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MINI REVIEW ARTICLE

Cardiopulmonary Resuscitation in Obstetric Patient: Special Considerations

Sadhana Kulkarni[1] · **Savani S. Futane**[2]

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Abstract

The prevalence of cardiac arrest in pregnant women varies from 1/20,000 to 1/50,000 pregnancies and is associated with high fetomaternal mortality. The pregnant mother is more susceptible to cardiac arrest as hypoxia is poorly tolerated. Hemorrhage, eclampsia, sepsis, and embolism are common causes of arrest. Cardiac arrest is preventable if a predisposing clinical problem is detected in time by an early warning score and treated immediately. Resuscitation in obstetric patient is challenging and special as it involves the lives of two patients, the mother and the fetus. Physiological and anatomical changes during pregnancy need special considerations during cardiopulmonary resuscitation. Chest compressions, defibrillation, and drug administration guidelines are similar to those in non-pregnant women. Early endotracheal intubation by an expert is desirable but bag-mask ventilation with oxygen supplementation should be initiated immediately by the first responder to prevent hypoxia. Hyperventilation should be avoided. An intravenous line should be established above the level of the diaphragm. Manual left lateral uterine displacement is necessary to relieve aortocaval compression when uterine height is more than 20 weeks. Perimortem cesarean delivery at the site is a part of resuscitation if spontaneous circulation is not established within 4 min, after detection of the arrest. Echocardiography and ultrasonography can help to find out the etiology of the arrest. Targeted temperature management and extracorporeal cardiopulmonary resuscitation should be considered as needed. The newborn will be taken care of by a neonatologist. Following emergency protocols, early warning scores, training and updating resuscitation guidelines, simulations, collecting a national database of pregnant mothers along with the teamwork of obstetrician, anesthesiologist, neonatologist, and emergency physician can reduce fetomaternal mortality.

Keywords Cardiopulmonary Resuscitation · Pregnancy · Perimortem cesarean section delivery · Early warning score

Introduction

Maternal mortality is a key health indicator. The prevalence of cardiac arrest in pregnant women varies from 1/20,000 to 1/50,000 and is associated with high maternal (30–80%) and neonatal (60%) fatality rates [1]. As per WHO estimates; out of 529,000 maternal deaths globally; 136,000 deaths (25.7%) are contributed by India each year [2].

Treatment of cardiac arrest in obstetric patients is challenging due to altered maternal anatomy and physiology. Mother, as well as fetus, is at risk. Resuscitation guidelines are special and a multidisciplinary team approach is essential for cardiopulmonary resuscitation [CPR]. Obstetricians, neonatologists, anesthesiologists, emergency physicians, and those involved in the 'Maternal Code Blue Team' must be aware of special considerations related to CPR.

The available literature about CPR in an obstetric patient is largely observational, and treatment decision is based on

Dr. Sadhana Kulkarni is a Professor and HOD of Emergency Medicine and in- charge skill development Unit, MGM Medical college Aurangabad.(M.S.), India. Constituent unit of MGMIHS, Navi Mumbai. She was a former Professor and Head of Department of Anaesthesiology at Govt. Medical College, Aurangabad. She has 42 years experience of Anasthesiology and 22 years in critical care and pain management. She is instructor for Basic and Advanced Cardiac Life Support courses of American Heart Association and Indian Resuscitation Council. She is a Fellow of Academic college of Emergency Experts (ACEE). Her areas of interest are obstetric anesthesia, CPR and Skill lab. Dr. Sadhana Kulkarni. (MD. Anesthesia) Professor and HOD of Emergency Medicine, MGM Medical College and Hospital Aurangabad, Maharashtra India. Dr. Savani Futane is Assistant Professor in Department of Anaesthesiology.

✉ Sadhana Kulkarni
kulkarnisadhana@yahoo.com

Extended author information available on the last page of the article

the physiology of pregnancy and extrapolations from non-arrest pregnancy state [3].

