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## Technical Tips

### CARE OF THE CRITICALLY ILL PREGNANT PATIENT AND PERIMORTEM CESAREAN DELIVERY IN THE EMERGENCY DEPARTMENT

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**Abstract—Background:** Maternal resuscitation in the emergency department requires planning and special consideration of the physiologic changes of pregnancy. Perimortem cesarean delivery (PMCD) is a rare but potentially life-saving procedure for both mother and fetus. Emergency physicians should be aware of the procedure’s indications and steps because it needs to be performed rapidly for the best possible outcomes. **Objective:** We sought to review the approach to the critically ill pregnant patient in light of new expert guidelines, including indications for PMCD and procedural techniques. **Discussion:** The prevalence of maternal cardiac arrest and survival outcomes of PMCD in the emergency department setting are difficult to estimate. Advanced cardiovascular life support protocols should be followed in maternal arrest with special considerations made based on the physiologic changes of pregnancy. The latest recommendations for maternal resuscitation are reviewed, including advance planning, rapid determination of gestational age, emergent delivery, and postprocedure considerations for PMCD. **Conclusions:** Maternal resuscitation requires knowledge of physiologic changes and evidence-based recommendations. PMCD outcomes are best for both mother and fetus when the procedure is performed rapidly and efficiently in the appropriate setting. Emergency physicians should be familiar with this unique clinical scenario so they are adequately prepared to intervene in order to improve maternal and fetal morbidity and mortality. © 2016 Elsevier Inc. All rights reserved.

**Keywords—emergency department; maternal resuscitation; perimortem cesarean delivery**

#### INTRODUCTION

##### *Background*

Perimortem cesarean delivery (PMCD) is a rare yet potentially life-saving procedure that falls within the scope of emergency medicine practice. Recent data from the U.S. Nationwide Inpatient Sample quote cardiac arrest in 1:12,000 admissions for delivery, but importantly this does not include emergency department cesarean sections, unless the patient survives to admission (1). Interestingly, this inpatient sample showed a remarkable rate of maternal survival to hospital discharge of 58.9%, far higher than other cardiac arrest populations, reinforcing the importance of adequate preparation for this rare scenario.

Maternal death is difficult to accurately calculate worldwide, given its relative rarity and the lack of data in low-income countries. However, a recent study by Kassebaum et al. estimated that 18.5 mothers died for every 100,000 U.S. births in 2013, a rate twice that of Canada and Saudi Arabia and three times higher than in the UK. This represents a concerning rise from 7.2 per 100,000 in 1987. This may be explained by better reporting, higher rates of significant comorbidities, such

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as diabetes and hypertension, and mothers with previously life-limiting illnesses surviving to adulthood and conceiving (2). Important to note is that this study included postpartum maternal deaths  $\leq 1$  year after birth. Overall, 24% of deaths occurred antepartum, a quarter intrapartum or immediately postpartum, and the rest occurring  $\geq 24$  hours after delivery. The recommendations discussed below would not apply postpartum or early antepartum patients. Kassebaum et al. address the debate around classifying maternal deaths (2). In their data, only deaths where pregnancy is considered a causal factor are included. Accidental and incidental deaths in pregnant women were not counted, and may account for a substantial number of critically ill pregnant patients presenting to the emergency department. To our knowledge, there is no reliable estimation of these numbers.

#### *Rationale for Perimortem Cesarean Delivery*

In the direst of circumstances, delivery of the fetus may be life-saving for both patients. One review showed that PMCD led to a clear maternal survival benefit in 31.7% of cases, and no case showed a deleterious effect on maternal survival (3). As outlined above, many of the recommendations for care of the critically ill pregnant patient are based upon the physiologic changes of pregnancy, most importantly uterine obstruction of venous return. For example, by emptying the uterus via PMCD, aortocaval compression is relieved, which results in a 60% to 80% increase in cardiac output (4). As discussed in the American Heart Association (AHA) statement, timely delivery is important for two key reasons: first, by improving venous return to the mother through relief of aortocaval compression, and second, by ensuring early delivery of the fetus, decreasing the risk of permanent neurologic damage (5). Best outcomes have been shown for both mother and fetus when the procedure is performed within 5 minutes of maternal cardiac arrest; therefore, rapid and decisive action must be taken under the appropriate circumstances (6–9).

