I. Mission statement:

The Society for Obstetric Anesthesia and Perinatology’s Committee on Cardiac Arrest in Pregnancy was convened to develop a consensus statement to disseminate information and strategies to improve knowledge of and adherence to maternal cardiac arrest guidelines in order to optimize maternal and neonatal outcomes.

General goals were to:

1) Produce a consensus statement* based on the latest available evidence, including existing guidelines†, multidisciplinary expert opinion, literature reviews, simulation data and case reports.
2) Clarify critical elements of existing American Heart Association (AHA) algorithms, review key technical, cognitive, and behavioral interventions during maternal cardiac arrest, and highlight differences in cardiopulmonary resuscitation techniques in pregnant women in order to facilitate implementation.

3) Emphasize the importance of immediate preparation for rapid fetal delivery after maternal cardiac arrest without return of spontaneous circulation (goal of incision within 4 minutes and delivery within 5 minutes) and address potential barriers.

4) Produce concise point of care (POC) cognitive aids to enhance team performance during maternal cardiopulmonary arrest, and encourage institution-specific modifications to in order to reflect local operational reality.

5) Provide information to care teams, facilities and organizations that will aid emergency preparedness, continuing education and quality improvement processes.

* Consensus Statement: A statement of the advised course of action in relation to a particular clinical topic, based on the collective views of a body of experts (1).

† “Guidelines” is used in this document to describe recommendations generally complying with the following: “Guidelines are systematically developed recommendations that assist the practitioner and patient in making decisions about health care. These recommendations may be adopted, modified, or rejected according to clinical needs and constraints and are not intended to replace local institutional policies. In addition, practice guidelines are not intended as standards or absolute requirements, and their use cannot guarantee any specific outcome. Practice guidelines are subject to revision as warranted by the evolution of medical knowledge, technology, and practice.” (2)
II. Introduction:

Maternal cardiac arrest during pregnancy is particularly challenging for healthcare teams because of the technical and ethical issues associated with the simultaneous care of two critically ill patients, mother and unborn baby. Obstetric healthcare teams lack experience in maternal resuscitative measures because cardiac arrest in pregnancy is estimated to occur in only 1:20-50,000 women. Knowledge gaps have been demonstrated among obstetric healthcare team members (3–5). Team performance during simulated maternal cardiac arrests is sub-optimal (6). American Heart Association Advanced Cardiac Life Support (AHA ACLS) course completion rates among obstetric providers vary, and long-term retention of skills is poor (7). Standard ACLS courses do not routinely devote significant (or any) resources to teaching obstetric-specific interventions, and such courses tend to stress fund of knowledge and technical skills over critically important non-technical (behavioral) skills (8,9). Finally, standard ACLS courses cannot address institutional systems issues (latent errors in the system) that may negatively impact quality of care (9–14).

III. Methodology:

This document is intended to complement the 2010 AHA Guidelines Part 12.3, Cardiac Arrest Associated with Pregnancy and Maternal Cardiac Arrest Algorithm (Figure 1) (15) and further develop implementation strategies for recommendations derived from the literature, other interested groups (16) and consensus among committee participants. The committee responsible for creating this document was comprised of physicians and nurses, including experts in resuscitation science and simulation. The disciplines of anesthesiology, cardiology, critical care, emergency medicine, maternal-fetal medicine, neonatology and obstetrics were represented, as well as both the academic and private practice domains. Although this consensus statement is based on the latest (through March 2013) available published material (including simulation data, case reports and series, literature reviews, and
expert opinion), the evidence supporting many proposed clinical interventions is limited because of the nature and rarity of maternal arrests.

IV. Key Cognitive and Technical Interventions In Maternal Resuscitation:

**Important note:** Although listed numerically, interventions should be performed in parallel as resources permit and certain interventions should occur as soon as possible (e.g. defibrillation if available and indicated).

1. **IMMEDIATE Basic Life Support (BLS) and Calls For Help**

High quality chest compressions should be started immediately to optimize maternal and fetal outcomes, a defibrillator or AED brought to the scene, airway opened and ventilation commenced (see airway management and ventilation section below) (15). A “Code OB” (i.e., a clearly identified obstetric-oriented code team response) should be activated immediately, and the Neonatal Team contacted simultaneously. In a study of simulated maternal cardiac arrests, over 80% of teams delayed calling for the Neonatal Team (6).

2. **Chest compressions:** Compressions should be hard (achieving ~5 cm depth), fast (100 compressions/minute), and uninterrupted (17). Minimizing interruptions in chest compressions is a key concept taught by the AHA with important consequences for patients who present with shockable rhythms (17). The “peri-shock pause” (to check for a shockable rhythm immediately pre-shock) should be limited to < 5 seconds; even brief pauses (>5 seconds) decrease the chance for return of spontaneous circulation (ROSC) (17,18). To further minimize interruptions in compressions, pulse checks performed immediately post-shock are no longer endorsed by the AHA (17-19). If the patient’s trachea is intubated, chest compressions should be performed constantly. If not, compressions should be performed in a ratio of 30 compressions to 2 breaths(17). Chest compressors should be rotated every two minutes.
because compressions are physically rigorous and provider fatigue develops rapidly (17,20-22). For third trimester patients, the AHA recommends that hand placement be 2-3 cm higher on the sternum than in non-pregnant individuals, although this recommendation is based on expert consensus only (see Q. 9 in the Questions and Controversies Section) (15).

