all women age 12 to 50 years old. Resuscitation, evaluation, and monitoring algorithms are altered in pregnancy; nonetheless, these management principles will involve the mother primarily. Improvements in fetal and neonatal management allow better administration of medical care to save the life of the fetus, despite a higher incidence of fetal mortality with surgical disease (around 2% to 20%, depending on disease [10]). Of note, motor vehicle crashes still are the leading cause of fetal death due to maternal trauma (11,12). When evaluating pregnant women for a surgical or traumatic process, it is important to understand the basics of their altered physiology.

MATERNAL PHYSIOLOGY AND LABORATORY VALUES

Maternal adaptations in physiologic and anatomic parameters are paramount for fetal growth and maternal protection during parturition. A full explanation of maternal adaptations with pregnancy is beyond the scope of this chapter, but understanding the basics of cardiopulmonary, gastrointestinal, renal, and hematologic changes are important for management and resuscitation of these patients. Selected physiologic laboratory parameters are displayed in Table 80.2.

The maternal blood volume increases by 40% to 50%, starting at about 8 weeks of gestational age (wGA), to peak around 32 wGA. A physiologic anemia is induced by estrogen’s effects on the renal–angiotensin–aldosterone system as blood plasma increases in greater proportion than that of the red blood cell mass (13–15). Placental factors to include progesterone and placental chorionic somatotropin increase erythropoietin production and bone marrow stimulation of red blood cell synthesis (16). Blood vessels are more prone to vasodilation causing a reflex tachycardia, and in conjunction with a higher blood volume and cardiac preload, cardiac output increases by about 1.5% (17,18). There is a higher oxygen consumption that increases with gestational age as blood flow to the uterus increases from 2% in the nonpregnant uterus to about 17% at term.

With anatomic compression of the abdominal contents by the uterus, there is a reduction in total lung capacity, residual volume, and expiratory reserve volume. Tidal volume and respiratory rate increase to create a higher minute ventilation, a respiratory alkalosis, relative hypocarbia, and a compensatory reduced bicarbonate (19). With the increase in 2,3-diphosphoglycerate, there is a relatively unchanged hemoglobin–oxygen dissociation curve, while the partial pressure of oxygen (PaO₂) reduces slightly due to lung atelectasis and intrapulmonary shunting (20,21). Of note, fetal oxygenation is the best with a PaO₂ above 70 mmHg and oxygen saturation over 95% (21).

There is increased renal blood flow and glomerular filtration with a resultant reduction in blood urea nitrogen and creatinine (22). The normalized hemoglobin is reduced and white blood cells are slightly increased, with an unchanged platelet count. In order to prevent exsanguination at delivery, maternal adaptations increase fibrinogen by about 50%, reduce fibrinolysis, and increase excretion of Protein S, creating a hypercoagulable state and increasing the risk of deep vein thrombosis and pulmonary embolism. Lastly, there is reduced gut motility,
increased insulin resistance, and maternal hyperglycemia to improve nutrition to the fetus (19). These and many more maternal adaptations are pivotal for fetal development, and normalization of maternal physiology to these parameters is recommended as endpoints of resuscitation.

**PRETERM LABOR**

A preterm birth is defined as a delivery between 20 0/7 and 36 6/7 weeks of gestation (23) and is the second leading cause to neonatal mortality in the United States (second to birth defects) (24). Advancements in neonatal medicine have reduced mortality, but there is still a strikingly high rate of disability in periviable neonates that survive (23). As preterm death is the highest risk factor for preterm birth, it is crucial for the clinician to recognize the syndrome and employ appropriate counseling and management in conjunction with the collaborative services of the Obstetrician and Neonatologist and/or Pediatrician.

**Preterm Labor Evaluation**

Preterm labor is defined as regular uterine contractions in conjunction with cervical dilation and/or effacement (25). Multiple risk factors for preterm labor include nonwhite race, age less than 17 or more than 35 years old, low socioeconomic status, low prepregnancy weight, history of preterm birth, vaginal bleeding during pregnancy, and smoking (26). The physiopathology of preterm labor relates to activation of the labor process that is similar, but prior, to a term gestation. There is a physiologic activation of the “common labor pathway,” with anatomical, biochemical, immunologic, and endocrinologic events that dilate the cervix, rupture amniotic membranes, and cause uterine contractions to evacuate the fetus. The preterm activation of this “common labor pathway” is considered pathologic and may relate to a multitude of diseases to include underlying uterine infections, systemic infections and microbial induced inflammation, uterine distention, placental demise, and even maternal stress (27). Both surgical syndromes and trauma may induce the activation of preterm labor, making it critical to recognize and employ treatment when appropriate. Preterm labor is frequent among surgical interventions. In one series of 77 patients undergoing nonobstetric surgery, preterm labor was seen in 26% of patients in the second trimester and in 82% of those in the third trimester. Preterm labor leading to preterm delivery was most common after appendicitis and adnexal surgery, where preterm birth was seen in 16% of the patients. However, only 5% of surgical cases demonstrated a clear established link to the surgical procedure (10). Another study showed 18% of 62 pregnant subjects with nonobstetric abdominal surgery delivered preterm, again associating abdominal surgery to preterm birth (28).

The evaluation of preterm labor may include imaging and laboratories in addition to the history and physical examination. Fetal monitoring should begin to assess the frequency of patient perceived and nonperceived contractions and to evaluate fetal status by the fetal heart rate pattern. In general, patients with pregnancies beyond 34 wGA are monitored for contractions and cervical change, evaluated for rupture of membranes (ROM) and urinary tract infections, hydrated, and if the fetal heart rate is reactive (reassuring), then the patient is expectedly managed in an observed environment. A re-examination will determine the presence of preterm labor and for appropriate disposition (25). For those patients between 24 and 34 wGA, additional diagnostic modalities may include an ultrasound for cervical length, fetal fibronectin screen (FFN), vaginitis swab, and culture for Gonorrhea or Chlamydia for those at risk for the disease (25,29). The cervical length is performed by an intravaginal ultrasound that measures the external os distance from the internal os and presenting fetal part in the lower uterine segment over a 5-minute period. Cervical lengths of more than 3 cm indicate a low likelihood of preterm labor, while lengths of 1.5 to 3 cm require further diagnostic intervention or monitoring, usually in conjunction with FFN. Lengths less than 1.5 cm have a high incidence of preterm labor. The detection of the biomarker fetal fibronectin in the vaginal vault can be used independently

**TABLE 80.1 ACOG Statement and Recommendations for Nonobstetric Surgery**

<table>
<thead>
<tr>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• No current anesthetics have been shown for teratogenic effects at standard concentrations at any gestational age</td>
</tr>
<tr>
<td>• Fetal monitoring</td>
</tr>
<tr>
<td>• May aid in intraoperative maternal positioning</td>
</tr>
<tr>
<td>• Preivable fetus: preoperative and postoperative fetal anesthetics</td>
</tr>
<tr>
<td>• Viable fetus</td>
</tr>
<tr>
<td>• At least preoperative and postoperative fetal monitoring is recommended</td>
</tr>
<tr>
<td>• Intraoperative monitoring is advised if it is physically possible</td>
</tr>
<tr>
<td>• The procedure, an obstetric provider is available and able to intervene</td>
</tr>
<tr>
<td>• The nature of surgery can safely accommodate an emergency</td>
</tr>
<tr>
<td>• And when possible, the woman has given informed consent for cesarean delivery</td>
</tr>
<tr>
<td>• Surgery to be performed at an institution with obstetric and neonatal/pediatric care</td>
</tr>
<tr>
<td>• A pregnant woman should not be denied indicated surgery, regardless of trimester of gestation</td>
</tr>
<tr>
<td>• Avoidance of elective surgery in pregnancy</td>
</tr>
<tr>
<td>• If able, avoidance of surgery until the second trimester</td>
</tr>
</tbody>
</table>


