Review Article

An Update on Maternal Cardiac Arrest : Causes And Management

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Abstract
Abstract- Cardiac arrest in pregnant women is a dangerous and complex condition owing to the presence of two patients (mother and fetus) is defined by WHO as death of woman from pregnancy related causes or within 42 days of pregnancy. Across the developing world a woman dies every 2 minutes from the complication of pregnancy and child birth. The present article an update on maternal cardiac arrest aims to highlight the causes and its management.
Key Words: Maternal mortality, Maternal Cardiac arrest, Management of maternal cardiac arrest

Introduction

Cardiac arrest during pregnancy is a rare and challenging event. This special situation entails two lives at risk - the mother and the fetus, the successful survival of whom largely depends upon the expert and timely decision making and management by the resuscitation team.

The fourth MBRRACE report has stated the overall maternal death rate (2013- 2015) in UK to be 8.76% per 1,00,000(1) with a worldwide daily incidence of 800 maternal deaths (2,3).

However, the recent data also shows that the rate of survival to hospital discharge after maternal cardiac arrest may be as high as 58.9% (4), which again emphasises and justifies continuum training and preparation for this specific arrest situation to improve focus on responding appropriately to these complications.

Causes of maternal arrest

Maternal mortality is defined as the death of a woman during pregnancy and upto 42 days after delivery or termination of pregnancy, provided that the cause of death is related to or aggravated by the pregnancy or its management.

The recent MBRRACE - UK report found Thrombosis & Thromboembolism as the leading causes of direct maternal death during or upto 6 weeks after the end of pregnancy(1). Cardiac disease remains the most common indirect cause of death. The most common causes of maternal death from Cardiac disease are myocardial infarction, aortic disssection, congenital heart diseases and pulmonary hypertension (5).

Some of the leading causes of maternal arrest include:-

Direct	Indirect
Thromboembolism	Cardiac conditions
Hemorrhage	Infections
Hypertension	Trauma
Sepsis	Nonobstetrics hemorrhage
Abortion	Epilepsy
Embolism	Anaphylaxis

Anaesthetic complications

Common causes of maternal collapse can also remembered as BEAU-CHOPS

Bleeding / DIC
Embolism – coronary, pulmonary, amniotic fluid
Anaesthetic complications
Uterine atony
Cardiac disease – MI, ischaemia, aortic dissection, cardiomyopathy
Hypertension, pre-eclampsia, eclampsia
Others: differential diagnosis of standard ACLS guidelines ("H'sT's")
Hyper-/hypokalemia, hypothermia, hypovolemia, hydrogen ion (acidosis), hypoxia
Tension pneumothorax, tamponade (cardiac), thrombus (coronary, pulmonary), toxins
Placenta abruption/previa Sepsis

Maternal physiology

The resuscitation of a pregnant mother is similar to the standard resuscitation of adult patients except for a few differences attributed to the physiological changes of pregnancy. The awareness of these physiological changes as well as their implications is important for the successful outcome.

Table 1. Physiological Changes of Pregnancy Affecting ACLS Protocol (Ramsay et al6)

System	Change	Affect on ACLS
Respiratory	Hyperemia and vocal cord edema	Need for smaller ETT
	Decrease minute ventilation	Accelerated hypoxemia
	Decreased FRC	Increase difficulty with bag mask ventilation
	Decrease chest wall compliance	
	Increased oxygen consumption	
Cardiovascular	Increase cardiac output with 17% diversion to gravid uterus	Limited cardiac output with CPR (partially diverted to uterus)
	Aortocaval compression from gravid uterus	Decreased preload
		Decrease effectiveness of chest compression
		Need to displace uterus
	Decreased cardiac output following delivery	Benefit to maternal hemodynamics of fetal delivery
Gastrointestinal	Delayed gastric emptying	Increased risk of aspiration, therefore pressure and early intubation
	Increased intragastric pressure importance of cricoid	
	Relaxation of lower esophageal sphincter	
Hematological	Anaemia	Need for hundred percent oxygen

Management of cardiac arrest

The Basic Life Support Algorithm provided by American Heart Association in 2015 should be used as a guide to management of cardiac arrest (7).

BLS Recommendations by AHA (Actions Are Simultaneous, Not Sequential)

1. Rapid notification should be provided to the maternal cardiac arrest response team (Class I; Level of Evidence C).
2. The time when pulselessness was confirmed should be documented (Class I; Level of Evidence C).
3. High-quality CPR should be paired with uterine displacement, and a firm backboard should be used (Class I; Level of Evidence C).
4. Rapid automated defibrillation should be provided whenever it is indicated as appropriate by rhythm analysis (Class I; Level of Evidence C).
5. Appropriate BLS airway management should be initiated.

a. A member of the first responder team should perform bag-mask ventilation with 100% oxygen flowing to the bag at a rate of at least 15 L/min (Class IIb; Level of Evidence C).

b. Two-handed bag-mask ventilation is preferred (Class IIa; Level of Evidence C).

6. Hospitals need to establish first-responder roles that satisfy all of the requirements for BLS, including modifications recommended during pregnancy. A minimum of 4 staff members should respond for BLS resuscitation of the pregnant patient. All hospital staff should be able to fulfill first-responder roles (Class I; Level of Evidence C).