According to Leonardsen et al., it might be difficult for obstetricians to maintain the skill of CPR as cardiac arrest is rare in pregnancy. His study revealed that 82% of caregivers agreed that there is a need for additional knowledge and training for CPR [4]. Obstetricians need to update themselves about recent guidelines as correct and timely intervention can alter outcomes of resuscitation [5].

Factors Responsible for Cardiac Arrest During Pregnancy

Cardiac arrest may be due to cardiac or non-cardiac factors.

Cardiac Risk Factors

Common cardiac risk factors are complex congenital heart disease with pulmonary hypertension, valvular disease, cardiomyopathy, coronary artery disease, connective tissue disorders, and prior cardiac surgery [6, 7]. Triggers such as hemodynamic shifts due to arrhythmias, myocardial ischemia, thrombosis, and electrolyte abnormalities can lead to sudden cardiac arrest.

Non-cardiac Risk Factors

Hemorrhage, sepsis, eclampsia, and anemia are common causes in India [2]. Pulmonary embolism, hemorrhage, sepsis, stroke, eclampsia, and complications related to anesthesia are common factors reported in western countries [1].

Pregnant women can also have a cardiac arrest from other causes as in non-pregnant women of the same age group.

Following, 'A' through 'H', mnemonic is devised by the American Heart Association 2015 for causes of cardiac arrest in pregnant women [7].

A. Anesthetic complications, accident/trauma
B. Bleeding
C. Cardiac causes
D. Drugs
E. Embolism
F. Fever
G. General causes—including hypoxia, electrolyte disturbances, etc.
H. Hypertension

Resuscitation outcomes of in-hospital pregnant women are better than non-pregnant women, probably because the majority of mothers are young and have potentially reversible causes related to cardiac arrest [8].

Prevention of cardiac arrest, by early detection of critically ill patients, is an important link in adult basic life support. Early warning score monitoring can help to initiate timely treatment and reduce mortality.

Obstetric Early Warning Score (EWS)

Direct causes of maternal deaths are well known, largely preventable, and treatable [9]. EWS to discriminate between survivors and non-survivors among critically ill obstetric patients in ICU is suggested by Carle et al. [10]. Clinical signs like systolic blood pressure, pulse rate, respiratory rate, supplementary oxygen required to maintain oxygen saturation (SpO2) > 95%, temperature and altered consciousness (using Glasgow Coma Score) are monitored, and scores are

Table 1 Obstetric Early Warning Score (EWS) *

Sr. No	Parameters	Scores**				
		2	1	0	1	2
1	Temperature (degree Celsius)	< 35	35- < 36	36- < 38		> 38
2	Pulse rate/min	< 40	40- < 50	50- < 100	100–120	> 120
3	Respiratory rate/min	0–10		11–20	21–30	> 30
4	Systolic blood pressure (mm Hg)	< 90	90- < 100	100- < 150	150–160	> 160
5	Urine volume ml/hr	< 20	20–30	> 30		
6	Mode of birth	Cesarean Section		Vaginal		Cesarean Section
7	Consciousness level	Response to pain/ unresponsive	Response to voice	Alert	Response to voice	Response to pain/ unresponsive

*Aminu Umar, Alexander Manu, Matthews Mathai, and Charles Ameh. Development and validation of an obstetric early warning system model for use in low resource settings. BMC Pregnancy and Childbirth 2020; 20:531–540

**For a score of 0 or 1, repeat observation as for the postoperative patient, for a score of two, repeat observation after 30 min and if it remains 2 or rises, inform concerned doctor, for a score of 3 or more call concerned doctor immediately

given. Unstable mothers with a > 6 score have a mortality rate of 6. 3% [11].

A simple prediction model for evaluation of severe maternal outcome (SMO) in the ward and resource-limited settings is introduced by Umar et al. [12]. Score based on clinical parameters can predict SMO (Table 1) and will be of help during triaging and follow-up of patients. Women having abnormal clinical measurements (either lower or higher than normal) were more likely to have SMO than controls.

The unstable patient should be administered oxygen and be placed in a lateral position. An intravenous line should be secured, and treatment is initiated at the earliest taking help of experts, and the patient is shifted to ICU.