**TABLE 80.2 Normal Laboratory Values during Pregnancy**

<table>
<thead>
<tr>
<th>Value</th>
<th>Change</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC</td>
<td>Increased</td>
<td>5,000–15,000 cells/mm³</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>Decreased</td>
<td>10.5–13.5 g/dL</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>Decreased</td>
<td>30.5–39%</td>
</tr>
<tr>
<td>Platelet</td>
<td>Unchanged</td>
<td>150–380 x 10³ /μL</td>
</tr>
<tr>
<td>Fibrinogen</td>
<td>Increased</td>
<td>265–615 mg/dL</td>
</tr>
<tr>
<td>D-Dimer</td>
<td>Frequently positive</td>
<td>—</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>Compensatory acidosis</td>
<td>18–22 mEq/L</td>
</tr>
<tr>
<td>BUN</td>
<td>Decreased</td>
<td>3–4 mg/dL</td>
</tr>
<tr>
<td>Creatinine</td>
<td>Decreased</td>
<td>0.4–0.7 mg/dL</td>
</tr>
<tr>
<td>Albumin</td>
<td>Decreased</td>
<td>2.7–3.7 g/dL</td>
</tr>
<tr>
<td>AST, ALT</td>
<td>Unchanged</td>
<td>12–38 U/L</td>
</tr>
<tr>
<td>Bilirubin</td>
<td>Unchanged</td>
<td>0.2–0.6 mg/dL</td>
</tr>
<tr>
<td>Alkaline phosphate</td>
<td>Increased</td>
<td>60–140 IU/L</td>
</tr>
</tbody>
</table>

ALT, aspartate aminotransferase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; HCO₃⁻, bicarbonate; WBC, white blood cell count.

or in conjunction with cervical length screening, and if negative, carries a 98% negative predictive value (NPV) for subsequent delivery in the next 7 days and rules against preterm labor (30). FFN has a poor positive predictive value (PPV), so if the test is positive, further diagnostic workup should ensue. A limited abdominal ultrasound (US) documenting fetal number and position, amniotic fluid (maximum vertical pocket or amniotic fluid index), and location and characterization of the placenta is performed. The underlying cause of preterm labor should be aggressively sought after and treated, especially in cases of acute abdomen and/or trauma.

Evaluating if the patient has ROM is paramount in every preterm labor evaluation. In addition to the patient history, this can be diagnosed by a sterile speculum examination and visualization of pooling amniotic fluid from the cervix, or in the use of adjuvant laboratories evaluating for alkaline fluid in the vagina (i.e., Nitrazine), biomarker detection of amniotic fluid containing PAMG-1 (i.e., AmniSure) (31), or the presence of ferning on a microscopic slide. The gold standard detection of ruptured membranes in equivocal cases is the tampon dye test, involving an infusion of inert dye (at the time of amnioncentesis) into the uterine cavity and evaluating a vaginally placed tampon for colored dye 1 hour after. In the event of membrane rupture, the diagnosis of preterm premature ROM indicates immediate hospital admission and specific management protocols as these patients have higher risks of labor, placental abruption, and intrauterine infection (32).

Preterm Labor Management

Patients with preterm labor after 34 wGA usually are managed expectantly, that is, without attempts to stop the labor process. In most patients between 24 and 34 wGA, there is indication for antenatal corticosteroid administration for neonatal benefit to reduce neonatal acute respiratory distress, necrotizing enterocolitis, intraventricular hemorrhage, and other disabling neonatal diseases (33,34). Two common regimens include either two doses of intramuscular betamethasone 12 mg given 24 hours apart or four doses of intramuscular dexamethasone 6 mg 6 hours apart (34). To quell the uterine contractions for the full administration and effect of corticosteroid administration, it is common to utilize a tocolytic regimen such as indomethacin PO, nifedipine i.v. or PO, or magnesium sulfate 6 mg 6 hours apart (34). To quell the uterine contractions for the full administration and effect of corticosteroid administration, it is common to utilize a tocolytic regimen such as indomethacin PO, nifedipine i.v. or PO, or magnesium sulfate i.v. drip for approximately 48 hours. The choice of drug is determined by the maternal condition and gestational age. Contraindications to tocolytic medications include intrauterine fetal demise, lethal fetal anomalies, nonreassuring fetal status, severe preeclampsia or eclampsia, maternal bleeding and hemodynamic instability, preterm premature ROM (in most cases), and maternal intolerance of the tocolytic (25). Finally, there is recent evidence that administration of magnesium sulfate i.v. drip within hours of delivery for neonates less than 32 wGA can reduce cerebral palsy in the survivors, commonly termed as “magnesium for fetal neuroprotection” (35).

Consultants

The recognition, management, and treatment of preterm labor or preterm premature ROM should be in conjunction with an obstetrician and neonatologist/pediatric consultation at a hospital that provides such services. These consultants will be able to provide consultation on the labor and postpartum course for the mother and fetus and help the general surgeon or intensivist with specifics of management. In the event of a surgical procedure, ACOG has stated, “it is important for a physician to obtain an obstetric consultation before performing nonobstetric surgery and some invasive procedures (e.g., cardiac catheterization or colonoscopy) because obstetricians are uniquely qualified to discuss aspects of maternal physiology and anatomy that may affect intraoperative maternal–fetal well-being” (3). In addition, the obstetrician may provide information to help distinguish the acute abdomen from pregnancy related conditions and give recommendations on timing and route of delivery, appropriate medication and diagnostic imaging usage in pregnancy, and updates on fetal status. The neonatologist consultant works closely with the obstetrician to provide continued care for the neonate after delivery, educate families regarding neonatal aspects of care, and whether to perform a cesarean section and/or neonatal resuscitation on an individualized basis. Although the overall prognosis for premature infants has steadily improved, the morbidity and mortality for extremely low–birth-weight infants remains high. The mean survival rates for infants born between 23 and 25 wGA increase from 30%, to 52%, to 76% with each additional week of development. Likewise, the survival for infants weighing 401 to 800 g ranges from 11% in those under 500 g to 74% in those over 701 g. Severe disability is common among survivors in this group of vulnerable neonates and noninitiation of resuscitation for newborns under 23 wGA or 400 g birth weight is appropriate (36).