Continuous capnography measures the partial pressure of carbon dioxide (CO$_2$) in the expired respiratory gases, and typically displays a graph of end-tidal CO$_2$ plotted against time. Current AHA-ACLS guidelines recommend capnography as a modality with which to confirm endotracheal tube placement and to assess the efficacy of chest compressions(17). Capnography reflects the quality of chest compressions because it indirectly measures cardiac output in an intubated patient under stable ventilation conditions (23). During resuscitation, end-tidal CO$_2$ levels above 10 mmHg and/or rising end-tidal CO$_2$ levels suggest adequacy of chest compressions and may be predictive of ROSC (24-28). Continuous capnography may not yet be readily available in all hospital settings outside the operating room (e.g., Labor and Delivery units). Attempts to use it should never distract from or interrupt the provision of high quality chest compressions, nor delay preparations for timely perimortem delivery in the event of no ROSC.

3. Patient position and Left Uterine Displacement: Left uterine displacement (LUD) is recommended after 20 weeks’ gestational size or if the uterus is palpable or visible at or above the umbilicus (15) in order to minimize the adverse effects of vena caval compression by the gravid uterus on venous return and cardiac output (29). Caval compression may occur even earlier in pregnancy (30), and the provision of LUD should be based on individual circumstances such as multiple gestation, polyhydramnios, or other conditions where vena caval obstruction may be a relevant concern, even if the gestational age is <20 weeks. The cardiac output produced from chest compressions is optimized when the arrested parturient is placed on a firm surface (e.g., a backboard) in the supine position with manual left uterine
Left manual uterine displacement is optimally performed using two hands from the left side of the patient (Figure 2a) (15). The designated provider must pull leftward and upward, because if downward force is inadvertently applied, inferior vena caval compression may worsen. If it is not possible to perform manual LUD from the left, it may be applied from the right side of the patient by pushing with one or both hands, although this approach may be technically more difficult to perform adequately (Figure 2b) (15). Left lateral tilt of the patient to a full 30 degrees (i.e., pelvic tilt) can also be used to provide LUD, but this position may make the provision of adequate chest compressions more challenging as the force transmitted to the chest wall is reduced (Figure 2c) (15,34-36). In a study of simulated maternal cardiac arrests, initiation of LUD was often neglected (6).

4. Defibrillation: “The AHA strongly recommends performing CPR while a defibrillator or AED is readied for use and while charging for all patients in cardiac arrest” (17). Defibrillation should be performed for shockable rhythms as soon as it is available. In sudden cardiac arrest with ventricular fibrillation, the earlier defibrillation occurs the greater the chance of successful defibrillation and ROSC with continuing chest compressions. Defibrillation is safe for the fetus in the setting of maternal cardiac arrest (15). AHA-recommended energy requirements for adult defibrillation are the same in pregnancy and do not need to be altered (15). The AHA addressed the use of automatic external defibrillators (AEDs) in the 2010 guidelines: “Despite limited evidence, AEDs may be considered for the hospital setting as a way to facilitate early defibrillation (a goal of shock delivery <3 minutes from collapse), especially in areas where staff have no rhythm recognition skills or defibrillators are used infrequently” (17,37). In most obstetric settings, use of an AED device (or the AED mode on a defibrillator) is the most practical approach for rapid defibrillation. Ideally, when an AED is used, the device should have a user over-ride function to allow an experienced provider to deliver the shock without waiting for the prescribed built-in analytical algorithm. The benefits of using pads rather than paddles include provider safety (the ability
to step away from the patient during shock), decreased potential for task saturation (it is unnecessary to hold the pads once they are placed), and the continuous display of electrical cardiac activity. If pads are placed in the anterior and posterior positions, they can be used to both defibrillate and pace. If maternal CPR is ongoing and a fetal scalp electrode (FSE) is in place to monitor the fetal heart rate, it is reasonable to disconnect it from the power source prior to shock. If external fetal monitors are being used, it is reasonable to remove them from the patient prior to shock and in preparation for cesarean delivery. The key point to remember in the setting of maternal cardiac arrest is that fetal monitoring is not necessary to guide management and may distract staff from or delay the provision of maternal CPR and fetal delivery (see Q. 7 in the Questions and Controversies Section).

5. Airway management and ventilation: A simplified airway algorithm is shown in Figure 3. First-responders without advanced airway experience must use strategies to oxygenate the patient (e.g., jaw thrust, oral airway, bag-mask ventilation). Oral airways are preferred over nasal airways in pregnant patients because of the potential for epistaxis. Repeated airway manipulations should be minimized to avoid airway trauma and interruptions in chest compressions. To avoid interference with chest compressions in the non-intubated patient, AHA guidelines emphasize two 500-700 mL tidal volumes (each delivered over one second for two seconds total time) alternated with 30 compressions(17). Only personnel with experience in advanced airway management should perform laryngoscopy. Care must be taken to avoid fixation errors associated with one specific technique of airway management (e.g., “must intubate”) (9), and alternative airway control strategies such as supra-glottic airway control devices (e.g., laryngeal mask airways) should be considered. Although pregnant patients are at risk of aspiration(38,39), oxygenation and ventilation must always remain the primary objective and take priority over aspiration prevention strategies. Evidence suggests that cricoid pressure may not be effective at preventing aspiration, (40-42) and that it can impede ventilation and laryngoscopy. AHA
2010 guidelines do not recommend cricoid pressure in non-pregnant patients (15) and there is no specific information to support its use in pregnant patients. If cricoid pressure is utilized, it should be released or adjusted if ventilation is challenging or the view during laryngoscopy is poor.

6. Intravenous access: Intravenous (IV) access is essential for rapid intravascular volume repletion and administration of resuscitation drugs. In the setting of massive obstetric hemorrhage, life-saving interventions include multiple sites of large gauge vascular access, a massive transfusion protocol, and a device to rapidly infuse and warm fluids and blood products, and sub-hepatic manual compression of the aorta. The timely arrival of gynecologic oncologists, vascular surgeons, and/or trauma surgeons may also be life-saving (43). Each institution should develop an algorithm to be used in the event of difficult peripheral IV access, including alternatives such as intra-osseous access in the proximal humerus, or ultrasound-assisted peripheral or central venous access. Obtaining intravenous or intra-osseous access above the diaphragm is recommended to avoid the potentially deleterious effects of vena caval compression, which would increase the time required for fluids or administered drugs to reach the heart or even prevent their circulation altogether (15,19).

