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Part 10.8: Cardiac Arrest Associated With Pregnancy

During attempted resuscitation of a pregnant woman, providers have two potential patients, the mother and the fetus. The best hope of fetal survival is maternal survival. For the critically ill patient who is pregnant, rescuers must provide appropriate resuscitation, with consideration of the physiologic changes due to pregnancy.

Key Interventions to Prevent Arrest

To treat the critically ill pregnant patient:

- Place the patient in the left lateral position (see below).
- Give 100% oxygen.
- Establish intravenous (IV) access and give a fluid bolus.
- Consider reversible causes of cardiac arrest and identify any preexisting medical conditions that may be complicating the resuscitation.

Resuscitation of the Pregnant Woman in Cardiac Arrest

Modifications of Basic Life Support

Several modifications to standard BLS approaches are appropriate for the pregnant woman in cardiac arrest (Table). At a gestational age of 20 weeks and beyond, the pregnant uterus can press against the inferior vena cava and the aorta, impeding venous return and cardiac output. Uterine obstruction of venous return can produce prearrest hypotension or shock and in the critically ill patient may precipitate arrest.^{1,2} In cardiac arrest the compromise in venous return and cardiac output by the gravid uterus limits the effectiveness of chest compressions. The gravid uterus may be shifted away from the inferior vena cava and the aorta by placing the patient 15° to 30° back from the left lateral position (Class IIa) or by pulling the gravid uterus to the side.³ This may be accomplished manually or by placement of a rolled blanket or other object under the right hip and lumbar area. Other modifications are discussed below.

- Airway and breathing
 - Hormonal changes promote insufficiency of the gastroesophageal sphincter, increasing the risk of regurgitation. Apply continuous cricoid pressure during positive-pressure ventilation for any unconscious pregnant woman.
- Circulation
 - Perform chest compressions higher on the sternum, slightly above the center of the sternum. This will adjust for the elevation of the diaphragm and abdominal contents caused by the gravid uterus.⁴

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- Defibrillation
 - Defibrillate using standard ACLS defibrillation doses (Class IIa).⁵ Review the ACLS Pulseless Arrest Algorithm (see Part 7.2: “Management of Cardiac Arrest”). There is no evidence that shocks from a direct current defibrillator have adverse effects on the heart of the fetus.
 - If fetal or uterine monitors are in place, remove them before delivering shocks.

Modifications of Advanced Cardiovascular Life Support

The treatments listed in the standard ACLS Pulseless Arrest Algorithm, including recommendations and doses for defibrillation, medications, and intubation, apply to cardiac arrest in the pregnant woman (see the Table). There are important considerations to keep in mind, however, about airway, breathing, circulation, and the differential diagnosis.

- Airway
 - Secure the airway early in resuscitation. Because of the potential for gastroesophageal sphincter insufficiency with an increased risk of regurgitation, use continuous cricoid pressure before and during attempted endotracheal intubation.
 - Be prepared to use an endotracheal tube 0.5 to 1 mm smaller in internal diameter than that used for a nonpregnant woman of similar size because the airway may be narrowed from edema.⁶
- Breathing
 - Pregnant patients can develop hypoxemia rapidly because they have decreased functional residual capacity and increased oxygen demand, so rescuers should be prepared to support oxygenation and ventilation.
 - Verify correct endotracheal tube placement using clinical assessment and a device such as an exhaled CO₂ detector. In late pregnancy the esophageal detector device is more likely to suggest esophageal placement (the aspirating bulb does not reinflate after compression) when the tube is actually in the trachea. This could lead to the removal of a properly placed endotracheal tube.
 - Ventilation volumes may need to be reduced because the mother’s diaphragm is elevated.
- Circulation
 - Follow the ACLS guidelines for resuscitation medications.
 - Vasopressor agents such as epinephrine, vasopressin, and dopamine will decrease blood flow to the uterus. There are no alternatives, however, to using all indicated medications in recommended doses. The mother must be resuscitated or the chances of fetal resuscitation vanish.
- Differential diagnoses. The same reversible causes of cardiac arrest that occur in nonpregnant women can occur during pregnancy. But providers should be familiar with