DIAGNOSTIC IMAGING IN PREGNANCY

Several modalities are available for diagnostic imaging to aid in the evaluation of surgical diseases in the gravid patient. Medically necessary diagnostic tests should not be withheld solely on the basis of pregnancy, but one should contemplate the potential advantages and disadvantages when selecting a particular testing method. Ultrasound (US) uses sound waves and thus does not expose the patient and fetus to ionizing radiation and is typically considered the first-line imaging tool to image the abdomen in pregnancy (37). Magnetic resonance imaging (MRI) makes use of the altered energy state of protons to create imaging and also does not expose the patient to ionizing radiation. MRI provides good sensitivity and specificity for surgical disorders in the stable pregnant patient. Although time consuming and more expensive, an MRI can evaluate placental abnormalities (placenta accreta) and characterize fetal central nervous system (CNS) malformations in addition to surgical processes in the abdomen. To date, MRI and ultrasound has been used safely during pregnancy are consistent with American College of Radiology guidelines. Radiography and computed tomography (CT) involve ionizing radiation, and for this reason, need to be used judiciously in gravid patients (38). Radiation and fetal teratogenicity has a dose-dependent relationship, with risk malformation and damage with fetal doses 150 to 200 mGy and 500 mGy, respectively (37,39). In perspective, a fetal dose of 100 mGy carries a 1% risk of organ malformation or childhood cancer (39), and an unshielded abdominopelvic CT provides about 25 mGy (38). Exposure to 50 to 100 mGy during the preimplantation period may cause blastocyst implantation failure and spontaneous abortion (37). Given the above

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information, it is paramount to image the pregnant abdomen with the appropriate imaging technique, with preferred use of nonionizing techniques of US and MRI.

**Ultrasound**

Obstetric US serves to assess fetal number, viability, size, gestational age, position, anatomy, as well as amniotic fluid volume, uterine mapping, and placental location and characterization (38). Obstetric US studies can be limited to evaluate basic pregnancy information or provide comprehensive information on detailed anatomy or even fetal echocardiography.

In the trauma setting, surgeon-performed focused assessment with sonography for trauma (FAST) is a useful screening tool for intra-abdominal bleeding and has similar sensitivity in the pregnant and nonpregnant individuals (40). The finding of free fluid in blunt trauma in pregnancy indicates a higher intra-abdominal injury rate, noting that free fluid is not necessarily a normal or physiologic finding of pregnancy (41). At one institution, FAST was additionally used as a screen for pregnancy where 18 of 144 (11%) of female patients were newly diagnosed with pregnancy prior to a pregnancy test (42). With diagnosis of pregnancy, FAST contributed to a significant decrease in fetal radiation exposure when compared to other trauma patients diagnosed with pregnancy by serum human chorionic gonadotropin (HCG) screening (42). However, FAST and US are of limited value in the diagnosis of placental abruption after trauma and may provide false-negative results in up to 30% to 58% of cases. The vascular nature of the placenta may have the same echogenicity as blood, so identification of retroplacental bleeding is not always possible (43,44).

Graded compression ultrasonography (GCUS) is still the initial test of choice in the assessment of appendicitis during pregnancy, despite a low sensitivity for diagnosis of 20% to 36% (45). Imaging is approximated on the self-reported area of maximal pain as McBumey’s point changes based on the size of the uterus (46) with diagnostic criteria of a dilated (≥7 mm), fluid-filled, noncompressible, blind-ending tubular structure (45). MRI is the second preferred modality for evaluating appendicitis in pregnancy with sensitivity of 96.8%, specificity of 99.2, accuracy of 99%, PPV of 92.4%, NPV of 99.7% (47). CT scan is reserved for those patients for which a rapid and accurate diagnosis is required, to prevent the potential dangerous sequelae of appendix rupture.

Imaging of the biliary tract is similar to that of the nonpregnant patient. Acute cholecystitis detection using US with findings of cholelithiasis, gallbladder wall thickening, peri-cholecystic fluid, and Murphy’s sign confers a 94% PPV compared to 88% when gallstones are present in isolation (45). Magnetic resonance cholangiopancreatogram (MRCP) is the appropriate second-line agent to evaluate for biliary disease approaching 98% sensitivity and 94% specificity for biliary tract disorders. Endoscopic retrograde cholangiopancreatography (ERCP) typically is utilized only if therapeutic intervention is expected or necessary, as it does expose the patient to ionizing radiation and is associated with several potential complications (45).

**Magnetic Resonance Imaging**

MRI has become a useful tool to identify the source abdominal pain in clinically stable pregnant patients. It is considered a safe modality in all trimesters of pregnancy, but due to thermal increases of imaging tissue during the MRI, there is a theoretical fetal teratogenic risk during the first trimester (37). Additionally, paramagnetic contrast agents such as gadolinium can cross through the placenta and enter the fetal circulation, and have proven higher rates of spontaneous abortion, skeletal abnormalities, and visceral abnormalities in animals when given as a dose two to seven times the normal dose. There have not been any reports of human teratogenicity. This agent should be used in pregnancy only if it provides substantial benefit over potential risk (38,48). Given the theoretical fetal risks, it is recommended to consent for this procedure (48). A clinician should use MRI with the knowledge that it is time consuming and challenging to evaluate an unstable patient while undergoing the examination and is reserved for clinically stable patients (38). MRI has been a useful imaging technique for appendicitis, inflammatory bowel disease, pancreatitis, intussusception, hydronephrosis and pyelonephritis, fibroids (and fibroid degeneration), adnexal masses (49), and placental abnormalities (accreta, percreta, increta) (49). MRI studies confirm that the appendix and cecum are superiorly displaced as pregnancy advances (46) and more reliably identifies the appendix than does US, with a sensitivity approaching 100% (49–51).

**Computed Tomography**

CT may be considered for evaluation of the abdomen if other studies are equivocal or unavailable, for blunt trauma, or as a triaging tool to prevent delays in treatment. The radiation dose can be reduced to limit excessive ionizing radiation exposure to the fetus, and as the doses are cumulative, it is suggested to avoid repeated studies if clinically appropriate (45,52,53).

**Angiography**

Ionizing radiation with fluoroscopy presents at about 100 mGy/min (24) and should be used with caution in pregnancy, particularly in the use of evaluating and treating pelvic bleeding. Abdominal shielding and limiting fluoroscopy time should be considered when performing this procedure. It is currently not recommended to use embolization techniques directly to the pregnant uterus (6). Alternatives to treat pelvic bleeding include laparotomy and preperitoneal packing with possible external fixation of the pelvis (54).

**SPECIFIC ABDOMINAL SYNDROMES**

**Trauma**

Trauma complicates 1 in 12 pregnancies and is the leading cause of nonobstetric death under 40 years of age, accounting for 46% of maternal deaths in the United States. The mean age for trauma is 24 years old with a mean gestation of 25.9 wGA and is caused by motor vehicle accidents (55%), falls (23%), assaults (22%), and burns (1%) (6,55). Sequelae can lead to significant maternal morbidity with higher incidence of spontaneous abortion, preterm premature ROM, preterm birth, uterine rupture, cesarean delivery, placental abruption, and stillbirth. Approximately 5% to 24% of patients admitted for trauma will deliver during the same admission, suggesting...
that these patients should be transported to a center that provides trauma, obstetric, and neonatal service lines (5,6,36). Identified risk factors for traumatic accidents include younger women (<25 years old), African Americans, Hispanics, under-insured (5), use of illicit drugs or alcohol, history of domestic violence, and noncompliance to seatbelt use (6) (Table 80.3).