Although the algorithm of Umar et al. does not include measurement of SpO2 using pulse oximeter, other studies have demonstrated that SpO2 is a valuable predictor of serious obstetric complications [13].

(A) Basic Life Support (BLS):

Immediately after detection of unresponsiveness, apnoea, and the absence of carotid pulse, multidisciplinary maternal code blue should be activated.

BLS protocol needs special considerations in the obstetric patient (Table 2). The time of cardiac arrest, must be documented. If spontaneous circulation is not restored after 4 min, perimortem cesarean delivery should be performed [7].

Chest Compressions

The position of hands for chest compressions is similar in a pregnant and non-pregnant patient as no significant vertical displacement of the heart was observed in MRI during the third trimester of pregnancy relative to a non-pregnant state [3, 14].

5–6 cm deep chest compressions on lower one-third of the sternum, rate of 100–120/min, and compression : ventilation ratio of 30:2 is recommended. The patient should be on a hard surface (cardiac board). Chest compressions should never be interrupted for more than 10 seconds [7].

Manual Left Lateral Uterine Displacement

Inferior vena cava and aorta get compressed by gravid uterus in the supine position, particularly if uterine height is at or above the umbilicus (Fig. 1). Compression may be observed as early as 12 weeks. Left lateral Uterine Displacement (LUD) should be implemented during CPR whenever compression is likely irrespective of gestational age [15].

Table 2 Summary of Cardiopulmonary Resuscitation profile in Non-pregnant and pregnant patient

Sr. No	Particulars	Non-pregnant patient	Pregnant patient
	Persons affected	one	**Mother and fetus**
	Chest compressions sites	Lower one-third of the sternum	Lower one-third of the sternum
	Airway	Nasopharyngeal, Oropharyngeal airway ETT, LMA	**No nasopharyngeal airway. ETT 1 mm smaller in size, intubation may be difficult** Early intubation by expert beneficial
	Breathing	A single person can ventilate with a bag- mask. Hyperventilation avoided as it leads to low COP and reduces cerebral perfusion	**May need two persons for two hands bag-mask ventilation as airway resistance is more. A pregnant patient is more prone to hypoxia than non-pregnant patient.** Oxygenation is more important than the risk of aspiration Hyperventilation is avoided as it leads to low COP, reduces cerebral perfusion, and can produce **fetal acidosis**
	Defibrillation	120–200 J	Safe,120–200 J
	I.V. access	Preferably UE	**Above the level of the diaphragm is must (UE)**
	Drugs	Adrenaline, Amiodarone	Both the drugs can be used safely **Calcium gluconate** for Magnesium toxicity and Intralipid for local anesthetic toxicity
Special measures	ECHO, USG, ECMO	Useful to diagnose hypovolemia, embolism, pericardial effusion, cardiomyopathy, myocardial infarction, etc	Same uses. ECMO is useful for Amniotic fluid embolism, LA toxicity, and potentially reversible causes **LUD** is recommended during CPR for relieving aortocaval compression. **PMCD** should be carried out if resuscitation is unsuccessful after 4 min if uterine height is more than 20 weeks

ETT—Endotracheal Tube, LMA—Laryngeal Mask Airway, COP—Cardiac Output, UE—Upper Extremities, ECMO—Extracorporeal Membrane Oxygenator, LA—Local Anesthetic, LUD—Left lateral Uterine Displacement, PMCD—Perimortem Cesarean Delivery

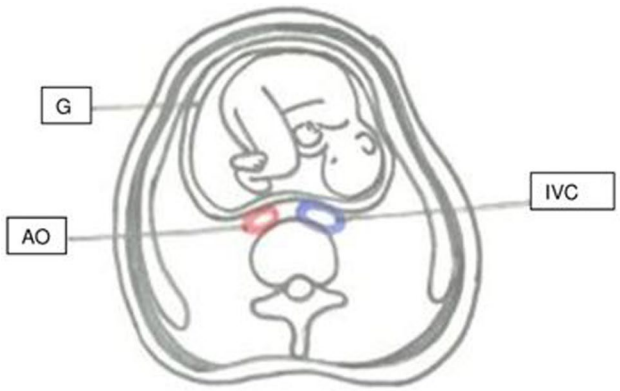

Fig. 1 Aortocaval compression due to gravid uterus in supine position. IVC—Inferior Venacava, G—Gravid Uterus, AO—Aorta