It is important to consider which advanced resources are available at the site where the procedure may be performed. The availability of a skilled neonatal resuscitation team, for instance, would likely improve morbidity and mortality for the fetus. In the discussion of other rare procedures in the emergency department, we often consider which interventions are temporizing and necessitate transfer for higher level care, such as in the case of emergency department thoracotomy. The important difference in the case of PMCD is that the procedure can potentially be life-saving for both the mother and the fetus and, if successful, the immediate postprocedure

management is within the scope of the emergency physician (EP).

## DISCUSSION

### *General Approach to Cardiac Arrest in Pregnancy*

*Etiology of maternal arrest.* Major causes of cardiac arrest to consider in pregnant patients include cardiac disease, thromboembolism, hemorrhage, sepsis, peripartum cardiomyopathy, preeclampsia/eclampsia, amniotic fluid embolism, and trauma. Cardiac disease remains the most common cause of death in pregnant women, with myocardial infarction as the leading cause, followed by aortic dissection (10). Deaths from hemorrhage, hypertension, and maternal sepsis have decreased over the past decade according to the Kassebaum et al. (2). The highest proportion of maternal deaths are attributable to pregnancy complications in high-income regions like the United States, followed by exacerbation of underlying illness, such as sickle cell anemia, obesity, or chronic kidney disease. Interestingly, accidental deaths, including trauma, were excluded. It is important to keep in mind that pregnant women are at higher risk for domestic violence, which may represent a significant number of deaths. In the United States, 324,000 pregnant women report intimate partner violence per year, with a known skew toward underreporting overall (11).

*Institutional planning for maternal arrest.* In October of 2015, the AHA released the first Scientific Statement on maternal resuscitation, titled “Cardiac Arrest in Pregnancy.” First, they recommend that pregnant women who become ill should be risk stratified using a validated obstetric early warning score and that hospital units that care for pregnant women should ensure proper pre-event planning for maternal resuscitation (class Ic). The guidelines detail the makeup of a maternal cardiac arrest team composed of staff to care for two critically ill patients. The team should ideally include an adult resuscitation team, an obstetrician and obstetric nurse, anesthesia care providers, and a neonatology team, with defined leaders for each subgroup (class Ic).

*Emergency medical services considerations.* The AHA guidelines state that the emergency medical services (EMS) response to maternal cardiac arrest should include enough staff to ensure chest compressions, manual lateral uterine displacement (LUD), defibrillation, and airway management (class Ic). Transport should be directed to a facility capable of performing PMCD, but transport time should not be delayed  $>10$  minutes for this purpose (class IIb). Communication between EMS and the receiving emergency department should be facilitated so that the

emergency department can mobilize the maternal cardiac arrest team and have equipment available (class Ic).

*Care of the unstable pregnant patient.* Several important steps should be taken in the management of all unstable pregnant patients. According to the AHA guidelines, these steps (class Ic) include application of 100% oxygen, placement of the patient in the left lateral tilt position, intravenous or intraosseous access above the diaphragm, and an investigation of precipitating factors. Given the physiologic changes of pregnancy, women who are apneic, supine, and gravid are at high risk of hypoxemia and hypotension. Maternal hypotension is known to lead to hypoperfusion of the placenta (12,13).