Primary and Secondary ABCD Surveys: Modifications for Pregnant Women

ACLS Approach	Modifications to BLS and ACLS Guidelines
Primary ABCD Survey	<p>Airway</p> <ul style="list-style-type: none"> No modifications. <p>Breathing</p> <ul style="list-style-type: none"> No modifications. <p>Circulation</p> <ul style="list-style-type: none"> Place the woman on her left side with her back angled 15° to 30° back from the left lateral position. Then start chest compressions. or Place a wedge under the woman's right side (so that she tilts toward her left side). or Have one rescuer kneel next to the woman's left side and pull the gravid uterus laterally. This maneuver will relieve pressure on the inferior vena cava. <p>Defibrillation</p> <ul style="list-style-type: none"> No modifications in dose or pad position. Defibrillation shocks transfer no significant current to the fetus. Remove any fetal or uterine monitors before shock delivery.
Secondary ABCD Survey	<p>Airway</p> <ul style="list-style-type: none"> Insert an advanced airway early in resuscitation to reduce the risk of regurgitation and aspiration. Airway edema and swelling may reduce the diameter of the trachea. Be prepared to use a tracheal tube that is slightly smaller than the one you would use for a nonpregnant woman of similar size. Monitor for excessive bleeding following insertion of any tube into the oropharynx or nasopharynx. No modifications to intubation techniques. A provider experienced in intubation should insert the tracheal tube. Effective preoxygenation is critical because hypoxia can develop quickly. Rapid sequence intubation with continuous cricoid pressure is the preferred technique. Agents for anesthesia or deep sedation should be selected to minimize hypotension. <p>Breathing</p> <ul style="list-style-type: none"> No modifications of confirmation of tube placement. Note that the esophageal detector device may suggest esophageal placement despite correct tracheal tube placement. The gravid uterus elevates the diaphragm: <ul style="list-style-type: none"> —Patients can develop hypoxemia if either oxygen demand or pulmonary function is compromised. They have less reserve because functional residual capacity and functional residual volume are decreased. Minute ventilation and tidal volume are increased. —Tailor ventilatory support to produce effective oxygenation and ventilation. <p>Circulation</p> <ul style="list-style-type: none"> Follow standard ACLS recommendations for administration of all resuscitation medications. Do not use the femoral vein or other lower extremity sites for venous access. Drugs administered through these sites may not reach the maternal heart unless or until the fetus is delivered. <p>Differential Diagnosis and Decisions</p> <ul style="list-style-type: none"> Decide whether to perform emergency hysterotomy. Identify and treat reversible causes of the arrest. Consider causes related to pregnancy and causes considered for all ACLS patients (see the 6 H's and 6 T's, in Part 7.2: "Management of Cardiac Arrest").

pregnancy-specific diseases and procedural complications. Providers should try to identify these common and reversible causes of cardiac arrest in pregnancy during resuscitation attempts.⁷ The use of abdominal ultrasound by a skilled operator should be considered in detecting pregnancy and possible causes of the cardiac arrest, but this should not delay other treatments.

– *Excess magnesium sulfate.* Iatrogenic overdose is possible in women with eclampsia who receive magnesium sulfate, particularly if the woman becomes oliguric. Administration of calcium gluconate (1 ampule or 1 g) is

the treatment of choice for magnesium toxicity. Empiric calcium administration may be lifesaving.^{8,9}

– *Acute coronary syndromes.* Pregnant women may experience acute coronary syndromes, typically in association with other medical conditions. Because fibrinolytics are relatively contraindicated in pregnancy, percutaneous coronary intervention is the reperfusion strategy of choice for ST-elevation myocardial infarction.¹⁰

– *Pre-eclampsia/eclampsia.* Pre-eclampsia/eclampsia develops after the 20th week of gestation and can produce severe hypertension and ultimate diffuse organ system

failure. If untreated it may result in maternal and fetal morbidity and mortality.