7. Resuscitation and other Drugs: Resuscitation drugs should be administered as per current AHA guidelines. None of these drugs (e.g., epinephrine, amiodarone, etc.) should be considered contraindicated during maternal cardiac arrest (15). Although physiologic changes of pregnancy (increases in intravascular volume, decreases in protein binding, and increases in glomerular filtration rate) may alter the volume of distribution and clearance of drugs, this is likely to be irrelevant in the low or no-flow state of maternal cardiac arrest. If local anesthetic-induced cardiac arrest is suspected, lipid emulsion may be administered as an adjunctive therapy as in the non-pregnant patient (36,44). Since there are no data on which to base dosage of lipid emulsion or other resuscitative drugs in the pregnant
patient, the usual doses used in non-pregnant individuals should be administered (see Q. 10 in the
Questions and Controversies Section for dosing) (15,45,46). In addition to its uterotonic effect, oxytocin
is a systemic vasodilator and a negative inotrope and therefore may precipitate cardiovascular collapse
if administered in large (5-10 international units) bolus doses (47,48). Though beyond the scope of this
document, staff should be familiar with contraindications to and side effects of commonly used
uterotonic agents.

8. Perimortem Cesarean or Operative Vaginal Delivery: Current guidelines support rapid
delivery of the fetus (15,16,19,49-53). When vaginal delivery is not immediately possible, perimortem
cesarean delivery (PMCD) in the setting of maternal cardiac arrest is required in order to improve the
chance of ROSC and survival (15,16,19,49-53). Delivery should be performed as soon as possible if
ROSC has not occurred within minutes of the start of the cardiac arrest. Teams should continue CPR
throughout and strive to make incision at 4 minutes in order to effect fetal delivery at 5 minutes after
the start of cardiac arrest. The team should be actively preparing for expedited delivery as soon as the
arrest is confirmed. (15,19,52,54). The decision to do an operative vaginal delivery instead of PMCD
should be at the discretion of the obstetrician.

Proposed mechanisms for the efficacy of PMCD include immediate relief of vena caval
obstruction with improved venous return and cardiac output, decreased oxygen demand, and improved
pulmonary mechanics. While it is not an easy decision to operate on a patient already in extremis, PMCD
may provide the best option to optimize maternal survival. Although definitive evidence is lacking (and
may be unobtainable), numerous reports describe ROSC or improvements in hemodynamics after
delivery has occurred (49-53,55-72). In a series of 38 cases of PMCD, 12 of 20 women for whom
maternal hemodynamic outcome was recorded had ROSC immediately after delivery; no cases of
worsened maternal status after PMCD were reported (51). In a more recent review of 91 published
cases of (mostly witnessed) maternal cardiac arrests, 54% of mothers survived to hospital discharge (53).
Perimortem cesarean delivery was performed in 76 (87%) of viable pregnancies and was determined to have benefited the mother in 32% of cases and not been harmful in any of the other cases. In-hospital arrest and PMCD within 10 minutes were associated with better maternal outcomes in this series (53).

Although the AHA and others propose aiming for delivery within 5 minutes of the onset of maternal arrest without ROSC (15,19,50-52), it is difficult to achieve delivery within such a time frame. In a recent review, only 4 of 76 women were delivered within 5 minutes (53). Under the ideal conditions that prevailed in a study of simulated maternal arrests, incision was completed in < 5 minutes in only 14% of teams randomized to transfer from the labor room to the operating room for PMCD (73). Even teams randomized to perform PMCD at the site of arrest in the labor room found it challenging: only 57% made incision within 5 minutes (73). Providers and institutions should develop strategies to minimize delays associated with the performance of PMCD.

Neonatal survival may also be greatest (if past viability at 24-25 weeks) when the fetus is delivered within 5 minutes (50,74). Although maternal and neonatal survival has been reported when even longer intervals from arrest until ROSC occur, prolonged low flow states increase the risk of permanent maternal and neonatal disabilities or demise (34,50-54,74,75).

In the absence of an obstetrician or surgeon or in circumstances such as an out-of-hospital arrest, it may be difficult or impossible to perform immediate delivery. However, in most situations, the timing of delivery remains more critical than the location of delivery. When maternal cardiac arrest occurs in the Labor and Delivery unit, Emergency Medicine Department or Intensive Care Unit (ICU), transporting the arrested patient to the OR for delivery is not recommended. Patient transport distracts rescuers from the core tasks of resuscitation, interferes with high quality, continuous chest compressions, and delays delivery (73,76). Based on simulation studies, anecdotal reports, and reviews of maternal arrests in the literature, the committee strongly recommends performing perimortem
cesarean delivery (or operative vaginal delivery) at the site of maternal arrest, when possible, rather than first relocating to the operating room.

If PMCD is performed and results in ROSC, transport to the nearest OR can occur after delivery when patient condition permits. Similarly, if ROSC occurs without prior delivery, transport to the OR can be undertaken, with the team ready to perform immediate cesarean delivery should the mother or fetus deteriorate. Subsequent transfer to the ICU for continuing care should take place when the clinical situation permits. Sterile preparation of the skin is not a priority during PMCD. Teams electing to perform sterile preparation of the skin should do so within the first few minutes of the arrest so as not to delay incision.

V. Key behavioral interventions in maternal resuscitation:

1. Organization of response teams: Immediate and effective communication that an emergency is occurring is critically important during maternal cardiac arrest because of the number of teams that must be rapidly mobilized and coordinated. Key calls often missed in the opening moments of simulated maternal cardiac arrest include those to the neonatal team and for equipment necessary for emergency delivery (i.e., scalpel) (6,73). We recommend an emergency call system (with backup) in which all providers in the maternal/neonatal resuscitation teams are activated immediately and simultaneously (“Code OB” is one suggested approach). The service lines comprising the emergency response team should be listed at the point-of-care (i.e., the emergency call button or phone) and with hospital telephone operators.