*Advanced cardiovascular life support considerations.* For a pregnant patient in cardiac arrest, there should be no delay in starting the usual advanced cardiovascular life support (ACLS) treatment protocols. Fetal assessment should not be performed during resuscitation (class Ic). The provision of high-quality cardiopulmonary resuscitation (CPR) is of the utmost importance. Decreased CPR quality has been shown for patients in the left lateral tilt position compared to the supine position (14). Therefore, the AHA guidelines recommend continuous manual LUD in the supine position during maternal resuscitation, when the uterus is palpated at or above the umbilicus (class Ic) or if the uterus is difficult to assess and LUD is technically feasible (class IIb). Manual LUD can be performed from the left or the right of the patient, with care taken to avoid pushing down on the uterus. The guidelines also affirm that hand placement for chest compressions should be the same as that for the nonpregnant patient, not slightly higher, as previously recommended (Class IIa).

It is important to anticipate a difficult airway in the pregnant patient. Pertinent physiologic changes of pregnancy include airway edema, mucosal friability, and increased secretions. Hypoxemia should always be considered as a cause of maternal cardiac arrest and endotracheal intubation should be performed by an experienced laryngoscopist (class Ic).

In addition, cardioversion and defibrillation are considered safe for all pregnant patients, regardless of pregnancy stage (15). AHA guidelines recommend the standard defibrillation protocol as in the nonpregnant patient (class Ic). Care should be taken to place the lateral pad under the breast tissue (class IIa). ACLS medication dosing does not require alteration to accommodate physiologic changes of pregnancy at this time, and no medication should be withheld during arrest because of teratogenicity concerns (class IIb). Epinephrine is preferable to vasopressin because vasopressin can induce uterine contraction (class IIb).

### *Evaluation for Perimortem Cesarean Delivery*

*Indications for PMCD.* Minimum gestational age for delivery is an important factor in the decision to perform PMCD. Most centers consider 22 to 24 weeks' gestation to be a potentially viable age. This corresponds to a uterus palpated above the umbilicus. As cited by the AHA, "one review of emergency cesarean sections in maternal cardiac arrest before the third trimester concluded that if the fundus extends above the level of the umbilicus, aortocaval compression can occur, and emergency cesarean section should be performed regardless of gestational age" (16,17). The published evidence is limited, but the AHA recommendations conclude that it is appropriate to perform a PMCD if the uterine fundus can be palpated at or above the umbilicus (class Ic). If the uterus is difficult to assess, bedside ultrasound may help guide decision making (class IIa).

*Timing of PMCD.* Delivery of the fetus within 5 minutes of maternal cardiac arrest has been reported to be associated with improved fetal neurologic outcomes and increased chances of maternal return of spontaneous circulation (ROSC) (6,18). In one case series of 38 patients, 12 of 20 women had ROSC postdelivery (6). The AHA guidelines state that during maternal arrest, if ROSC is not achieved with usual resuscitation efforts and manual uterine displacement, it is advisable to prepare to evacuate the uterus (class Ic). They discuss the complex factors that may influence timing decisions and ultimately state that PMCD should be strongly considered for every mother in whom ROSC has not been achieved after approximately 4 minutes of resuscitative efforts (class IIa). In other words, if high-quality CPR in

