**Chapter 41  
Physiology of pregnancy: EMS implications**

**David J. Hirsch**

**Introduction**

Evaluation and treatment of the pregnant patient represent a challenge for all levels of medical providers, from first responder through EMS physician. Thankfully, major complications and acute life-threatening illnesses are rare. However, when they occur, many special considerations must be taken into account in order to provide the best medical care. This chapter will provide an overview of physiological changes in pregnancy and their implications for prehospital care. Although many of the conditions require further diagnostic testing and treatment beyond the current capabilities of EMS, familiarization by EMS providers and EMS medical directors is critical. This will enable EMS providers to consider life-threatening conditions that require immediate intervention, formulate a preliminary differential diagnosis, initiate treatment, and make the best determination for transport destination.

**General considerations**

**Anatomical**

The anatomical changes that a woman undergoes during pregnancy are not confined to the reproductive organs. One of the most apparent changes is weight gain. By full term, a woman of average weight should be expected to gain between 25–35 pounds (11.5–16 kg) [1]. Most of this weight is made up of the fetus and uterus, but contributions are also made by the breasts and additional fluid in the form of blood volume and extracellular fluid. This additional weight, particularly its distribution, provides distinct challenges for EMS providers in certain circumstances such as airway management and traumatic injury, which will be discussed in detail later.

**Physiological**

Innumerable physiological changes occur during pregnancy. Discussion will be limited to those with the most direct prehospital effects. The increase in blood volume, on average 48% above that of a non-pregnant patient, is one of the most dramatic changes. This is an absolute increase of about 1500 mL [2]. This increased volume improves blood flow and provides nutrients to the growing uterus and fetus, protects the fetus from impaired venous return from maternal supine position, and protects the mother from the effects of blood loss during delivery [3]. Other notable changes include increased baseline heart rate, increased cardiac output, and normal to low blood pressure ([Box 41.1](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c41.xhtml#c41-fea-0001)).

**Box 41.1 Physiological changes in pregnancy**

* Blood volume increased by 50%
* Baseline heart rate increased 10–15%
* Respirations increased 10–15%
* Cardiac output increased
* Blood pressure decreased or normal

**Critical care and trauma**

The core of any EMS provider’s training is based on initial evaluation and stabilization of the most critically ill or injured patient. This is best accomplished by using a systematic method such as the ABCs (airway, breathing, circulation). The pregnant patient should be approached in a similar manner, with specific additional considerations. Any resuscitation during pregnancy places at least two lives at stake, considering the mother and one or more fetuses.

**Airway**

Airway management is among the most critical skills for the EMS provider to master. Without proper airway maintenance, a patient has a small chance of even arriving at the hospital alive. Several anatomical changes to the airway during pregnancy can complicate airway management in the prehospital setting [4]. Edema, caused by increased extracellular fluid volume, can lead to more profound airway obstruction in states of decreased responsiveness, complicating basic airway maneuvers such as bag-valve-mask ventilation. Edema may also lead to swelling of the glottic structures, causing a decreased glottic opening and complicating advanced airway interventions. Additional important considerations are listed in [Box 41.2](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c41.xhtml#c41-fea-0002).

**Box 41.2 Airway and breathing considerations**

* Increased airway edema
* Increased risk of regurgitation and aspiration
* Increased risk of bleeding due to capillary engorgement
* Decreased functional residual capacity (20%)
* Increased oxygen consumption (30–60%)

Source: Lewin et al. 2000 [4]. Reproduced with permission of Elsevier.

Emergency medical services providers must anticipate these issues, and pay close attention to basic airway techniques, with more liberal use of airway adjuncts such as oral or nasal airways as appropriate. Suctioning devices must be ready and available at all times to address vomiting. For advanced airway interventions, ALS providers should perform an airway assessment using standardized scoring systems such as Mallampati to help predict the presence of a difficult airway. A smaller sized endotracheal tube than anticipated should be kept on hand in case of difficulty passing the tube through the glottic opening. Standard monitoring such as oxygen saturation and waveform capnography is critical.

**Breathing**

The gravid uterus causes significant upward displacement of the diaphragm, restricting lung function. Functional residual capacity is decreased by approximately 20% in pregnancy [4]. This, in combination with increased oxygen consumption of 30–60% and decreased venous return due to inferior vena cava compression, can lead to rapid desaturation with any medical or traumatic insult. The patient with respiratory distress or who is requiring ventilation should be placed as upright as feasible to decrease abdominal pressure on the thorax. Oxygen should be used more liberally to ensure the fetus is receiving adequate oxygenation.