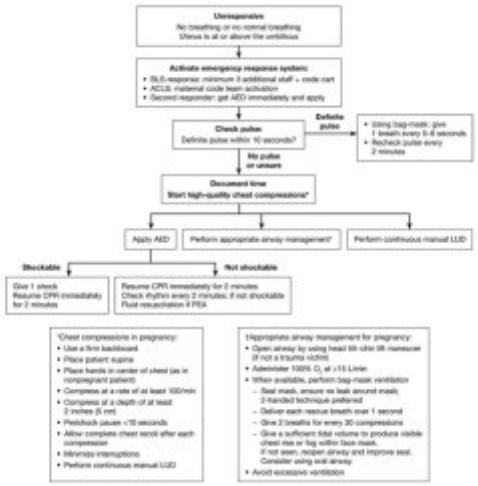

Figure 1. Cardiac arrest in pregnancy in hospital basic life support (BLS) simultaneous C-A-B-U (chest compression/ current-airway- breathing- uterine displacement). ACLS indicates advanced cardiovascular life support; AED, automated external defibrillator; CPR, cardio pulmonary resuscitation; LUD, left uterine displacement; and PEA, pulse less electrical activity.

Chest compressions in pregnancy

Chest compressions recomended for the pregnant patient are the same as for any other adult. There is no scientific evidence to recommend placing the hands slightly higher on the sternum in the pregnant patient.

Left uterine displacement

Continuous manual left uterine displacement should be used to relieve aortocaval compression using two hands from the left side of the patient. Manual LUD allows the patient to be supine with improved access to the airway, ease of defibrillation, IV access and enables high quality chest compressions.

Figure 2. Manual left uterine displacement by the 2- handed technique from the left of the patient

Defibrillation during pregnancy

Application of defibrillation and cardioversion is considered safe during all stages of pregnancy.

AHA recommendations

1. The same currently recommended defibrillation protocol should be used in the pregnant patient as in the nonpregnant patient. There is no modification of the recommended application of electric shock during pregnancy (Class I; Level of Evidence C).
2. The patient should be defibrillated with biphasic shock energy of 120 to 200 J (Class I; Level of Evidence B) with subsequent escalation of energy output if the first shock is not effective and the device allows this option.
3. Compressions should be resumed immediately delivery of the electric shock (Class IIa; Level of Evidence C).
4. For in-hospital settings where staff have no ECG rhythm recognition skills or where defibrillators are used infrequently such as in an obstetric unit, the use of an automated external defibrillator may be considered (Class IIb; Level of Evidence C).
5. The lateral pad/paddle should be placed under the breast tissue, an important consid-eration in the pregnant patient. (Class IIa; Level of Evidence C).

Airway and breathing

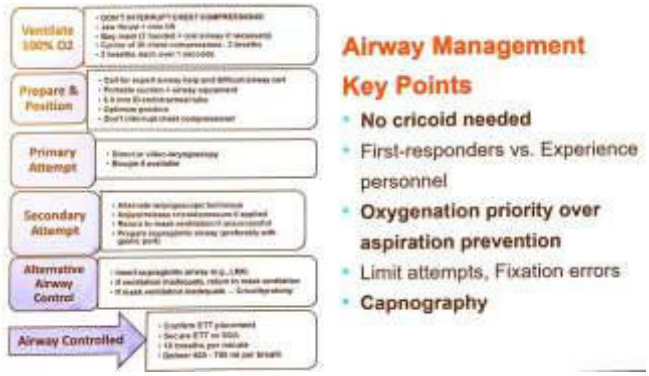

Figure 3. An example of a simplified airway algorithm for airway control during maternal cardiac arrest. Abbreviations: ETT = endotracheal tube; LMA = laryngeal mask airway; mL = milliliters; mm = millimeters; PPV = positive pressure ventilation; SGA = supraglottic airway. All the checklists contained in this document may be modified, printed, laminated, and posted on the code cart or in other areas (8).

- Initial responders without advanced airway skills should use simple techniques to oxygenate the patient.
- Only personnel with experience in advanced airway management should perform laryngoscopy.

- Manual cricoid pressure may not be effective as it can impede ventilation and laryngoscopy.