Fig. 2 Left lateral uterine displacement performed by a provider on the left side of the patient

Fig. 3 Left lateral uterine displacement performed by a provider on the right side of the patient

Fig. 4 Left lateral uterine displacement using firm wedge placed below the right lumbar region

Manual LUD is optimally performed by a provider on the left side of the patient using two hands. The uterus is pulled leftward and upward toward the ceiling (Fig. 2). Vena caval compression may be worsened by inadvertently applied downward force. If it is not possible to perform manual LUD from the left side, it may be applied from the right side of the patient by pushing away the uterus with one hand, although providing adequate shift using this approach may be technically more difficult (Fig. 3) [13]. A 1.5–2 inches shift helps to optimize venous return and stroke volume during CPR [1].

A wooden wedge or firm towel roll can be used for LUD (Fig. 4). Access for effective chest compressions, defibrillation, and intubation is easy when manual LUD is adopted as the upper torso remains in the supine position. 15–30 degrees pelvic tilt used for LUD may hamper effective chest compressions [15]. LUD will not be sustained when soft folded pillows are used.

Airway Management

The airway should be opened using head tilt and chin lift maneuver unless a cervical injury is likely. The oropharyngeal airway can be used. The use of the nasopharyngeal airway should be avoided as nasal mucosa is congested during pregnancy. Early tracheal intubation protects the airway from aspiration and makes ventilation easy.

Breathing

A pregnant mother is vulnerable to the development of hypoxia due to decreased functional residual capacity,

increased oxygen consumption, and intrapulmonary shunting [1].

Although the mother is at risk of aspiration, oxygenation and ventilation are the priority and the first responder, who may not be able to intubate, should initiate bag-mask ventilation [15].

Lower tidal volumes are needed due to elevated diaphragm. Two-handed bag-mask ventilation with reservoir bag and > 15 L/min oxygen supplementation should be used as airway resistance is increased [1]. Suction should be kept ready.

Ventilation at a rate of 8–10 breaths/min can prevent iatrogenic respiratory alkalosis. Large tidal volumes decrease cardiac output leading to fetal acidosis [1].

Defibrillation

The defibrillator should be used as soon as available. The energy required [120–200 J for biphasic shock] for defibrillation is similar in pregnant and non-pregnant patients [3]. DC shock has no adverse effect on the fetus. Before delivering a shock, the fetal monitor should be removed to prevent electrocution, although the risk is theoretical [15]. An automated external defibrillator (AED) can also be used.

(B) Advanced Cardiac life support [ACLS]

Advanced airway devices, intravenous fluids, medications, and monitors (Cardiac monitor, Capnography, USG, ECHO) are used during ACLS.

Chest Compressions, Airway, and Breathing

Chest compressions should be performed continuously and ventilation is provided at a rate of 10 breaths /min. using 100% oxygen, after intubation.

The size of an endotracheal tube in a pregnant mother should be 0.5 to 1.0 mm less as compared to a non-pregnant woman. The patient should be intubated after ventilation with 100% oxygen. Proper placement of the endotracheal tube is to be confirmed by using Capnography. With effective chest compressions, Capnography readings will be more than 10 mm Hg. The use of cricoid pressure during intubation is controversial [1]. Expert help for intubation or laryngeal mask airway may be required.

Intravenous Access

Intravenous access should be established with two 14–16 gauge catheters above the level of the diaphragm (upper extremity), considering vena cava compression due to the gravid uterus.

Intraosseous access can also be used. If both these routes are not available, a double dose of the drug (Epinephrine, Lignocaine, Naloxone) diluted in 10 ml normal saline can be administered via endotracheal tube. Drugs like calcium gluconate, sodabicarb should not be administered through an endotracheal tube [7].

Drugs Used During CPR of Obstetric Patient

Similar dosages of all drugs are used in pregnant and non-pregnant patients [3].