**Circulation**

As described earlier, pregnancy is accompanied by increased blood volume which may allow initial compensation for even major blood loss, followed by rapid deterioration. Given this, patients should be treated aggressively with fluid resuscitation for potential hypovolemic states. The shift toward a permissive hypotension approach to trauma patients should likely not be applied to pregnant patients, though data on this are lacking. Given the relative anemia of pregnancy, blood transfusion may be necessary earlier in resuscitative efforts than in a non-pregnant patient. Vasopressors may be used if necessary to correct shock.

Complications such as pulmonary edema and third spacing with crystalloid infusions due to lower oncotic pressure should be anticipated. Patients with hypotension and/or those who are supine should always be placed tilted to the left 15–30° using sandbags or pillows. This allows the gravid uterus to be moved off the inferior vena cava, improving venous return to the heart.

**Disease states by system**

In the preceding section, the evaluation and management of the pregnant patient *in extremis* were discussed. In the following sections, a general overview of disease states by system will be presented. Particular attention will be paid to pathophysiology seen in the pregnant patient compared to standard pathophysiology.

**Cardiovascular**

Aside from the gynecological system, the cardiovascular system undergoes the most dramatic changes during pregnancy. The heart of the pregnant woman actually remodels, increasing contractile force [5], and when combined with the increased blood volume, increased heart rate, and decreased vascular resistance, a 50% increase in cardiac output results.

When evaluating the pregnant patient, the ALS provider must be aware of ECG changes that occur normally in pregnancy. Due to elevation of the diaphragm and pressure on the heart, ECG changes including left axis deviation, ST-wave flattening, and T-wave inversions are seen particularly near full term. The ST- and T-wave changes seem to appear primarily in the inferior and precordial leads [6]. While most of the cardiovascular changes are beneficial, pathophysiological states can occur. Arrhythmias during pregnancy are fairly common, including supraventricular tachycardia (SVT), paroxysmal atrial fibrillation or flutter, or, more rarely, ventricular tachycardia [7].

Because safety data on many of the antiarrhythmic medications for treatment of the tachyarrhythmias are limited, pharmacological therapy is best avoided when possible during pregnancy [8]. That being said, patients who enter the EMS system often require emergency treatment and medications will be necessary. In cases of SVT, vagal maneuvers should be attempted first. Adenosine is considered a relatively safe intervention if vagal maneuvers fail. Calcium channel blockers such as verapamil and diltiazem are not felt to be as safe, but may be considered [8].

In patients who present in ventricular tachycardia with a pulse, lidocaine is indicated, with procainamide considered a second-line treatment. Amiodarone should be avoided unless absolutely necessary due to reports of fetal bradycardia and other serious adverse effects on the fetus [9]. Electrical cardioversion is considered safe if the patient is unstable or presents with pulseless ventricular tachycardia or ventricular fibrillation.

One of the feared cardiovascular complications of pregnancy is idiopathic cardiomyopathy. Patients present with findings consistent with standard congestive heart failure but may be otherwise young and healthy without the standard cardiovascular risk factors. Symptoms include shortness of breath, dyspnea on exertion, orthopnea, and increased peripheral edema. Prehospital management is similar to that of non-pregnant patients, with supplemental oxygen, positive pressure ventilation, and nitrates in the acute setting. For volume overload and chronic treatment, diuretics are used. After the pregnancy is completed, some patients have return of normal cardiac function, and some do not. Subsequent pregnancies carry a significant risk of recurrence of cardiomyopathy.

**Pulmonary**

Several changes occur during pregnancy that affect the pulmonary system. Because of the deviation of the diaphragm upward into the thorax, respiratory mechanics are affected. The functional residual capacity, vital capacity, residual volume, and inspiratory capacity all decrease [10]. Patient position greatly affects the patient’s mechanics, and EMS providers should place the patient in as much inclination as feasible.

Patients with underlying chronic pulmonary disorders, most commonly asthma, are at risk for worsening status during pregnancy due to the restricted respiratory mechanics. Fortunately, standard prehospital treatments for asthma exacerbations are considered safe in pregnancy. Standard therapy with supplemental oxygen, bronchodilators, and corticosteroids is indicated. Continuous monitoring with pulse oximetry and waveform capnography is critical. Positive pressure ventilation should be used as needed to help avoid the need for endotracheal intubation.

**Toxicological**

While many medications have different and largely unknown effects in pregnant patients, one of the most relevant toxicological exposures for EMS providers to be aware of is carbon monoxide (CO). This exposure deserves particular attention because it is fairly unique in that the fetus is at higher risk of adverse effects than the mother [11]. Pregnant patients have higher susceptibility to CO due to increased minute ventilation, in addition to increased endogenous production from the fetus [12]. Fetal hemoglobin has a higher affinity for CO than maternal hemoglobin, and the fetus is at risk for life-threatening exposure even if the mother appears relatively well.