Advanced cardiac life support

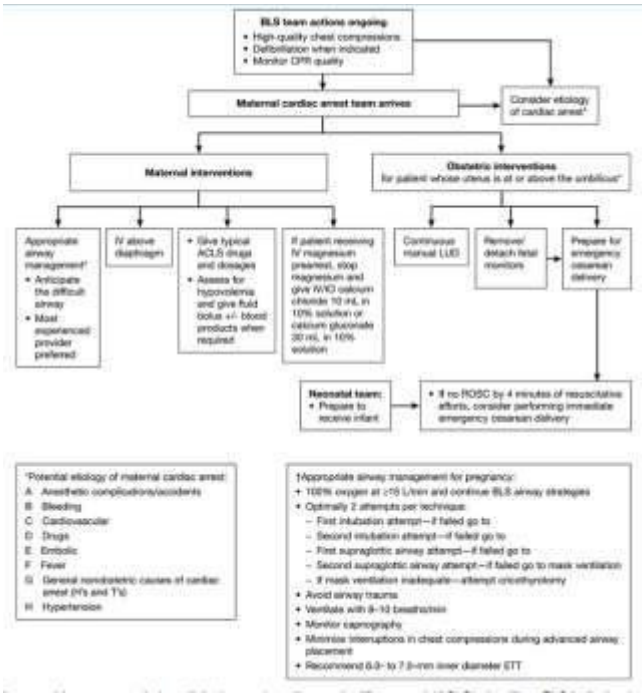

Figure 4. Cardiac arrest in pregnancy in-hospital advanced cardiovascular life support (ACLS) algorithm (7). BLS indicates basic life support; CPR, cardio pulmonary resuscitation; ETT, endotracheal tube; IV intravenous; LUD, left uterine displacement; and ROSC, return of spontaneous activity.

Trauma During Pregnancy

Trauma during pregnancy is the leading nonobstetric cause of maternal death(9), with haemorrhagic shock and brain injury as the most common mechanisms of death in pregnant trauma victim(10). Although rare (0.6% of injuries), uterine rupture is a major threat to the life of both the mother and the fetus (near 100% mortality)(11).

The management of a pregnant trauma patient follows the same BLS and ACLS protocols, along with the below mentioned points to focus (12).

- Excessive head tilt maneuvers should be avoided till Cervical Spine injury is ruled out by radiographic and physical examination criteria(13).
- Avoid nasopharyngeal airway in patients with suspected facial or basal skull fractures.
- Spine should be protected using in-line stabilization or a hard cervical collar.
- Chest tubes if needed,have to be put more cephalad than normal.
- RSI is to be used to perform tracheal intubation with a target pCO2 of 28-32mmHg.
- FAST should be done to rule out intra abdominal bleeding.

Perimortem cesarean delivery

The law of Caesar, as issued in 715 BC by Romans, dictated that no child should be burried within the dying mother.

Katz et al14 in 1986 derived a 4 minute rule for cardiac arrest - initiation of cesarean section at 4 minutes based on the physiological understanding of pregnancy and the knowledge that the irreversible brain damage from anoxia occurs within four to six minutes of inadequate cerebral perfusion.

Though the optimum interval from arrest to delivery is 5 minutes, yet studies have found good neonatal outcomes even if the delivery occurred after more than twenty minutes of arrest. So, positive neonatal and maternal outcomes are still possible despite the time delays (15).

So, the current guidelines recommend perimortem delivery even if it will not be completed within the 5 minutes window.

Practical aspects of perimortem cesarean delivery (7)

Once the decision is made to perform PMCD, no time should be wasted looking for fetal viability, as delivery of the fetus is supposed to relieve Vena caval obstruction with an increase in venous return and cardiac output and improved respiratory mechanics.

If the arrest has occurred in a hospital setting, the patient needs not to be shifted to O.T., delivery should be performed bedside only. The surgeons should use the incision which they are best well versed with.

CPR should be continued throughout and after the procedure. The abdomen has to be closed quickly.

If maternal resuscitation is successful, the patient should be shifted to ICU, for mechanical ventilation and supportive care.

Post arrest care

After successful resuscitation, critical care of the patient has to be carried in an Intensive Care Unit as this is the time when complications like hemodynamic instability, disseminated intravascular coagulation (DIC) and multi organ failure are anticipated. Precautions should be taken to maintain hydration, meet the nutritional demands and to prevent infections. The cause of cardiac arrest should continue to be considered and treated accordingly.

The use of therapeutic hypothermia has to be considered on a case to case basis and the patient receiving hypothermia should be monitored for fetal bradycardia (16,17).

Management of Brain Dead patients

Esm et al analysed 30 cases of extended maternal life support after brain death with pregnancy and the resulting neonatal outcomes, that occured between 1982 and 2010 and found that 12 out of 30 viable infants survived beyond the neonatal period (18). Whether to sustain somatic functions with life support in brain dead pregnant women is a clinical and ethical dilemma.

The gestational age of fetus and chances of fetal survival must be considered. Along with that gross fetal malformations should be ruled out before the decision making process. The family members must be counselled about the possible adverse effect of medications used during the extended somatic support.

Furthermore, after the delivery, mothers could be considered as potential organ donor, keeping in mind, the feasibility of donating organs which are still functioning at the time of delivery.

However, the legal and the ethical issues as well as the experience of the responsible team should be taken under consideration.

Quality Control and Implementation Strategies

- Early warning scores should be used for the early recognition of pregnant women at risk of life threatening events.
- Each hospital should have a specific maternal code blue, the composition of which must reflect that two critically ill patients (mother and fetus) must be resuscitated.
- Regular simulation and mock drills should be conducted to practice critical skills.
- All cases of cardiac death and maternal near miss should be reviewed by the maternal cardiac arrest committee for the hospital to correct the idientifiable deficiencies.
- It is important that we continue to learn from the unfortunate deaths of women as well as those who survived an arrest.

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