The immediate goal for a pregnant trauma patient is to stabilize the mother first, as fetal outcomes are dependent on early and aggressive maternal resuscitation (36). The primary survey includes the evaluation and prompt treatment of the maternal airway, ensuring adequate ventilation and oxygenation, and effective circulatory volume. In the event of cardiac arrest, prompt initiation of advanced cardiac life support (ACLS) should be performed with slight alterations described below. It is important to note that the maternal physiologic manifestation of increased plasma volume and red blood cell mass will allow more blood loss prior to changes in the maternal vital signs, but fetal perfusion may be impaired. Uterine compression of the vena cava can reduce blood return to, and preload of, the heart. Therefore, in gestations beyond 20 wGA the uterus needs to be displaced upward and leftward by either a 15- to 30-degree left lateral tilt or manual displacement upon its recognition. Spinal precautions and C-spine mobilization should be maintained through the uterine displacement process if indicated. An assessment of disability and exposure of the patient for a full primary survey is paramount prior to approaching the fetal status, which is typically performed in the secondary survey (except for in instances of obvious uterine hemorrhage, then prompt measures to correct the circulatory volume and address the bleeding is in the primary survey) (57).

The secondary survey (Table 80.4) immediately follows the primary survey, the initial resuscitation, and initial adjuncts to care such as cardiac monitoring, blood pressure monitoring, pelvic binding or shock trousers, and pulse oximetry. During the secondary survey, pregnancy should be assessed by history, physical examination, HCG (urine or blood) in women of childbearing age, and possibly by the FAST. The entire trauma team should be made aware of pregnancy status, have placement of intravenous access above the diaphragm as pelvic compression may limit resuscitative medications and fluids to the circulatory volume. All indicated traumatic bedside procedures can be performed as indicated with consideration to alter technique (57). A diagnostic peritoneal lavage can be preferably performed above the umbilicus and fundus in a pregnancy beyond 20 wGA to avoid uterine instrumentation, usually performed after gastric decompression. Additionally, chest tubes should be placed one to two rib spaces above its normal placement of above the fifth rib, to prevent abdominal entry (56). A limited obstetric US should be performed by an experienced provider to determine fetal number, viability, size and gestational age, position, and evaluation of placenta for abruption and uterus for rupture. Continuous fetal monitoring should ensue if the gestation is beyond 20 wGA by means of a fetal cardiotocography (heart rate monitor and monitor for contractions). An assessment of labor and ROM should be performed by history, physical examination, sterile speculum examination, cervical examination, and other adjunctive tests as indicated. Consultants may include an obstetrician, anesthesiologist, neonatologist, and/or pediatrician (57).

Treatment of the pregnant trauma patient should be virtually identical to a non-pregnant patient with several specific alterations. Usage of all diagnostic modalities, including CT scan should be performed if indicated. Placing abdominal shielding and attenuating the dose of radiation may help reduce unnecessary radiation exposure to the fetus if feasible to achieve the appropriate image. CT of the head and neck involves very low fetal exposure and should be performed as per routine hospital protocols (58). If avoidance of ionizing radiation (CT and radiography) is plausible, then alternative methods to diagnosis should be employed. In addition to the aforementioned consultants, a pharmacist should review medications prescribed to prevent unnecessary administration to the fetus. However, there are very few medications that need to be withheld for treatment of the pregnant woman. In case of the need for an emergent delivery for fetal or maternal indications, the medical center should ensure that clinicians have easy and prompt access to a neonatal warmer and resuscitation kit, cesarean section surgical kit, and fetal monitoring
system. These items should be with the patient at all times (intensive care unit, operating room, imaging suite, etc.).

The obstetrician as a consultant should remark on the following:

1. If the patient is Rh negative, a Kleihauer–Betke (KB) test and 300 μg of Rh-D immunoglobulin (Rh-D Ig) should be administered within 72 hours of the trauma. An additional dose of Rh-D Ig 300 μg should be given to all Rh-negative women for every additional 30 mL of fetal blood found on KB testing, to prevent isoimmunization of the mother that can have deleterious effects on a subsequent pregnancy (12).

2. If the patient is between 24 and 34 wGA and a preterm birth is anticipated in the next 7 days, consideration for administration of antenatal corticosteroids and tocolysis may be indicated.

3. There should be comments on fetal status, indicated length of monitoring, appropriate positioning to monitor of the fetus and patient, and determination for further fetal evaluation with ultrasound.

4. Depending on the maternal and fetal conditions, the consultant should comment on timing and recommended route of delivery, patient disposition, and outpatient follow-up.

5. The consultant should obtain records or directly obtain routine prenatal labs, cultures, and diagnostics, as well as group B streptococcal screening and treatment if indicated. Of note, routine KB tests have been widely adopted in the trauma assessment; however, it has a poor predictive value of fetal distress or death, preterm birth, placental abruption, and typically does not alter management (12,56). Its utility has remained in aiding the calculated amount of Rh-D Ig to administer.

Duration of fetal monitoring recommendations after minor and major trauma is still controversial, and there is a lack of level I evidence for management guidelines. However, the EAST Practice Management in 2010 developed several level II and III guidelines to guide the clinician for appropriate duration of monitoring: “All women >20 week gestation who suffer trauma should have cardiotocographic monitoring for a minimum of 6 hours. Monitoring should be continued (for 24–48 hours) and further evaluation should be carried out if uterine contractions (>1 contraction per 10 minutes), a non–reassuring fetal heart rate pattern, vaginal bleeding, significant uterine tenderness or irritability, serious maternal injury (Injury Severity Score [ISS] >9, ejection from motor vehicle, motorcycle or pedestrian accident), or ROM is present” (59).

The rationale for extended fetal monitoring in the above criteria is that screening modalities such as history, physical examination, and obstetrical ultrasound are poor predictors for placental abruption, preterm labor, and fetal death. In a retrospective study, there was a higher rate of placental abruption for patients in motor vehicle accident ejections, maternal tachycardia above 110 beats/min, ISS over 9, or fetal bradycardia or tachycardia, suggesting a minimum of 24 hours of monitoring in this cohort of patients (43). Older studies have noted that placental abruption did not occur in trauma patients with less than one contraction every 10 minutes when monitored for a 4-hour period (12,44,60). Many hospitals follow the guideline for a minimum of 4 to 6 hours of cardiotocographic monitoring for patients who do not meet the above criteria for extended monitoring.

Five percent to 24% of pregnant patients admitted for trauma deliver during that hospitalization and usually within 24 hours of the trauma. This is likely a result of placental abruption causing uteroplacental insufficiency and fetal distress, activating the labor process (6). In studies that include route of delivery after trauma, about 75% of all deliveries are performed by cesarean section (5,6). The route of delivery is decided by routine obstetric guidelines in addition to the following conditions. Pelvic fracture is not an absolute contraindication to vaginal delivery, even in highly displaced pelvic fractures or hardware placement. However, large dislocating or unstable fractures may prohibit an attempt at vaginal delivery, and may require a cesarean delivery (12,61). Delivery induction is recommended for patients suffering burns over 40% of the body because of the high fetal mortality rate, aggressive fluid resuscitation, high need for ventilatory support, and high suspicion for thrombosis and/or sepsis (62,63). In burns, an early delivery may improve maternal condition and prevent fetal death (Fig. 80.1).