- *Aortic dissection.* Pregnant women are at increased risk for spontaneous aortic dissection.
- *Life-threatening pulmonary embolism and stroke.* Successful use of fibrinolytics for a massive, life-threatening pulmonary embolism^{11–13} and ischemic stroke¹⁴ have been reported in pregnant women.
- *Amniotic fluid embolism.* Clinicians have reported successful use of cardiopulmonary bypass for women with life-threatening amniotic fluid embolism during labor and delivery.¹⁵
- *Trauma and drug overdose.* Pregnant women are not exempt from the accidents and mental illnesses that afflict much of society. Domestic violence also increases during pregnancy; in fact, homicide and suicide are leading causes of mortality during pregnancy.^{6,7}

Emergency Hysterotomy (Cesarean Delivery) for the Pregnant Woman in Cardiac Arrest

Maternal Cardiac Arrest Not Immediately Reversed by BLS and ACLS

The resuscitation team leader should consider the need for an emergency hysterotomy (cesarean delivery) protocol as soon as a pregnant woman develops cardiac arrest.^{4,16–18} The best survival rate for infants >24 to 25 weeks in gestation occurs when the delivery of the infant occurs no more than 5 minutes after the mother's heart stops beating.^{16,19–21} This typically requires that the provider begin the hysterotomy about 4 minutes after cardiac arrest.

Emergency hysterotomy is an aggressive procedure. It may seem counterintuitive given that the *key to salvage of a potentially viable infant is resuscitation of the mother.*^{6,10,22–24} But the mother cannot be resuscitated until venous return and aortic output are restored. Delivery of the baby empties the uterus, relieving both the venous obstruction and the aortic compression. The hysterotomy also allows access to the infant so that newborn resuscitation can begin.

The critical point to remember is that you will lose both mother and infant if you cannot restore blood flow to the mother's heart.^{4,18,25,26} Note that 4 to 5 minutes is the maximum time rescuers will have to determine if the arrest can be reversed by BLS and ACLS interventions. The rescue team is not required to wait for this time to elapse before initiating emergency hysterotomy.²⁷ Recent reports document long intervals between an urgent decision for hysterotomy and actual delivery of the infant, far exceeding the obstetrical guideline of 30 minutes.^{28,29}

Establishment of IV access and an advanced airway typically requires several minutes. In most cases the actual cesarean delivery cannot proceed until after administration of IV medications and endotracheal intubation. Resuscitation team leaders should activate the protocol for an emergency cesarean delivery as soon as cardiac arrest is identified in the pregnant woman. By the time the team leader is poised to deliver the baby, IV access has been established, initial medications have been administered, an advanced airway is in place, and the immediate reversibility of the cardiac arrest has been determined.

Decision Making for Emergency Hysterotomy

The resuscitation team should consider several maternal and fetal factors in determining the need for an emergency hysterotomy.

- *Consider gestational age.* Although the gravid uterus reaches a size that will begin to compromise aortocaval blood flow at approximately 20 weeks of gestation, fetal viability begins at approximately 24 to 25 weeks. Portable ultrasonography, available in some emergency departments, may aid in determination of gestational age (in experienced hands) and positioning. However, the use of ultrasound should not delay the decision to perform emergency hysterotomy.³⁰
 - Gestational age <20 weeks. Urgent cesarean delivery need not be considered because a gravid uterus of this size is unlikely to significantly compromise maternal cardiac output.
 - Gestational age approximately 20 to 23 weeks. Perform an emergency hysterotomy to enable successful resuscitation of the mother, not the survival of the delivered infant, which is unlikely at this gestational age.
 - Gestational age approximately ≥ 24 to 25 weeks. Perform an emergency hysterotomy to save the life of both the mother and the infant.
- *Consider features of the cardiac arrest.* The following features of the cardiac arrest can increase the infant's chance for survival:
 - Short interval between the mother's arrest and the infant's delivery¹⁹
 - No sustained prearrest hypoxia in the mother
 - Minimal or no signs of fetal distress before the mother's cardiac arrest³¹
 - Aggressive and effective resuscitative efforts for the mother
 - The hysterotomy is performed in a medical center with a neonatal intensive care unit
- *Consider the professional setting.*
 - Are appropriate equipment and supplies available?
 - Is emergency hysterotomy within the rescuer's procedural range of experience and skills?
 - Are skilled neonatal/pediatric support personnel available to care for the infant, especially if the infant is not full term?
 - Are obstetric personnel immediately available to support the mother after delivery?