If cardiac arrest is due to magnesium toxicity, calcium gluconate [30 ml, 10%] should be used in addition to other drugs.

Early administration of a 20% lipid emulsion [Intralipid] is life-saving during resuscitation of local anesthetic toxicity. It traps the local anesthetic and increases cardiac output. A bolus of 1.5 ml/kg intralipid is administered over one minute, followed by 0.25 ml/kg/min infusion for at least 10 min after circulatory stability. Amiodarone can be used if there is ventricular fibrillation due to Bupivacaine toxicity [16].

The Five-minutes Rule for Perimortem Cesarean Delivery (PMCD)

At times, routine resuscitation efforts may not be effective. Irreversible brain damage can occur after four minutes of anoxia in non-pregnant patients [1]. Standard guidelines [11, 13, 14] recommend perimortem cesarean delivery [PMCD] if spontaneous circulation is not restored after four minutes, in mothers with a gestational period of more than 20 weeks. It is also referred to as 'resuscitative hysterotomy' [17]. At a gestational period of more than 24–25 weeks, emergency hysterotomy can save the life of both the mother and fetus.

Factors like the cause of cardiac arrest, maternal pathology, cardiac function, gestational age of the fetus, and resources available should be taken into consideration while deciding PMCD [3]. A review of 94 cases reported that 30.7% of women were benefited, and there was no report of detrimental impact from PMCD [18].

To achieve delivery within 5 min, PMCD needs to be conducted at the site, which may not be the operation theater [15]. Shorter time intervals from arrest to delivery appear to improve maternal and neonatal outcomes. A successful outcome is reported at 30 min of PMCD [3]. Only PMCD within 10 min for in-hospital arrest was predictive of maternal and neonatal survival [1].

The decision to perform PMCD will be the obstetrician's responsibility. Chest compressions and LUD are to be continued during PMCD.

Emergency Cesarean Delivery Kit and Procedure

Kit includes preloaded scalpel with 10 number blade, sutures, needle holders, towel clips, retractors, forceps, scissors, suction tube, sponges, Kelly clamps, uterine pack, and equipment for neonatal resuscitation [1]. Antiseptic is poured over the abdomen during early resuscitation to prepare for PMCD by one provider.

There are no published reports of physician liability for performing PMCD without consent following maternal cardiac arrest in USA [1].

Adequate uterine exposure and access to transabdominal cardiac massage can be achieved by taking a vertical skin incision. After the baby and placenta are delivered, the uterine incision is closed with absorbable suture using running locking stitches, at the site or in operation theater depending on the patient's condition [19]. Bleeding may be a problem after hemodynamic stability is restored.

Assisted Instrumental Vaginal Delivery

This is advocated when vaginal delivery is imminent and can be achieved within five minutes following arrest [1].

Use of Oxytocin

After successful resuscitation, intravenous infusion of Oxytocin (20miliunits/minute) or 10 units dose in myometrium is administered to avoid cardiovascular collapse [1].

Broad-spectrum antibiotics should be administered after delivery.

Treatment of Cause of Arrest

Hypovolemia, hypoxia, acidosis, electrolyte imbalance, tension pneumothorax, trauma, embolism, anaphylaxis, poisoning, etc., should be treated simultaneously.

Direct Cardiac Massage: Open chest or transabdominal cardiac massage, when the abdomen is already open, can be implemented 15 min after unsuccessful closed chest compressions to achieve higher cerebral and coronary flow [1].

Tools Useful During Resuscitation

Cardiopulmonary Limited Ultrasound Examination (CLUE) and Trans-Esophageal Echocardiography [TEE] are quick, portable, and reliable means of identifying hypovolemia, pulmonary embolism, unrecognized heart disease, pericardial effusion, myocardial infarction, and cardiomyopathy [20].

Extracorporeal Cardiopulmonary Resuscitation (ECPR)

ECPR is recommended in patients developing refractory arrest with reversible causes like local anesthetic toxicity, amniotic fluid embolism, cardiogenic shock, etc [6]. In ECPR, a portable extracorporeal membrane oxygenator is used to maintain end-organ perfusion for improving long-term survival and neurological outcomes. Hysterectomy may be needed to control massive bleeding as anticoagulants are used during ECPR.