All response team members should be aware of the fastest routes to the Labor and Delivery Unit, Emergency Medicine Department, and all ICU’s, and be familiar with the location of critical equipment (i.e., scalpel, umbilical cord clamps, maternal and neonatal resuscitation supplies). In many institutions, security on the Labor and Delivery unit is enhanced, including limited elevator access and
locked stairway and door entry/exit points. The requirements for entry should be reviewed, electronic cards or keypad sequences distributed, and barriers to emergency access evaluated. All these systems should be tested in routine and periodic obstetric emergency drills and local protocols developed or revised to address deficiencies.

2. **Communication within the team during resuscitation:** “Open-air” commands (commands not directed at specific individuals) are common communication errors during crises. “Failing to close the loop” (i.e., not verbally acknowledging, performing, and verbally confirming completion of an order) may result in redundancy of effort, global task saturation, and delays in critical interventions (77). It may also increase the potential for drug overdose because multiple staff may action the same order to administer a drug. We recommend the use of brief, periodic “time-outs” during the provision of CPR, but without interrupting chest compressions. During the “time-out,” the leader or timer/documenter should succinctly review what has happened and clarify ongoing goals, track progress, and coordinate care.

3. **Workload delegation and assignment of roles:** Workload delegation is an important component of effective team performance because, during the initial minutes of a code, there are likely more interventions that must be completed than individuals present to perform them. Although avoidance of redundancy is particularly important, studies of simulated maternal arrests indicate that redundancy is a recurrent error during obstetric codes (e.g., several nurses involved in preparing the abdomen or placing a urinary catheter) (6).

   Key roles that often go unassigned include those of timer/documenter, an assistant to aid in airway management, a second person to rotate performance of chest compressions, and a staff person...
dedicated to performing LUD (6). Key interventions often neglected include timely defibrillation, backboard insertion, and LUD (6).

4. **Leadership**: During maternal cardiac arrest, two individuals (mother and unborn baby) require the coordinated interventions of multiple care teams (nursing, obstetric, neonatal, anesthesia, and the adult code team). As a result, maternal cardiac arrests may require shared decision-making. Communication and coordination among the various teams are critically important during such events, and often have major impacts on patients’ outcome (77,78).

The code leader should be an individual with knowledge of the management of pregnant patients who is not task saturated, and is able to direct and cross check interventions, communicate effectively and periodically reassess management goals and outcomes. A point-of-care checklist emphasizing key tasks (Table 1) should be immediately available (e.g. attached to the resuscitation cart), for a designated team member to refer to and read out loud during the maternal arrest (79,80).

VI. Contributing Causes, Diagnosis and Treatment:

The AHA has developed a mnemonic, BEAUCHOPS, (Figure 1) to help memorize contributing causes in the event of a maternal cardiac arrest (17). However, any mnemonic that facilitates remembering potential causes is acceptable and can be utilized. A simple checklist for contributing causes such as that outlined in Table 2 should be immediately available for reference (e.g., attached to the resuscitation cart). A recent comprehensive review article on maternal cardiac arrest found that better outcomes resulted when the arrest occurred in highly monitored clinical settings (53). Thus, any patient in whom there is concern for impending cardiopulmonary decompensation should be identified as “high risk” and admitted to an appropriate clinical setting if she is not already located there.
VII. Post-Cardiac Arrest Care: Interventions and Resources:

The AHA guidelines for post-resuscitation care should be followed to prevent secondary deterioration in maternal condition (17). In patients status post-delivery who remain refractory to post-resuscitation interventions, the use of mechanical circulatory support such as veno-arterial extracorporeal membrane oxygenation or cardiac bypass may be appropriate as a bridging intervention if available (81,82). Reversible etiologies of arrest in an otherwise healthy parturient can lead to rapid return of cardiac output after resuscitation and delivery. As a result, healthcare teams may need to manage uterine bleeding in the post-arrest patient. The return of cardiac output may also result in maternal awareness, necessitating the provision of anesthetic or amnestic drugs. Maternal transfer to an ICU should be accomplished as soon as possible after PMCD is completed. Skilled intensivist and nursing care is essential regardless of the patient’s location, and care should continue according to the suspected etiology of the arrest.

In most patients, delivery relieves vena caval compression, and the supine position will then optimize the quality of chest compressions and facilitate access for laparotomy, surgical repair and vascular access placement. If uterine distension or an obese abdominal wall continues to obstruct venous return to the heart, left uterine or abdominal wall displacement should be maintained. After ROSC in an undelivered patient, the full left lateral decubitus position should be utilized to optimize uterine blood flow and venous return and thus minimize the risk of recurrent cardiac arrest.

Therapeutic hypothermia is recommended in comatose non-pregnant patients status post cardiac arrest to decrease the impact of injury to cardiac or neuronal tissue (17,83). Therapeutic hypothermia has been reported in several women who had a cardiac arrest during the first half of pregnancy (84-86). No adverse fetal effects resulted except in one case in which multiple other complications were present that could have explained or contributed to the stillbirth (86). Hypothermia
has been used during pregnancy for maternal neurosurgical and cardiac procedures (87,88), however at the time of this consensus development, we could find no reports regarding the use of therapeutic hypothermia after cardiac arrest in undelivered women closer to term. Based on recommendations for non-pregnant patients status post cardiac arrest, we believe that therapeutic hypothermia for maternal benefit should be strongly considered after cardiac arrest in obstetric or post-partum patients for similar indications as in the general population (83). However, it must be acknowledged that the fetal effects of maternal hypothermia in this circumstance remain largely unknown. Because fetal bradycardia has been reported during maternal hypothermia, continuous electronic fetal monitoring should be used to guide obstetric management (89) Caution must also be exercised when utilizing hypothermia in a setting of maternal hemorrhage and coagulopathy because hypothermia may impair hemostasis and worsen or precipitate further blood loss (90).