Treatment includes removing the patient from the source of exposure, initiating high-flow oxygen, and considering hyperbaric oxygen (HBO). EMS providers should consider transport to a specialty center that can provide HBO if indicated (see [Box 41.3](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c41.xhtml#c41-fea-0003)) according to local protocols.

**Box 41.3 Indications for hyperbaric oxygen therapy in the pregnant patient**

* Carboxyhemoglobin level ≥20%
* Mental status depression
* Seizures
* Metabolic acidosis
* Fetal distress
* Cardiotoxicity
* Any neurological findings in the mother

Source: Shannon 2007 [11]. Reproduced with permission of Elsevier.

**Neurological**

One of the most serious neurological complications associated with pregnancy is seizures of eclampsia. Preeclampsia can affect almost every organ system in the body, and is typically diagnosed based on the combination of hypertension and proteinuria. Other associated symptoms include headaches, epigastric pain, and visual changes. If the syndrome progresses, the patient may develop eclampsia, with generalized seizure activity and significantly elevated blood pressure (see Volume 1, [Chapter 42](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c42.xhtml)).

**Thromboembolic conditions**

Venous thromboembolism is an important cause of maternal morbidity and mortality that EMS providers should be aware of. The most important of these conditions includes deep venous thrombosis (DVT) and pulmonary embolism (PE). Pregnant women are 4–5 times more likely to develop venous thromboembolism than non-pregnant women [13] due to the hypercoagulable state that is associated with pregnancy. Some studies have quoted rates of 1.72 per 1000 deliveries with 1.1 deaths per 100,000 [14].

The major concern regarding DVT is the possibility of dislodgment of the thrombus and travel to the lungs. Pulmonary embolism is a serious life-threatening condition, and prompt diagnosis and treatment are imperative. Diagnosis of DVT is best performed by duplex ultrasonography. PE can be diagnosed by computed tomography angiogram. Treatment includes anticoagulation with heparin or low molecular weight heparin. In cases of massive PE with persistent shock or cardiac arrest, thrombolytics can be considered.

**Genitourinary**

Due to anatomical changes, pregnant women are at higher risk for urinary tract infections (UTI) than non-pregnant women [15]. UTI can progress to pyelonephritis, or kidney infection, which is the most common cause of serious bacterial infection in pregnant women [16]. Serious bacterial infections in the mother can put the pregnancy at risk, and so early treatment is important.

**Gastrointestinal**

Most women in pregnancy have some degree of nausea and vomiting. This is most common in the first trimester and then typically improves. In some patients, this condition is severe and is referred to as hyperemesis gravidarum, defined as vomiting that is severe enough to produce weight loss, dehydration, and electrolyte abnormalities, particularly hypokalemia [3]. For patients with hyperemesis gravidarum, treatment is centered around antiemetics, IV fluid replacement, and correction of electrolytes.

Two surgical emergencies, appendicitis and cholecystitis, deserve specific attention. The evaluation, diagnosis, and treatment are more difficult than in the non-pregnant patient, and missed diagnosis can have adverse outcomes for the mother and fetus.

Appendicitis is the most common non-obstetric surgical diagnosis in pregnancy [17]. Diagnosis is more difficult than in the non-pregnant patient due to a variety of factors. Typical presenting signs and symptoms of appendicitis commonly occur under normal conditions during pregnancy. These include nausea and vomiting, decreased appetite, and abdominal pain. In addition, the anatomical location of the appendix has been described as having the tendency to shift superiorly and posteriorly due to displacement by the uterus [18]. Due to these confounding variables, pregnant patients have a higher rate of missed early diagnosis and perforation of the appendix. This puts the fetus at risk, and there is a risk of premature labor and miscarriage.

Emergency medical services providers should consider this diagnosis in patients presenting with right-sided abdominal pain. The location may not be necessarily limited to the right lower quadrant, and may be located in the right upper quadrant or right flank area.

A second common cause of right-sided abdominal pain in pregnancy is biliary disease. Patients may suffer from recurrent postprandial pain due to biliary colic, or develop acute inflammation and pain in the gallbladder from cholecystitis. Acute cholecystitis is the second most common general surgical condition during pregnancy [19] and can, like appendicitis, put the mother and fetus at risk. Symptoms of cholecystitis include right-sided abdominal pain as described above, as well as nausea, vomiting, and fever. Management may be conservative initially and surgical intervention may be delayed until after delivery if possible.