Fortunately, severe trauma requiring admission to the ICU is infrequent (3 in 1,000 pregnancies). It is estimated that 1,300 to 3,900 fetuses are lost due to maternal trauma each year. Mild maternal injuries carry a 1% to 5% fetal loss rate, whereas life-threatening trauma is associated with loss rates up to 40% to 50%. Because mild trauma is more prevalent, most fetal loss is due to minor maternal injury (12). Pregnant patients with pelvic or acetabular fractures are associated with higher maternal and fetal death rates, 9% and 35%, respectively (64). The high fetal mortality rate is likely due to concentration of force enough to break the maternal pelvis, which is likely to also impact the fetus directly. As such, in penetrating abdominal injuries at the level of the uterus has a higher fetal morality rate, but actually has a reduced maternal mortality rate, presumably as the uterus shields other vital maternal organs (7,65). Population-based data indicate that motor vehicle crashes account for 82% of fetal deaths after trauma, with an overall rate of 3.7 per 100,000 live births. The highest rate of fetal death due to trauma is seen in patients between 15 and 19 years of age (11,66).

Acute Abdomen

Acute abdominal pain in the pregnant female is a very common complaint. Although most times it can be attributed to labor, round ligament pain, constipation, urinary tract infection, or gastrointestinal reflux, it is important to obtain an appropriate history and physical examination to screen for life-threatening disease. The diagnosis can be difficult as some complaints may start with vague symptomatology, compounded with the hesitancy of a clinician to perform invasive or radiologic procedures due to fear of fetal safety. The most common diagnosis yielded from “abdominal pain” nearing a term gestation is labor that typically presents with regular and increasing frequency of abdominal cramping, pelvic pressure, bloody or fluid vaginal discharge. Although it not characteristic to have rebound abdominal tenderness in labor, syndromes such as chorioamnionitis and placental abruption may cause exquisite fundal tenderness, further disguising an underlying surgical disease. Another confounding factor is that both term and preterm labor can be precipitated from these acute abdominal processes, necessitating the clinician to recognize an abdominal illness in addition to labor (67).
In a recent patient survey and chart review, the highest non-obstetric complaints lead to diagnoses of biliary ascariasis (28%), peptic ulcer disease (24%), lower urinary tract infection (10%), acute pyelonephritis (6%), acute gastroenteritis (6%), acute cholecystitis (6%), acute appendicitis (6%), renal colic (4%), cholelithiasis (3%), acute pancreatitis (2%), ovarian solid mass (2%), torsed ovarian mass (2%), and renal calculus (1%) (68). This section will focus on surgical diseases of the abdomen in pregnancy, which is estimated to occur in about 1 per 635 pregnancies (67).

**Acute Appendicitis**

Acute appendicitis complicates approximately 1 in 1,500 pregnancies, most commonly in the second trimester, and appendectomy is the most common nonobstetric procedure
performed in pregnancy (69–71). Appendicitis can be difficult to diagnose as the signs and symptoms, as well as normal pregnancy-induced physiologic leukocytosis, can obscure the diagnostic picture. It is more common for the presentation to be subsequent to a perforation as there is a reluctance to perform appropriate diagnostic imaging examinations and/or operate on a pregnant woman. Clinical features of appendicitis include periumbilical abdominal pain that migrates to McBurney’s point, which is more cephalic from the right lower quadrant the uterus enlarges. Anorexia, nausea, vomiting, fever over 38.5°C may subsequently develop. Occasionally, pain on rectal or vaginal examination and microscopic hematuria and leukocyturia can be present if the inflamed appendix is adjacent to the ureter or bladder. There is usually an elevated leukocytosis, C-reactive protein, and erythrocyte sedimentation rate, but these are all nonspecific for appendicitis (71). In a typical presentation, a compression abdominal US at the point of maximal pain is the first-line imaging technique of the appendix. If the US is equivocal and the patient is clinically stable, an MRI without contrast is the next best imaging study to evaluate the abdomen and appendix. A CT scan is reserved for cases where an urgent diagnosis is needed to prevent morbidity or to evaluate other abdominal structures as the potential cause of abdominal pain as it does confirm ionizing radiation to the fetus (38,45,71). Acute appendicitis is a histologic diagnosis where prompt surgical resection within 24 hours is recommended in pregnancy, despite recent literature of antibiotic therapy alone in nonpregnant patients. Preoperative antibiotics to cover gram-positive and gram-negative bacteria, and anaerobic bacteria are recommended in conjunction to surgery. A delay in diagnosis of more than 24 hours has lead to a higher prevalence of perforated appendix (14% to 43%) (72), which usually occurs in the third trimester of pregnancy. The risk of fetal loss in perforated appendicitis is about 36% versus the nonperforated appendicitis to be 1.5%, a higher rate of preterm delivery (11% vs. 4%), suggesting that there should not be any delay in operative treatment in suspected acute appendicitis (73). Given the dangerous sequelae of delayed treatment, a higher “negative appendectomy rate” of 20% to 35% is acceptable. The negative appendectomy rate may be reduced with the use of MRI diagnostic imagery in selected stable patients. The surgical technique can be by laparoscopic approach (preferred), infraumbilical vertical laparotomy, or by transverse laparotomy over the suspected location of the appendix in all trimesters in pregnancy. The prognosis for the patient is good, and despite lacking data on the ultimate fetal outcomes, studies to date have reported normal child development (71,74). An appendectomy during pregnancy is not an indication for cesarean delivery, and route/timing of delivery may be decided on by obstetric and fetal indications.

**Acute Cholecystitis**

Acute cholecystitis with gallstones affects almost 20% of women by age 40 (75). It has a predilection to women as estrogen increases cholesterol secretion and progesterone reduces soluble bile acids and gallbladder mobility promoting stone formation and subsequent inflammation (76). Other risk factors include race, weight, diet, physical activity, obesity, serum lipids, and family history. A reported incidence of 1% to 4% of pregnant women have asymptomatic cholelithiasis, and 0.1% become symptomatic during pregnancy (70,77). Symptoms of biliary colic include bloating, nausea, and heartburn with eating. Acute cholecystitis may be diagnosed with right upper quadrant (RUQ) pain and tenderness (Murphy’s sign), fever, tachycardia, leukocytosis, hyperbilirubinemia, transaminitis, and have ultrasonographic signs of gallbladder thickening over 5 mm, pericholecystic fluid, calculi, and possibly a dilated biliary duct on imaging (45,70). As mentioned above, MRCP is the next best imaging tool, and ERCP can be used if there is a need for an endoscopic removal of ductal stones. CT does not offer utility in diagnosis during pregnancy.

The first-line treatment is conservative therapy of intravenous hydration, pain control, bowel rest, and for those with systemic symptoms, antimicrobial therapy. Studies have demonstrated reduction of inflammation of the gallbladder with a short course of indomethacin prior to 32 wGA without fetal complications (70,77). Ursodeoxycholic acid, which can dissolve hepatic calculi, does not have safety data in pregnancy and is not recommended for treatment of cholelithiasis in pregnancy. Surgical therapy is indicated when acute cholecystitis is associated with sepsis, ileus, perforation, gallstone pancreatitis, refractory pain, and cholecodocholithiasis (78).