Data from ECPR use in parturient showed approximately 80% maternal survival and 65–70% fetal survival [21].

Treatment of Special Problems Leading to Cardiac Arrest

Myocardial Infarction

Increasing maternal age, hypertension, obesity, and smoking may predispose mothers to coronary insufficiency. Percutaneous coronary intervention is preferred over fibrinolytic for ST-segment elevation myocardial infarction [1].

Massive Thromboembolism

Systemic thrombolysis can be used as a life-saving measure for massive pulmonary embolism and ischemic stroke [22]. Close watch on postpartum hemorrhage is essential.

Post-Arrest Care

After the restoration of spontaneous circulation SpO2 (92%–98%), partial pressure of carbon dioxide (PaCO2:35–45 mm hg), systolic blood pressure (>90 mm), and blood sugar (150–180 mg %) should be maintained [3]. If the mother remains unconscious, Targeted Temperature Management (TTM) for therapeutic hypothermia (34 degrees Celsius) can be considered [23].

Continuous fetal monitoring is required during TTM if PMCD is not already performed. Impairment of coagulation during the postpartum period should be kept in mind if TTM is considered after PMCD.

Assessment of Fetus and Newborn

Resuscitation of the mother is the priority because it may lead to increased survival of both, the mother and fetus. Fetal