**Table 1. Supplies for Emergency Department Cesarean Delivery**

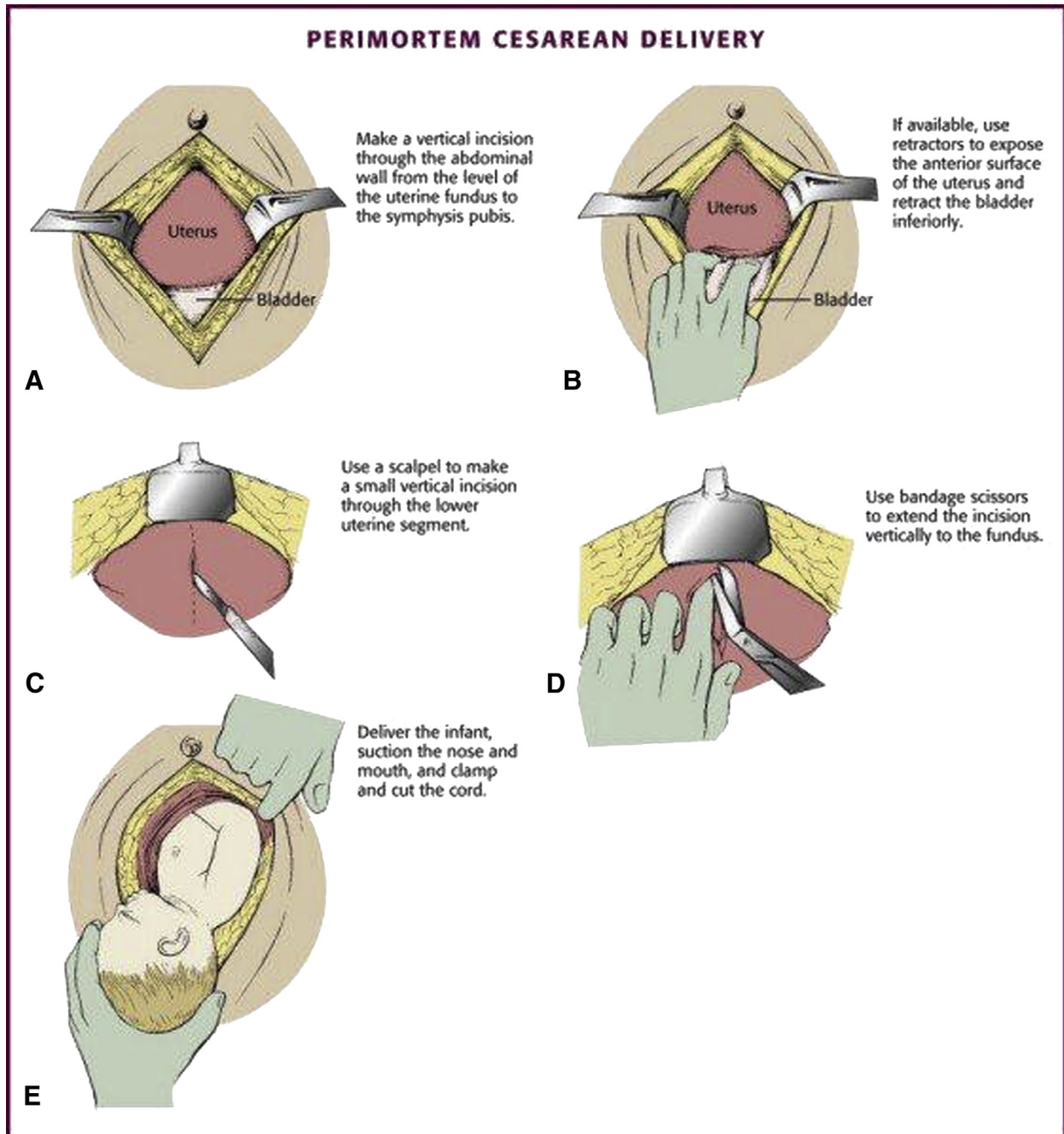
Antiseptic solution
Sterile gloves
No. 10 blade scalpel
Bandage (blunt end) scissors
Absorbable suture
Hemostats
Cord clamps
Towels
Sterile sponges (4 × 4)
Rubber bulb syringe
Laryngoscope with straight blades, no. 0 (preterm) and no. 1 (term)
Suction catheters (5F to 14F)
Neonatal endotracheal tubes (2.5-, 3.0-, 3.5-, and 4.0-mm internal diameter)
CO <sub>2</sub> detector or capnography setup
Neonatal Ambu bag
Newborn and premature-size face masks
Oxygen source
Neonatal incubator/warmer
Cardiorespiratory monitor for mother and neonate, including pulse oximetry

accordance with the typical ACLS algorithm is initiated immediately upon arrest and there is no ROSC by the fourth minute, an emergency cesarean delivery should begin. In the emergency department, EPs often see patients who are brought in by EMS and have already received  $\geq 4$  minutes of ACLS. In our opinion, this outside of hospital resuscitation time should be taken into consideration so as not to delay delivery. AHA guidelines also state that if maternal viability is not possible, the proce-

dures should be started immediately, for example, in the case of an obviously nonsurvivable injury (5). There are no case reports of live births by PMCD beyond 25 minutes after maternal arrest (6).