Advance Preparation

Experts and organizations have emphasized the importance of advance preparation.^{4,18,26} Medical centers must review whether performance of an emergency hysterotomy is feasible at their center, and if so, they must identify the best means of rapidly accomplishing this procedure. The plans should be made in collaboration with the obstetric and pediatric services.

Summary

Successful resuscitation of a pregnant woman and survival of the fetus require prompt and excellent CPR with some modifications in basic and advanced cardiovascular life

support techniques. By the 20th week of gestation, the gravid uterus can compress the inferior vena cava and the aorta, obstructing venous return and arterial blood flow. Rescuers can relieve this compression by positioning the woman on her side or by pulling the gravid uterus to the side. Defibrillation and medication doses used for resuscitation of the pregnant woman are the same as those used for other adults in pulseless arrest. Rescuers should consider the need for emergency hysterotomy as soon as the pregnant woman develops cardiac arrest because rescuers should be prepared to proceed with the hysterotomy if the resuscitation is not successful within minutes.

References

- Page-Rodriguez A, Gonzalez-Sanchez JA. Perimortem cesarean section of twin pregnancy: case report and review of the literature. *Acad Emerg Med.* 1999;6:1072–1074.
- Cardosi RJ, Porter KB. Cesarean delivery of twins during maternal cardiopulmonary arrest. *Obstet Gynecol.* 1998;92:695–697.
- Goodwin AP, Pearce AJ. The human wedge. A manoeuvre to relieve aorticaval compression during resuscitation in late pregnancy. *Anaesthesia.* 1992;47:433–434.
- Morris S, Stacey M. Resuscitation in pregnancy. *BMJ.* 2003;327:1277–1279.
- Nanson J, Elcock D, Williams M, Deakin CD. Do physiological changes in pregnancy change defibrillation energy requirements? *Br J Anaesth.* 2001;87:237–239.
- Johnson MD, Luppi CJ, Over DC. Cardiopulmonary Resuscitation. In: Gambling DR, Douglas MJ, eds. *Obstetric Anesthesia and Uncommon Disorders.* Philadelphia: WB Saunders; 1998:51–74.
- Department of Health, Welsh Office, Scottish Office Department of Health, Department of Health and Social Services, Northern Ireland. *Why mothers die. Report on confidential enquiries into maternal deaths in the United Kingdom 2000–2002.* London, England: The Stationery Office; 2004.
- Poole JH, Long J. Maternal mortality—a review of current trends. *Crit Care Nurs Clin North Am.* 2004;16:227–230.
- Munro PT. Management of eclampsia in the accident and emergency department. *J Accid Emerg Med.* 2000;17:7–11.
- Doan-Wiggins L. Resuscitation of the pregnant patient suffering sudden death. In: Paradis NA, Halperin HR, Nowak RM, eds. *Cardiac Arrest: The Science and Practice of Resuscitation Medicine.* Baltimore, Md: Williams & Wilkins; 1997:812–819.
- Turrentine MA, Braems G, Ramirez MM. Use of thrombolytics for the treatment of thromboembolic disease during pregnancy. *Obstet Gynecol Surv.* 1995;50:534–541.