The surgical management of symptomatic cholelithiasis is less clear. Recent studies suggest performance of a laparoscopic cholecystectomy with a skilled provider. The rationale for surgery is that risks are low with few complications noted in its performance in all three trimesters, and it will lead to a reduction of short- and long-term morbidity to include recurrent hospitalizations for the disease (79,80), parenteral nutrition during pregnancy, induction of labor, lost to follow-up, and recurrent symptoms in subsequent pregnancy (79,81). This negates the prior dictum of waiting to perform surgery until the postpartum period. Lastly, there are several case reports of image guided catheterization of the gallbladder for decompression without fetal or neonatal complications, but research is lacking in this modality of treatment.

**Adnexal Masses**

With the increase in early pregnancy evaluations by transvaginal or abdominal ultrasound, there is an increasing incidence of adnexal masses diagnosed during pregnancy. The prevalence of adnexal masses range from 2.3% to 5.3% (82–84), and most (>90%) resolve spontaneously. The adnexal mass can range from benign ovarian or fallopian tube tissue or cyst, to oncologic processes involving the fallopian tube, ovary, or metastasized tissue from a different organ. Occasionally, the adnexal mass identified is of a different organ tissue (i.e., uterine fibroid or loop of bowel). Despite the majority of masses being benign, up to 5% may represent a malignant process, most commonly a borderline ovarian tumor (84). US is the imaging of choice for an adnexal mass that can help discern its histopathologic morphology by evaluating size, location, laterality, presence of ascites, morphology of tumor, and blood flow within the mass (85). Characterization of the adnexal mass will lead the clinician to offer expectant management, additional and/or follow-up imaging, blood draw for tumor markers, or surgical management. Most masses will resolve spontaneously and require a follow-up image at a 4- to 8-week interval to document resolution. For masses that appear concerning for malignancy, tumor markers (cancer antigen-125, alpha fetoprotein, carcinoembryonic antigen, cancer antigen 19-9, beta-HCG, lactate dehydrogenase, human epididymis protein 4, inhibin B, serum testosterone) may be drawn with caution as
other pregnancy variables may cause elevations in these markers. Additional imaging with MRI may offer more detailed information regarding the mass and other organ involvement. CT imaging may determine cancer staging if suspicion of a high stage of cancer is suggested by US, MRI, or tumor markers (86). Positron emission tomography is currently not recommended in preoperative evaluation adnexal masses in pregnancy.

Most adnexal masses are asymptomatic, but occasionally can cause tremendous discomfort in the occurrence of adnexal torsion. Torsion is considered a surgical emergency for the viability of the fallopian tube and ovary. It is characterized by a sudden onset of immense right or left lower quadrant pain with nausea and vomiting. Demonstration of lack of blood flow on Doppler US does not preclude that the adnexa is not torsed, but typically demonstrates a 5- to 10-cm mass on the side of maternal pain (84). Suspicion of ovarian torsion is an indication for emergent laparotomy or laparoscopic procedure for removal of the mass and detorsion.

If the adnexal mass is likely a malignancy based on laboratory and imaging examinations, an individualized plan devised by a multidisciplinary team approach of obstetricians, gynecology oncologists, oncologists, neonatologist, and psychologists should be performed (87). Neoadjuvant or adjuvant chemotherapy can generally be performed after the 12th week of gestation to avoid complications of teratogenesis, but is associated with preterm birth and intrauterine growth restriction, and still carries a low risk of malformation (88). Surgical removal of a cyst, mass, or cancer is generally safe during pregnancy (89). However, care needs to be taken not to remove ovarian masses in pregnancies before 12 wGA without progesterone supplementation, as the mass may be the corpus luteum supporting the pregnancy and will cause a spontaneous abortion if removed.

Other Abdominal Syndromes and Abdominal Sepsis

Surgery on the maternal appendix, biliary tree, adnexal masses, and for trauma are the most frequent nonobstetric indications for abdominal surgery in pregnancy. There are multiple other indications for abdominal surgery in pregnancy and require a multidisciplinary team approach for management. Abdominal sepsis may be another indication for surgical procedures where there is no standardized approach for treatment (other than chorioamnionitis). It should be mentioned that interventional radiologic procedures are increasing in efficacy to remove collections of infectious material in the abdomen and should be considered in pregnancy to additionally complement laparoscopy and laparotomy. Septic etiologies should be considered in pregnancy with fever, leukocytosis, and labor or preterm labor. A common septic cause worth reviewing is an intra-amniotic infection, or chorioamnionitis.

Chorioamnionitis is a histopathologic diagnosis, typically resulting from bacterial infection of the amniotic membranes and fluid, as well as the placenta. As pathologic specimens are not available prior to delivery, physicians need a high index of suspicion for chorioamnionitis which can be diagnosed clinically by a maternal fever over 38°C, absence of other sources of infection including the urinary tract, and one of the following: uterine tenderness, foul-smelling leucorrhea, leukocytosis higher than 15,000 cells/mm³ (3), maternal tachycardia, or fetal tachycardia. An amniocentesis can be performed and the presence of a micro-organism (Gram stain and culture), glucose below 20 mg/dL, elevated interleukins-1 and -6, and high white blood cell count in the amniotic fluid are all sensitive predictors for chorioamnionitis. Chorioamnionitis is an indication for prompt antibiotic administration cover aerobic gram-positive and gram-negative microbes and for delivery of the fetus, regardless of gestational age (90).

PERIOPERATIVE MANAGEMENT

Anesthesia

Anesthesia for a nonobstetric surgery requires a skilled technician knowledgeable in adult and fetal medicine, usually requiring anesthesia consultation prior to surgery. Regional or local anesthetics are thought to be safer than general anesthesia in most cases. Regional anesthesia for abdominal surgery has the advantage of minimal fetal local anesthetic drug exposure and is less likely to be associated with maternal airway complications. Local anesthetics are not known to be teratogenic when used in this clinical setting (91).

Due to the risk of aspiration from gastroesophageal (GE) reflux and delayed gastric emptying, it is customary to administer a nonparticulate antacid or H₂ blocker as well as medication to improve GE sphincter tone preoperatively. If general anesthesia is planned, pre-oxygenation and rapid-sequence intubation are typically performed. Care should be taken to avoid hyperventilation, as uterine blood flow is impaired. Inhalational agents, such as isoflurane and others, decrease uterine tone and can effectively inhibit labor during surgery. Agents used for general anesthesia during pregnancy, including a single dose of benzodiazepines, nitrous oxide, and inhalational agents, do cross the placenta but have not been shown to be teratogenic (91). Nonobstetric surgery during pregnancy denotes a low maternal mortality of less than 1 in 10,000, did not increase the rate of birth defects, and does have an increased incidence of low–birth-weight nor preterm labor (92).

Fetal Monitoring

Intraoperative fetal monitoring is advised for viable pregnancies if it is plausible for an emergent delivery for fetal indications. This includes having the appropriate measures for delivery to include cesarean section operative equipment, personnel to evaluate fetal cardiotocography, an obstetric provider, and when possible, consent to perform a cesarean delivery. In addition, having a neonatologist or pediatrician and a neonatal resuscitation warmer, equipment, and resources available are recommended if delivery is indicated. In a preivable fetus, preoperative and postoperative fetal dopotones are appropriate (see Table 80.1) (3).