VIII. Quality Improvement and Implementation Strategies:

The actions of one provider or any single intervention rarely result in a positive or negative outcome in the event of maternal cardiopulmonary arrest; rather, it is the global performance of the resuscitation team and institutional preparedness for rare, critical events. Creating a portable emergency cesarean delivery instrument set (Table 3) or a locally relevant airway algorithm (Figure 3) does not require significant institutional resources. Greater effort is required to identify and correct recurrent communication failures among staff and the various service lines. Data analyzed by The Joint Commission showed that communication failures among teams were the root causes of morbidity and mortality in over 70% of neonatal sentinel events (78). We support recommendations by The Joint Commission, the Confidential Enquiries into Maternal and Child Health of the United Kingdom and others emphasizing the provision of periodic emergency drills, including drills that involve both the obstetric and neonatal teams. (11,12,78,91-93). However, specific objective metrics of team
performance during obstetric maternal arrest drills still need to be developed and validated (6,11,94). Drills can be used to train staff unfamiliar with roles or inexperienced with resuscitation algorithms. Unannounced drills may be appropriate for more experienced teams in order to practice the coordination and performance of a series of complex tasks under pressure (e.g., for “stress inoculation”), or to further test for latent systems errors. Ideally, drills should be timed and followed by a debriefing session to collectively analyze behavioral, cognitive, and technical skill-sets, as well as to identify and develop strategies to mitigate systems issues in all departments that may receive obstetric patients (Labor and Delivery, Emergency Medicine Department, Intensive Care Unit, Radiology). All these locations should be supplied with or have access to mobile carts containing equipment for maternal and neonatal resuscitation (Table 3).

IX. Questions & Controversies
1. Q. The 2010 AHA guidelines now recommend C-A-B (compressions, airway, breathing) rather than A-B-C. Is C-A-B applicable to pregnant patients or should A-B-C be used?

1. A. This Consensus Statement supports the current C-A-B sequence advocated by the AHA(17). The initial focus on the airway that was previously advocated may have detracted from the immediate provision of chest compressions. While respiratory arrest may be the initial event precipitating maternal collapse (e.g., magnesium or opioid overdose, high neuraxial block, failed intubation/ventilation after induction of general anesthesia for cesarean delivery etc.), cardiac arrhythmias may develop concurrently or shortly thereafter. The prompt provision of high quality chest compressions with minimal interruptions is emphasized by the C-A-B sequence. Health care teams should be aware that pregnant women develop hypoxia and acidosis rapidly during apnea because of higher basal metabolic rates of oxygen consumption, decreased functional residual capacity, and fetal oxygen requirements.
Adequate ventilation must therefore be initiated as soon as possible, in parallel with effective chest compressions and defibrillation, if indicated.

2. Q. Why is manual uterine displacement recommended rather than pelvic or patient tilt?

2. A. Although a recent mannequin study demonstrated that compressions can be performed well in both the supine and tilted position, the study utilized a one-meter long, 30-degree wooden wedge (95) that likely would not be immediately available in many labor units. Tilt creates mechanical disadvantages for chest compression because transmission forces are no longer perpendicular to the thorax (35). Tilt also complicates airway control and can impede access during laryngoscopy. Another study in healthy pregnant women undergoing cesarean delivery found that leftward manual uterine displacement decreased the incidence of spinal hypotension when compared to use of a 15 degree left table tilt (33). On balance, effective LUD in the setting of maternal arrest is probably best achieved with manual displacement.

3. Q. The operating rooms (OR) at an institution are located directly adjacent to the Emergency Medicine Department and the Labor and Delivery Unit. Wouldn’t it be best in this circumstance to immediately transport an arrested patient from these locations to the OR for optimal surgical conditions?

3. A. While transport to the nearby operating room (OR) seems logical, simulation studies on maternal cardiac arrest and perimortem cesarean have demonstrated that, even under ideal circumstances, transport from a labor room to the OR delayed uterine incision (73). Median (interquartile range) times from simulated maternal arrest to “incision” were approximately 4 (4–5) and 8 (7–9) min, respectively,
when cesarean delivery was performed in the labor room versus the OR (73). Most of the additional time was spent on tasks associated with the preparation for and recovery from exiting the labor room and entering the OR, rather than during actual transit time (50 ± 13 seconds) (73). Transport also resulted in more interruptions in chest compressions and degradation in the quality of chest compressions (73,76). We therefore recommend that, whenever possible, perimortem cesarean should be performed at the bedside in any pregnant patient >20 weeks gestation who sustains a cardiac arrest in any location.

4. Q. A patient in labor was found in cardiac arrest 7 minutes after the last recording of a low blood pressure. A nurse immediately started chest compressions upon discovering the patient. The code team arrived shortly thereafter. When should the baby be delivered in this circumstance?

4. A. The AHA recommends the immediate provision of high-quality chest compressions as well as fetal delivery within 5 minutes in the event of maternal cardiac arrest (at > 20 weeks gestation) (15). However, the following two statements both appear in the 2010 AHA Guidelines: 1) “Emergency cesarean section may be considered at 4 minutes after onset of cardiac arrest if there is no return of spontaneous circulation,” and 2) “if no ROSC by 4 min of resuscitative efforts, consider performing immediate emergency cesarean section: Aim for delivery within 5 minutes of onset of resuscitative efforts” (AHA algorithm for Maternal Cardiac Arrest)(15). These two statements may create confusion with respect to situations in which resuscitative efforts do not start until several minutes after the arrest (likely a common occurrence). In the above scenario, chest compressions and BLS /ACLS should be continued while preparations are made for an immediate cesarean delivery in the room. Resuscitation should continue, but it is not necessary to wait for an additional 4 minutes to elapse before delivery. If there is no ROSC, perimortem cesarean delivery should be performed as soon as possible to help maternal and fetal survival. The AHA also states that: “The rescue team is not required to wait 5 minutes
before initiating emergency hysterotomy, and there are circumstances that support an earlier start.”