**Endocrine**

While there are many endocrine changes that occur in the pregnant patient, the most commonly encountered and most relevant to the EMS provider is gestational diabetes. Although many patients are diagnosed through routine prenatal screening with glucose tolerance tests, some patients may not be aware of the condition. In cases of hyperglycemia, patients may have typical symptoms of diabetes including polydipsia and polyuria. Rarely, patients may present with hyperglycemic hyperosmolar non-ketotic syndrome or diabetic ketoacidosis (DKA). EMS providers should treat with IV fluids for dehydration, and perform an ECG to evaluate and treat for life-threatening hyperkalemia states which can be associated with DKA. The mainstay of treatment for these conditions in the hospital is insulin therapy and electrolyte management.

Complications which may occur due to diabetes for the fetus include macrosomia (increased fetal size) which can lead to difficulties with delivery. In addition, neonates may have episodes of profound hypoglycemia in the minutes after delivery due to high compensatory circulating levels of insulin. EMS providers should anticipate this if necessary and be prepared to give dextrose to the neonate according to local protocol.

**Conclusion**

There are many anatomical and physiological changes in pregnancy which require specific awareness and knowledge by EMS providers. With the appropriate training, continuous quality improvement, and medical oversight, providers can have confidence in initiating the best emergency medical care and transporting safely to the appropriate receiving facility.

**References**

1. 1 Rasmussen KM, Committee to Reexamine IOM Pregnancy Weight Guidelines, Food and Nutrition Board, Board on Children, Youth and Families, Institute of Medicine, Division of Behavioral and Social Sciences and Education, National Research Council. *Weight Gain during Pregnancy: Reexamining the Guidelines*. Atlanta, GA: National Academies Press, 2009.
2. 2 Prichard JA. Changes in blood volume during pregnancy and delivery. *Anesthesiology* 1965;26:393–9.
3. 3 Cunningham FG, Leveno KJ, Bloom SL, et al. *Williams Obstetrics*, 23rd edn. New York: McGraw-Hill; 2010.
4. 4 Lewin SB, Cheek TJ , Deutschman CS. Airway management in the obstetric patient. *Crit Care Clin* 2000;16:505–13.
5. 5 Thornburga KL, Jacobsona SL, Girauda GD, Morton MJ. Hemodynamic changes in pregnancy. *Semin Perinatol* 2000; 24:11–14.
6. 6 Perrotta E, Carillo C, Celli P. Electrocardiographic changes during at term labor. *G Ital Cardiol* 1999;29:48–53.
7. 7 Silversides CK, Harris L, Haberer K, et al. Recurrence rates of arrhythmias during pregnancy in women with previous tachyarrhythmia and impact on fetal and neonatal outcomes. *Am J Cardiol* 2006;97:1206–12.
8. 8 Page RL. Treatment of arrhythmias during pregnancy. *Am Heart J* 1995;130:871–6.
9. 9 Cox JL, Gardner MJ. Treatment of cardiac arrhythmias during pregnancy. *Prog Cardiovasc Dis* 1993;36:137–78.
10. 10 Prowse C, Gaensler EA. Respiratory and acid-base changes during pregnancy. *Anesthesiology* 1965;26:381–92.
11. 11 Shannon MW, Borron SW, Burns MJ. *Haddad and Winchester's Clinical Management of Poisoning and Drug Overdose*, 4th edn. Philadelphia: Saunders Elsevier, 2007.
12. 12 Longo LD. The biological effects of carbon monoxide on the pregnant women, fetus, and newborn infant. *Am J Obstet Gynecol* 1977;129:69–103.
13. 13 Heit JA. Trends in the incidence of venous thromboembolism during pregnancy or postpartum: a 30-year population-based study. *Ann Intern Med* 2005;143:697–706.
14. 14 James AH, Jamison MG, Brancazio LR, Myers ER. Venous thromboembolism during pregnancy and the postpartum period: incidence, risk factors, and mortality. *Am J Obstet Gynecol* 2006;194:1311–15.
15. 15 Foxman B. Epidemiology of urinary tract infections: incidence, morbidity, and economic costs. *Am J Med* 2002;113:5–13.
16. 16 Cunningham FG, Lucas MJ. Urinary tract infections complicating pregnancy. *Baillières Clin Obstet Gynaecol* 1994;8:353–73.
17. 17 Tracey M, Fletcher HS. Appendicitis in pregnancy. *Am Surg* 2000;66:555–9.
18. 18 Baer JL, Reis RA, Arens RA. Appendicitis in pregnancy with changes in position and axis of the normal appendix in pregnancy. *JAMA* 1932;98:1359–64.
19. 19 Indar AA, Beckingham IJ. Acute cholecystitis. *BMJ* 2002;325:639–43.