Laparoscopy in Pregnancy

Guidelines for the general surgeon regarding laparoscopy in pregnancy have been reviewed by the Society of American Gastrointestinal and Endoscopic Surgeons with the following consensus guidelines. Surgical laparoscopy for the acute abdomen has the same indications in all trimesters of pregnancy when compared to nonpregnant women, which has a good record of safety during pregnancy. Special considerations for laparoscopy during pregnancy might include the use of an...
open technique (Hassan) or alternate placement of optical trochars/veress needle for access into the abdominal cavity, direct visualization for additional trochar placement, lower insufflation pressures (10 to 15 mmHg), and positioning the patient in a leftward lateral recumbent position. Intraoperative monitoring of CO₂ levels by using end-tidal capnography and/or episodic arterial blood gases may help prevent maternal acid base disturbances and fetal acidemia. Laparoscopy is of additional benefit over laparotomy to reduce postoperative narcotic requirements, lower risk of wound complications, reduced respiratory splitting and hyperventilation, offer shorter hospital stays, and reduced thromboembolic events because of early ambulation. Use of abdominal shielding to prevent fetal exposure of intraoperative ionizing radiation is recommended. The consensus guidelines further evaluate specific procedures as to be able to be performed in pregnancy as well as remarks on venous thromboembolism prophylaxis (93, 94).

MATERNAL CARDIAC ARREST

Maternal cardiac arrest is a devastating occurrence that puts a woman and her baby’s life in extremis. Although this event is rare, the rate has risen almost 2.5 times in the past 10 years, as the maternal death rate is now 14.5 per 100,000 pregnancies (95). Typical ACLS courses do not devote instructional time to the specifics about maternal cardiac arrest and obstetric teams lack experience in its management, which may create a very chaotic maternal code situation. Recently, the Society for Obstetric Anesthesia and Perinatology created a consensus statement on cardiac arrest during pregnancy to highlight unique aspects on management (96).

In the event of a maternal code, initiation of usual ACLS with chest compressions and ventilation, early automated external defibrillator (AED) use, and activating the hospital-specific “obstetric code” are paramount. This specific code team should assemble an obstetrician and neonatal resuscitation team, in additional to intensivists, respiratory technicians, pharmacists, and code nurses. In addition to the ACLS algorithm (Fig. 80.1), there are several pregnancy-specific recommendations for resuscitation for patients beyond 20 wGA (Table 80.3) (96):

1. Perform compressions on the midsternum instead of the “lower half of the sternum.” The gravid abdomen displaces the diaphragm and heart orientation to a more superior and lateral position than nonpregnant women.
2. All intravenous access should be above the diaphragm (i.e., peripheral i.v., subclavian and internal jugular central venous catheters, midlines, or humeral head intraosseous access) to adequately access the central circulation.
3. Give typical ACLS medications and AED doses. There are no contraindicated medications for pregnant patients in extremis.
4. Assess for hypovolemia and give fluid boluses as indicated.
5. Due to the progesterone effect of slowed gastric emptying during pregnancy and common occurrence of laryngeal edema, the provider should anticipate a difficult airway and consider early placement of an advanced airway with a slightly smaller endotracheal tube than one would use for a nonpregnant woman. Also, continuous cricoid pressure is recommended during intubation during a maternal code.

### TABLE 80.3 Causes for Maternal Cardiac Arrest: H&T’s and BEAUCHOPS

<table>
<thead>
<tr>
<th>H&amp;T’s</th>
<th>BEAUCHOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemia</td>
<td>Bleeding, disseminated intravascular coagulopathy</td>
</tr>
<tr>
<td>Hypoxia</td>
<td>Embolism: coronary, pulmonary, amniotic fluid</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td>Anesthesia complications (epidural/spinal)</td>
</tr>
<tr>
<td>Hypothermia</td>
<td>Uterine atony</td>
</tr>
<tr>
<td>Tension pneumothorax</td>
<td>Cardiac disease (myocardial infarction, cardiomyopathy)</td>
</tr>
<tr>
<td>Tamponade, cardiac</td>
<td>Hypertension (preeclampsia, eclampsia)</td>
</tr>
<tr>
<td>Thrombosis, pulmonary</td>
<td>Other H&amp;T’s</td>
</tr>
<tr>
<td>Thrombosis, coronary</td>
<td>Placenta abruption/previa</td>
</tr>
<tr>
<td>Toxins</td>
<td>Sepsis</td>
</tr>
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6. If the patient has received recent magnesium sulfate infusions, stop the infusion and give calcium chloride 10 mL in 10% solution upon code initiation, which will empirically reverse a magnesium toxic dose.
7. Remove all fetal monitors. If the patient cannot perfuse her own heart and brain, she is not likely perfusing the fetus, and the fetal heart rate tracing will not change management during a cardiac arrest.
8. Prevent aorticaval compression by tilting the patient 15 to 30 degrees in the left lateral decubitus position or manually displace the uterus leftward and upward to improve blood return to the heart from the lower extremities.
9. If there is no return of spontaneous circulation (ROSC) by 4 minutes in a pregnancy beyond 20 wGA, start an emergent cesarean delivery (known as a resuscitative hysterotomy in this case) with the goal of delivery by 5 minutes of the cardiac arrest for maternal benefit of improving perfusion.
10. Continue all maternal resuscitation during and after the perimortem cesarean delivery (PMCD).
11. In addition to the “H&T’s” that are considered in the 2010 American Heart Association guidelines for ACLS, consider using the pneumonic BEAUCHOPS to aid in the recollection of the most common reasons for a pregnant patient to have a cardiac arrest.

**Perimortem Cesarean Delivery**

During a maternal cardiac arrest, the recorder should prompt the team when 4 minutes have occurred in the undelivered pregnant woman beyond 20 wGA. If ROSC has not been achieved, the team should promptly perform a PMCD within 1 minute and goal delivery within 5 minutes of maternal cardiac arrest (97). If feasible for an operative vaginal delivery (assisted with a fetal vacuum or forceps), an obstetrician should perform this prior to the 5-minute time from the initial cardiac arrest. As mentioned above, a PMCD is performed...
for maternal benefit with improved venous return to the heart by an auto-transfusion from the uterine blood flow and relief of caval compression, reduced oxygen demand from removal of the fetus and placenta, and improved pulmonary function with the reduction of abdominal/uterine compression (96–98). This may be lifesaving for the fetus. In a case series including 38 women undergoing PMCD, no cases of cesarean delivery worsened maternal condition and of the 20 women who had ROSC, 12 occurred immediately after delivery (10). In over 50% of maternal cardiac arrests does ROSC occur, and neonatal survival was based on in-hospital or in-community maternal arrest (99).

Maternal Brain Death

On rare occasions maternal brain death is identified in a pregnant woman while somatic support has been maintained and the fetus remains alive. Under these circumstances, a determination must be made as to whether to deliver the fetus immediately, to initiate supportive care to allow further fetal maturation, or to allow the fetus to die as the mother is removed from mechanical ventilation. Immediate delivery when gestational age is consistent with neonatal survival is usually preferred. However, if the mother’s condition permits, it is possible to support the mother and previable fetus until fetal maturation allows for neonatal survival. This somatic support can be provided for extended periods with no apparent neonatal or pediatric sequelae with 2-year follow-up reported (100,101).