(15)

5. Q. Why are AED’s recommended over more sophisticated manual defibrillators?

5. A. An AED is often the best choice for initial resuscitation on the labor and postpartum unit because healthcare teams rendering care in those areas may be less familiar with the use of a manual defibrillator. When in AED mode, the health care team member has access to (and the benefit of) timed two-minute intervals to guide routine analysis and shock that may be missed in the manual defibrillation (non-AED) mode unless an experienced provider is leading the resuscitation. Use of a defibrillator with both AED and non-AED modes (with default set in the AED mode) provides the Code Team with the option to use manual over-ride upon their arrival.

6. Q. Should family members stay in the room during maternal CPR?

6. A. Some healthcare professionals favor escorting family members out of the room during CPR, based on concerns ranging from medicolegal liability to that of family members becoming traumatized, distressed, or disrupting/delaying critical, life-saving interventions (96). A recent simulator study of emergency medicine residents demonstrated delayed defibrillation by residents randomized to scenarios including an overtly grieving family member, versus those scenarios with a quiet family member or no family member present (97). Resuscitation in the obstetric setting may be unique because arrest or death is usually unanticipated, a happy outcome for mother and baby is the expected norm, and family are frequently present in the room at the time of collapse. In many critical obstetric events, family members would be confronted with a dire emergency in which two lives were at stake
when, moments before, all was well. Witnessing an emergent perimortem cesarean during CPR of a pregnant patient may be particularly traumatic. Also, the need for multiple teams may make space a critical issue, particularly if delivery is occurring in a labor room or the Emergency Department.

Conversely, the AHA, the Emergency Nurses Association and public opinion all favor allowing family members to remain close to the patient during CPR (96). Many family members view it as a right rather than a privilege to be with a loved one during their last moments (96). Allowing the family to be present may facilitate the grieving process by avoiding issues of denial. A recent study found that relatives who did not witness CPR experienced symptoms of post-traumatic stress disorder, anxiety and depression more frequently than those who did witness CPR (98). Loved ones may achieve closure by seeing that everything that could have been done was done. Succinctly stated, what families see during a code, although difficult, may be far less difficult than what they can imagine (96). If the decision is made to allow family members to be present during resuscitation, a staff member not actively participating in the code should be designated to care for and support the family members.

7. Q. Why is there a recommendation to remove fetal monitors prior to delivery of shock?

7. A. If external fetal monitors are present, the theoretic potential for arcing or electrical burns during defibrillation is avoided if the monitors are detached from the patient’s abdomen. Removing external fetal monitors is also necessary in preparation for PMCD. If an internal fetal monitor, i.e., fetal scalp electrode (FSE) is being used to monitor the fetal heart rate, we recommend disconnecting the scalp monitor from the electrical source. With the FSE remaining on the fetal scalp, the potential for a burn during defibrillation still exists; however, removal will likely require additional time and may distract from more important interventions.
The critical point is that, in the setting of maternal cardiac arrest, fetal monitoring is neither practical nor logical and is not associated with any direct clinical benefit to mother or fetus. If ROSC does not occur, current recommendations are for rapid delivery for maternal and fetal benefit, regardless of fetal heart rate (15,19,50-52). A focus on fetal monitoring during a maternal code is likely to result in the misallocation of provider attention and delays in critical interventions.

8. Q. The Association of Women's Health, Obstetric and Neonatal Nurses (AWHONN) does not currently endorse requiring ACLS for all labor and delivery unit nurses. Should our institution require ACLS for our labor and delivery unit nurses?

8. A. The AWHONN position statement declares that the need for ACLS training depends on the acuity of the patient population served and the availability of a code team within the facility (99). While almost all facilities have a code team, the team's arrival on the labor and delivery unit may be delayed. Institutions should therefore conduct drills to determine the amount of time required for the code team to arrive, and should ensure that bedside personnel are prepared to manage a maternal resuscitation for at least the amount of time required for code team arrival under optimal circumstances (11,100). While ACLS course completion may be one strategy to prepare teams, several studies have suggested that obstetric health care team members possess a poor understanding of resuscitation of the pregnant patient despite ACLS certification (3,4,6). Further, knowledge degradation may occur rapidly (7). Obstetric-specific resuscitation training (e.g., OBLS) offered in conjunction with standard ACLS courses and routine obstetric emergency drills may be the most appropriate approach for obstetrical staff (91). A subset of nurses who undergo special training to perform high-risk or critical care obstetrics should be encouraged to pursue ACLS course completion.
9. Q. Why is the recommendation to place the hands higher than normal on the sternum during the provision of chest compressions to patients in their third trimester (15)?

9. A. The gravid uterus may displace the contents of the thorax, resulting in a cephalad anatomic shift in pregnant patients who are near term. Thus, for closed chest compressions to be most effective, expert opinion suggests that the hands should be placed at the sternal level under which the heart is likely to be located (15).

10. Q. If one suspects local anesthetic-induced cardiac arrest in a pregnant patient, should lipid emulsion be administered as in a non-pregnant patient?