- Thabut G, Thabut D, Myers RP, Bernard-Chabert B, Marrash-Chahla R, Mal H, Fournier M. Thrombolytic therapy of pulmonary embolism: a meta-analysis. *J Am Coll Cardiol.* 2002;40:1660–1667.
- Patel RK, Fasan O, Arya R. Thrombolysis in pregnancy. *Thromb Haemost.* 2003;90:1216–1217.
- Dapprich M, Boessenecker W. Fibrinolysis with alteplase in a pregnant woman with stroke. *Cerebrovasc Dis.* 2002;13:290.
- Stanten RD, Iverson LI, Daugharty TM, Lovett SM, Terry C, Blumenstock E. Amniotic fluid embolism causing catastrophic pulmonary vasoconstriction: diagnosis by transesophageal echocardiogram and treatment by cardiopulmonary bypass. *Obstet Gynecol.* 2003;102:496–498.
- Katz VL, Dotters DJ, Droegemueller W. Perimortem cesarean delivery. *Obstet Gynecol.* 1986;68:571–576.
- American Heart Association in collaboration with International Liaison Committee on Resuscitation. Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care: International Consensus on Science, Part 8: Advanced Challenges in Resuscitation: Section 3: Advanced Challenges in ECC. *Circulation.* 2000;102(suppl 1):I229–I252.
- Cummins RO, Hazinski MF, Zelop CM. Cardiac Arrest Associated with Pregnancy. In: Cummins R, Hazinski M, Field J, eds. *ACLS—The Reference Textbook.* Dallas: American Heart Association; 2003:143–158.
- Oates S, Williams GL, Rees GA. Cardiopulmonary resuscitation in late pregnancy. *BMJ.* 1988;297:404–405.
- Strong THJ, Lowe RA. Perimortem cesarean section. *Am J Emerg Med.* 1989;7:489–494.
- Boyd R, Teece S. Towards evidence based emergency medicine: best BETs from the Manchester Royal Infirmary. Perimortem caesarean section. *Emerg Med J.* 2002;19:324–325.
- Datner EM, Promes SB. Resuscitation issues in pregnancy. In: Rosen P, Barkin R, eds. *Emergency Medicine: Concepts and Clinical Practice.* 4th ed. St Louis, Mo: Mosby; 1998:71–76.
- Whitten M, Irvine LM. Postmortem and perimortem caesarean section: what are the indications? *J R Soc Med.* 2000;93:6–9.
- Kupas DF, Harter SC, Vosk A. Out-of-hospital perimortem cesarean section. *Prehosp Emerg Care.* 1998;2:206–208.
- Lanoix R, Akkapeddi V, Goldfeder B. Perimortem cesarean section: case reports and recommendations. *Acad Emerg Med.* 1995;2:1063–1067.
- Part 8: advanced challenges in resuscitation. Section 3: special challenges in ECC. 3F: cardiac arrest associated with pregnancy. European Resuscitation Council. *Resuscitation.* 2000;46:293–295.
- Stallard TC, Burns B. Emergency delivery and perimortem C-section. *Emerg Med Clin North Am.* 2003;21:679–693.
- MacKenzie IZ, Cooke I. What is a reasonable time from decision-to-delivery by caesarean section? Evidence from 415 deliveries. *BJOG.* 2002;109:498–504.
- Helmy WH, Jolaoso AS, Ifaturoti OO, Afify SA, Jones MH. The decision-to-delivery interval for emergency caesarean section: is 30 minutes a realistic target? *BJOG.* 2002;109:505–508.
- Moore C, Promes SB. Ultrasound in pregnancy. *Emerg Med Clin North Am.* 2004;22:697–722.
- Morris JA Jr, Rosenbower TJ, Jurkovich GJ, Hoyt DB, Harviel JD, Knudson MM, Miller RS, Burch JM, Meredith JW, Ross SE, Jenkins JM, Bass JG. Infant survival after cesarean section for trauma. *Ann Surg.* 1996;223:481–488; discussion 488–491.