Ethical Decision-Making

There is a potential for conflicts in decision-making between the clinician and the pregnant woman. Patients may be asked to consent to procedures that carry some risk to the fetus. Alternatively, interventions proposed for fetal benefit may present a risk to maternal health. Principle-based ethics, based on the concepts of autonomy, beneficence, and justice, have been used to aid choices. Providers also need to take into account the social and cultural contexts within which the patient is making her choices. According to the ACOG Ethical Guidelines, “Every reasonable effort should be made to protect the fetus, but the pregnant woman’s autonomy should be respected…. Intervention against the wishes of a pregnant woman is rarely, if ever, acceptable” (102).

In the case of a patient who is incapacitated, state laws vary with respect to who may serve as a surrogate decision-maker. The designees should base their decisions on the values and wishes of the patient, which may or may not have previously been stated in writing. Clinicians should try to anticipate such scenarios and attempt to adhere to the woman’s wishes regarding treatment for herself and/or her fetus. If there is no consensus about who should be designated, the advice of an ethics committee should be considered.

INJURY PREVENTION AND REDUCTION

Thromboembolism Prevention

Pregnancy induces a prothrombotic state and increases the risk of both venous and arterial thromboembolism to an incidence of 0.1% to 0.2% of pregnant women, with a higher propensity to affect the venous system (103,104) and occurrence during the postpartum period (105). Pulmonary thromboembolism (PE) has been reported to be the cause of death of 10.2% of maternal deaths between 1998 and 2005 and occurs in 0.6 to 1.8 per 1,000 deliveries (106). Placental factors increase protein S excretion and increase fibrinogen, cause mechanical compression iliac and caval venous vessels (especially the left iliac vein as it traverses the pelvis longer than the right iliac vein) that both injures the endothelium and causes blood stasis. Each risk factor of Virchow’s triad is elevated, which explains the propensity for thromboembolism in pregnancy. Firm guidelines are yet to be established in the United States, but the Royal College of Obstetricians and Gynecologists (RCOG) have recommended that all women undergo risk assessment for venous thromboembolism during early pregnancy. Those at high risk should be counseled for using chemoprophylaxis during pregnancy. Approved prophylactic agents in pregnancy include low–molecular-weight heparins and unfractionated heparin during the antepartum course, transitioning to unfractionated heparin during labor as it is more readily reversible with protamine sulfate in the case of bleeding. Coumadin is a longer-acting drug that has teratogenic effects and should be avoided during pregnancy, but is acceptable for administration postpartum (after postpartum day 3) as it does not get secreted in breast milk. If there is suspicion of a venous thrombus, a compression venous duplex US should be performed and treatment with therapeutic unfractionated heparin should ensue while diagnostic tests are completed. A compression venous duplex US is first line in diagnosis as the treatment for a venous thrombus and pulmonary embolism includes supportive therapy and therapeutic anticoagulation. This will avoid ionizing radiation of a CT scan of the chest during pregnancy. If the compression venous duplex is not remarkable for a thrombus, and a high suspicion for PE still exists, then a CT for pulmonary angiography or V/Q scan should be performed. If thrombus or pulmonary embolism is confirmed, treatment to therapeutic anticoagulation and clinical endpoints are the same in pregnant women when compared to non-pregnant women. During parturition, discontinuing or using reversal agents to negate the effects of anticoagulation is necessary until approximately 6 to 12 hours after delivery. Treatment should ensue for 3 to 6 months postpartum for most patients with thromboembolic disease (106).

Restraints and Motor Vehicle Accidents

Lack of seatbelt use has been shown to contribute to the severity of maternal and fetal injuries. Knowledge of proper seatbelt use is low among some patients, especially teens and those with low education levels. In one survey of 450 pregnant women, only 72.5% reported using the seatbelt in the proper location. Women who always wore restraints were more likely to report correct placement. Sixty percent of respondents thought restraints would protect their baby, whereas 11.6% thought restraints caused injury to the baby, and 37% were unsure. The most common reasons for lack of use were lack of comfort (52.8%) and forgetting (42.5%). However, only 36.9% of women reported receiving information about seatbelt use during that pregnancy (107). Another survey of 807 women revealed that although 79% of women used safety
Abuse & Incest National Network (RAINN) (800) 656-HOPE. National Domestic Violence Hotline (800) 799-SAFE and Rape Information in the United States on intimate partner violence are:

1. Two 24-hour toll-free hotlines to provide more information and develop a safety plan should be made for these patients using community resources.
2. Individualized plans of care and for ongoing care. Screenings are conducted by history, physical examination, and observation of the partner–patient relationship, ensuring that patient disclosure of violence is held confidential. Most states do not mandate abuse reporting, but providing resource information and developing a safety plan are initial steps to aid these patients. Individualized plans of care should be made for these patients using community resources.
3. These may be an underestimate as women may be afraid of disclosing these events for fear of repercussions from the partner. The female gender, adolescents, immigrants, disabled, and elderly women are all at increased risk for intimate partner violence. The effects can lead to a multiple sequelae of psychological, physical, and sexual syndromes. Most states do not mandate abuse reporting, but specific alterations in ascer taining diagnosis, and treatment should be considered.
4. There are several alterations in maternal ACLS, including prompt delivery in any gestation beyond 20 weeks of gestation before 20 weeks.

Intimate Partner Violence

Intimate partner violence occurs when an intimate partner displays controlling behavior that may include physical, psychological, or sexual abuse. Abusive patterns have a wide range of presentation, from constant threats and intimidation to financial and physical coercive techniques that result in the patient’s dependence on the partner.

Estimations of about one-third of women in the United States have experienced rape or physical violence, or have had an intimate partner stalking them. This may be an underestimate as women may be afraid of disclosing these events for fear of repercussions from the partner. The female gender, adolescents, immigrants, disabled, and elderly women are all at increased risk for intimate partner violence. The effects can lead to a multiple sequelae of psychological, physical, and sexual syndromes, as well as specific pregnancy risks of poor weight gain, tobacco use, pelvic fracture, placental abruption, preterm delivery, stillbirth, postpartum depression, and low birth weight. ACOG endorses the screening for intimate partner violence at well woman, family planning (contraception), and pregnancy clinical visits and for ongoing care. Screening is conducted by history, physical examination, and observation of the partner–patient relationship, ensuring that patient disclosure of violence is held confidential. Most states do not mandate abuse reporting, but providing resource information and developing a safety plan are initial steps to aid these patients. Individualized plans of care should be made for these patients using community resources.

Key Points

- Pregnancy induces different physiologic variables when compared to nonpregnant women.
- The primary survey in the trauma assessment for pregnant women is the same for nonpregnant women. There are multiple modifications in maternal positioning, diagnosis, and treatment within the secondary survey.
- Imaging of the acute abdomen in pregnancy usually consists of US, then MRI if the US is equivocal in stable patients. CT is reserved for patients who require immediate evaluation due to risk of delayed diagnosis or hemodynamically instability, due to the fetal risk of ionizing radiation.
- Surgical indications for the acute abdomen in the pregnant woman are virtually identical for that of the nonpregnant woman, but specific alterations in ascertaining diagnosis, treatment, and surgical technique should be considered.

References