10. A. Local anesthetic-induced cardiac arrest in a pregnant patient should be managed as in any other patient. The pregnant state may confer enhanced sensitivity to local anesthetic systemic toxicity, and cardiac toxicity resulting from high local anesthetic plasma concentrations may be particularly resistant to conventional resuscitative interventions. If standard resuscitative measures do not result in rapid ROSC, lipid emulsion may be administered as an adjunctive therapy if local anesthetic-induced cardiac arrest is suspected. The dosing and timing of lipid emulsion therapy during resuscitation of pregnant patients should follow standard algorithms used in non-pregnant patients (see below) (17,36,44-46,101). The fetal risk of lipid emulsion therapy remains unknown, but as in any maternal cardiopulmonary arrest, the fetus is best served by optimal management of the mother. Lipid emulsion is administered as part of parenteral nutrition in severe cases of hyperemesis gravidarum, and in extremely low birth-weight infants. The primary complications appear to be infectious (102,103). The use of ECMO or cardiac bypass as a temporizing measure may be appropriate in severe cases of local anesthetic toxicity (or amniotic fluid embolus) (45,82).
Lipid Emulsion Dosing Guidelines: (15,36,44-46,101).

1.5 mL/kg ideal body weight 20% lipid emulsion bolus (100 mL for a 70 kg individual).

0.25 mL/kg ideal body weight per minute of infusion, continued for at least 10 minutes after circulatory stability is attained. If circulatory stability is not attained, consider rebolusing and increasing infusion to 0.5 mL/kg ideal body weight per minute. Approximately 10 mL/kg lipid emulsion for 30 minutes is recommended as the upper limit for initial dosing.

*Propofol is not a substitute for lipid emulsion as the drug has cardiovascular depressant effects. Failure to respond to lipid emulsion and vasopressor therapy should prompt the team to consider the use of cardiopulmonary bypass as a temporizing measure.*

11. Q. Is the use of a backboard placed under the patient really necessary during the provision of chest compressions?

11. A. Simulation studies suggest that a backboard decreases bed mattress movement during chest compressions and, as a result, a backboard may optimize chest wall excursion. If a backboard is not available at the site of arrest, compressions can be started immediately while a designee is assigned to obtain one (31,32).

X. References:


60. DePace NL, Betesh JS, Kotler MN. 'Postmortem' cesarean section with recovery of both mother and offspring. JAMA : the journal of the American Medical Association 1982;248:971-3.


73. Lipman S, Daniels K, Cohen SE, Carvalho B. Labor room setting compared with the operating room for simulated perimortem cesarean delivery: a randomized controlled trial. Obstetrics and gynecology 2011;118:1090-4.


Table 1: Checklist of key tasks during the first minutes of in-house maternal cardiac arrest

*Checklist below is to assist in remembering interventions and should NOT imply serial processing. Steps should occur in parallel and certain interventions should occur as soon as possible (e.g. defibrillation when indicated).*

| CALL FOR HELP! | ☐ Call “OB Code”  |
|                | ☐ Call neonatal team |
|                | ☐ AED/defibrillator |
| START CPR      | ☐ IMMEDIATE BLS     |
|                | ☐ Adult code cart   |
|                | ☐ Adult airway equipment |
|                | ☐ Backboard         |
|                | ☐ Scalpel/Cesarean pack |
|                | ☐ Assign timer/documenter |

| CIRCULATION | ☐ Left uterine displacement (manual) |
| CHEST COMPRESSIONS | ☐ Hands mid-sternum |
|                  | ☐ 100 compressions/min |
|                  | ☐ PUSH HARD! PUSH FAST! |
|                  | ☐ Change compressors every 2 min |
|                  | ☐ Obtain IV access above diaphragm |

| AIRWAY | ☐ Chin lift/jaw thrust |
|        | ☐ 100% O2 at 10-15L/min |
|        | ☐ Use self-inflating bag-mask |
|        | ☐ Oral airway or |
|        | ☐ Experienced personnel: Intubation with 6.0 ETT or |
|        | ☐ Supraglottic airway (e.g. LMA with gastric port) |
|        | ☐ DO NOT INTERRUPT CHEST COMPRESSIONS! |

| BREATHING | ☐ If not intubated: 30 compressions to 2 breaths |
|           | ☐ If intubated: 10 breaths per min (500-700 mL per breath) |
|           | ☐ Administer each breath over 1 second |

| DEFIBRILLATE | ☐ Pads front and back |
|              | ☐ AED: Analyze/defibrillate every 2 min |
|              | ☐ Immediately resume CPR for 2 min |
|              | ☐ Prepare for delivery |

| EXTRACT FETUS | ☐ Aim for incision by 4 min |
|               | ☐ Aim for fetal delivery by 5 min |

(Adapted with permission from OBSIM and OBLS, Center for Advanced Pediatric & Perinatal Education [CAPE], Lucile Packard Hospital, Stanford University)

Abbreviations: CPR = Cardiopulmonary Resuscitation, BLS = Basic Life Support, AED = Automated External Defibrillator, IV = intravenous, LMA = Laryngeal Mask Airway, O2 = Oxygen, ETT = Endotracheal tube, L=liters, mL = milliliters
### Table 2: Checklist of Potential Contributing Factors to Maternal Cardiac Arrest

<table>
<thead>
<tr>
<th>A</th>
<th>Anesthetic complications (high block, loss of airway, aspiration, respiratory depression, hypotension, local anesthetic toxicity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Bleeding* (coagulopathy, uterine atony, placenta accreta, placental abruption, placenta previa, uterine rupture, trauma, surgical, transfusion reaction)</td>
</tr>
<tr>
<td>C</td>
<td>Cardiovascular causes (cardiomyopathy, myocardial infarction, aortic dissection, arrhythmias)</td>
</tr>
<tr>
<td>D</td>
<td>Drugs (anaphylaxis, illicit, drug error, magnesium, narcotic, insulin, oxytocin overdose)</td>
</tr>
<tr>
<td>E</td>
<td>Embolic (pulmonary embolus, amniotic fluid [AFE], air)</td>
</tr>
<tr>
<td>F</td>
<td>Fever* (infection, sepsis)</td>
</tr>
<tr>
<td>G</td>
<td>General non-obstetric causes of cardiac arrest (H’s and T’s)†</td>
</tr>
<tr>
<td>H</td>
<td>Hypertension* (preeclampsia/eclampsia/HELLP, intracranial bleed)</td>
</tr>
</tbody>
</table>

* = Often diagnosis is apparent or predicted from pre-arrest condition

**Most LIKELY causes:** Cardiac, hemorrhage and AFE. Suspect amniotic fluid embolus (AFE) with any sudden maternal cardiac arrest, particularly when accompanied by bleeding.