#### *Perimortem Cesarean Delivery Procedure*

*Preparation.* Given the ideal 5-minute window for completion of delivery of the fetus, immediate steps should be taken to prepare for cesarean section upon



**Figure 1.** (A) Vertical incision through the abdominal wall. (B) Retraction of the bladder inferiorly. (C) Incision through the lower uterine segment. (D) Extension of the incision superiorly. (E) Delivery of the fetus.

the loss of maternal pulses. The team should not spend time on lengthy antiseptic procedures—the AHA recommends either an abbreviated antiseptic pour or elimination of this step entirely (class IIa). The Society for Obstetric Anesthesia and Perinatology guidelines state that while sterile preparation is not a priority, when used early it may serve as a visual prompt to all staff present that PMCD is impending (19). For in-hospital arrest, the patient should not be transported to the operating room for cesarean delivery; rather cesarean delivery should be performed at the site of arrest (class Ic). The team should also not wait for surgical equipment, because only a scalpel is required (class IIa). Finally, continuous manual LUD should be performed until the fetus is delivered with care to avoid injury to the rescuer (class IIa).

**Equipment.** Although only a scalpel is required to begin, a typical precipitous delivery or trauma kit should have the other useful items for PMCD and be readily available. Items beyond the typical ACLS equipment include gown, gloves, blunt end scissors, cord clamps, sponges, suture material, suction, an infant warmer, and other supplies for neonatal resuscitation. Please refer to Table 1 for a complete list of supplies.

**Procedure.** Traditional teaching in obstetrics is that abdominal entry may be facilitated rapidly by a midline vertical incision from the uterine fundus to the pubic symphysis with a scalpel, using the linea nigra as a guide (20). The AHA guidelines state that the abdominal entry technique is at the discretion of the physician (midline vs. Pfannenstiel), but that vertical incision provides better visualization and is also considered faster (5). Incision should be continued through the fascia and muscle layer, into the peritoneum (Figure 1A). Care should be taken to avoid the bladder. Retractors may be used, if available, to expose the uterus and retract the bladder inferiorly (Figure 1B). After entering the peritoneum, a small, low, vertical uterine incision should be initiated through the lower uterine segment with a scalpel (Figure 1C). After a brief finger sweep, the incision can be extended superiorly using scissors (Figure 1D). It is important to have ample suction, because the placenta may be incised, resulting in significant bleeding. Then the fetus should be delivered, using fundal pressure if necessary. Next the cord should be clamped and cut (Figure 1E). Neonatal resuscitation can then be initiated.

**Postdelivery steps.** After delivery of the fetus, the placenta should be delivered by manually separating it from the wall of the uterus. Then the uterus can be quickly wiped clean with sponges (5). The AHA guidelines

recommend closure with a running locking stitch of absorbable suture and standard closure of the abdomen (5). Surgical assistance by general surgery or an obstetrician/gynecologist should be used for closure if available. If ROSC is not immediately achieved, resuscitation should continue as per the usual ACLS protocol. It is advantageous to have a separate team overseeing the resuscitation while others are performing the procedure. If maternal ROSC is achieved, antibiotics and oxytocin may be considered; however, oxytocin is known to precipitate rearrest and should be used with caution (5).

## CONCLUSION

Institutions that care for obstetric patients should use pre-event planning to prepare for maternal cardiac arrest and neonatal resuscitation. It is important for EPs to understand the physiologic changes of pregnancy and be familiar with the procedure for PMCD. In cases of maternal cardiac arrest, ABCs should be established and ACLS/advanced trauma life support (ATLS) should be initiated as in nonpregnant patients, remembering to use manual left uterine displacement for optimal venous return. Gestational age should be estimated by palpation of the fundus at or above the umbilicus. Maternal and fetal outcomes are best when PMCD is completed within 5 minutes of cardiac arrest, so delays in the delivery of the fetus should be minimized.

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