Table 3: Checklist of equipment for the patient’s procedure, providers’ protection and neonate’s care (in addition to a standard crash cart with backboard). Maps of fastest routes to operating room should be posted where appropriate.

| For providers:                      | Surgical gloves, size 6, 7, and 8 |
|                                    | Gowns (for obstetricians and neonatal team) |
|                                    | Masks with eye protection |
| For procedure*:                    | Sterile scalpels (one for incision, one for cord, one backup) |
|                                    | Prep solution (if time permits) |
|                                    | Lap pads (if ROSC after delivery, pack abdomen for move to OR) |
|                                    | Sharps container |
|                                    | Kelly clamps x 4 |
|                                    | Mayo scissors |
|                                    | Retractor |
| For neonate*:                      | Cord clamps |
|                                    | Blankets and heated incubator |
|                                    | Resuscitation supplies (bag mask, bulb suction, medication, etc.) |

*Most important item is a scalpel.* Perimortem cesarean delivery must not be delayed while waiting for a cesarean tray.

ROSC=return of spontaneous circulation; OR=operating room
Figure 1: AHA 2010 Maternal Cardiac Arrest Algorithm

Maternal Cardiac Arrest

First Responder
- Activate maternal cardiac arrest team
- Document time of onset of maternal cardiac arrest
- Place the patient supine
- Start chest compressions as per BLS algorithm; place hands slightly higher on sternum than usual

Subsequent Responders

Maternal Interventions
Treat per BLS and ACLS Algorithms
- Do not delay defibrillation
- Give typical ACLS drugs and doses
- Ventilate with 100% oxygen
- Monitor waveform capnography and CPR quality
- Provide post-cardiac arrest care as appropriate

Maternal Modifications
- Start IV above the diaphragm
- Assess for hypovolemia and give fluid bolus when required
- Anticipate difficult airway; experienced provider preferred for advanced airway placement
- If patient receiving IV/IO magnesium prearrest, stop magnesium and give IV/IO calcium chloride 10 ml in 10% solution, or calcium gluconate 30 ml in 10% solution
- Continue all maternal resuscitative interventions (CPR, positioning, defibrillation, drugs, and fluids) during and after cesarean section

Obstetric Interventions for Patient With an Obviously Gravid Uterus*
- Perform manual left uterine displacement (LUD)—displace uterus to the patient’s left to relieve aorticaval compression
- Remove both internal and external fetal monitors if present
- Obstetric and neonatal teams should immediately prepare for possible emergency cesarean section
- If no ROSC by 4 minutes of resuscitative efforts, consider performing immediate emergency cesarean section
- Aim for delivery within 5 minutes of resuscitative efforts
*An obviously gravid uterus is a uterus that is deemed clinically to be sufficiently large to cause aorticaval compression

Search for and Treat Possible Contributing Factors (BEAU-CHOPS)
- Bleeding/DIC
- Embolism: coronary/pulmonary/amniotic fluid embolism
- Anesthetic complications
- Uterine atony
- Cardiac disease (MI/ischemia/aortic dissection/cardiomyopathy)
- Hypertension/pre eclampsia/eclampsia
- Other: differential diagnosis of standard ACLS guidelines
- Placenta abruptio/previa
- Sepsis

[Ref Vanden Hoek 2010] Reproduced with permission from AHA. Abbreviations: BLS = Basic Life Support. ACLS = Advanced Cardiac Life Support. ROSC = Return of spontaneous circulation. IV/IO = intravenous/interosseous. CPR = cardiopulmonary resuscitation.
LUD Figures 2a, 2b & 2c:

Vanden Hoek T L et al. Circulation 2010;122:S829-S861
**Figure 3: A simplified airway algorithm for airway control during maternal cardiac arrest.** This cognitive aid can be revised based on locally available equipment and practice. It may be printed, laminated and attached to/posted on the code cart.

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
</table>
| Ventilate 100% O₂ | - DON'T INTERRUPT CHEST COMPRESSIONS!  
- Jaw thrust + chin lift  
- Bag mask (2 handed + oral airway if necessary)  
- Cycles of 30 chest compressions : 2 breaths  
- 2 breaths, each over 1 seconds |
| Prepare & Position | - Call for expert airway help and difficult airway cart  
- Portable suction + airway equipment  
- 6.0 mm ID endotracheal tube  
- Optimize position  
- Don't interrupt chest compressions! |
| Primary Attempt | - Direct or video-laryngoscopy  
- Bougie if available |
| Secondary Attempt | - Alternate laryngoscopic technique  
- Adjust/release cricoid pressure if applied  
- Return to mask ventilation if unsuccessful  
- Prepare supraglottic airway (preferably with gastric port) |
| Alternative Airway Control | - Insert supraglottic airway (e.g., LMA)  
- If ventilation inadequate, return to mask ventilation  
- If mask ventilation inadequate → Cricothyrotomy |
| Airway Controlled | - Confirm ETT placement*  
- Secure ETT or SGA  
- 10 breaths per minute  
- Deliver 500 - 700 mL per breath |

Abbreviations: O₂ = oxygen; ID = internal diameter; ETT = endotracheal tube; SGA = supra-glottic airway  
*Confirm placement with ETCO₂ and auscultation.