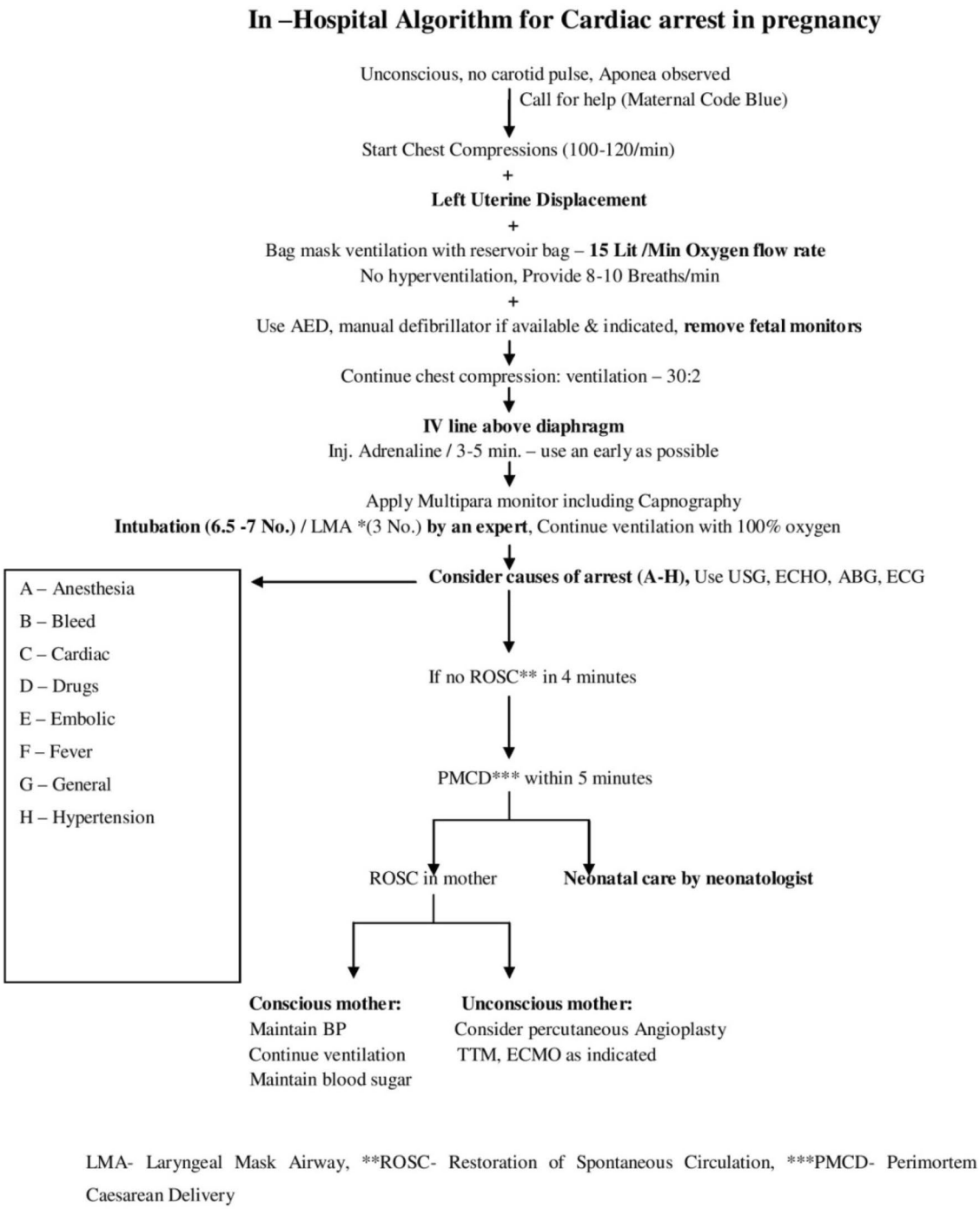

Fig. 5 In-hospital algorithm for cardiac arrest in pregnancy

monitoring does not achieve this goal and may distract from maternal resuscitation efforts, like defibrillation and PMCD [3]. The newborn will be taken care of by the neonatal resuscitation team after PMCD.

CPR algorithm for in-hospital pregnant patients is as shown in Fig. 5. It need not be followed vertically if a team is available at the site. Chest compressions, LUD, and ventilation can be initiated simultaneously (Fig. 5).

At present, a knowledge gap exists in certain aspects of maternal resuscitation. Research related to measures to relieve aortocaval compression effectively during resuscitation needs special attention [24]. Optimal timing of PMCD within five minutes to optimize fetomaternal outcomes may be difficult to achieve [15]. The time required may vary based on the provider's skill, available resources as well as patient-related problems. Apart from hemorrhage, eclampsia, and sepsis, the increasing number of mothers with congenital heart disease and increasing maternal age are additional challenges.

TTM, TEE, and ECMO are newer modalities added to resuscitation armamentarium. Health care professionals should be made aware of the fact that resuscitation in obstetric patients' needs special considerations (Table 2).

National databases are essential for the prevention of maternal cardiac arrest, understanding resuscitation science, and outcomes [22]. Institutional delivery of high-risk mothers, use of protocols for obstetric emergencies especially eclampsia and massive blood transfusion, EWS, provision for PMCD in the ward and emergency medical services, repeated training of team members, and mock drills on simulation are essential to improve fetomaternal outcomes [25].

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Conflict of interest The authors declare that they have no conflicts of interest.

References:

1. Zelop MC, Brickner B, Sudden cardiac arrest and death in pregnancy. Up ToDate.2021, Available from: https://www.uptodate.com/contents/sudden-cardiac-arrest-and-death-in-pregnancy
2. State of Maternal Health in India, Maternal Mortality in India. Available from: www.azadindia.org/social-issues/maternal-health-in-india
3. Panchal AR, Chair JA, José GC, Cabañas JA, et al Adult Basic and Advanced Life Support. 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation.2020; 142 (suppl 2):S366–S468. DOI: .1161/CIR.0000000000000916
4. Leonardsen A-C, Svendsen EJ, Heitmann GB, et al. Development and validation of a questionnaire to assess healthcare personnel competence in cardiac arrest and resuscitation in pregnancy. PLoS ONE. 2020;15(5): e0232984. https://doi.org/10.1371/journal.pone.0232984.
5. Kikuchi J, Deering S. Cardiac arrest in pregnancy. Semin Perinatol. 2018;42(1):33–8.
6. Brickner ME. Cardiovascular management in pregnancy, congenital heart disease. Circulation. 2014;130:273–82.
7. Jeejeebhoy FM, Zelop CM, Lipman S, et al. Cardiac Arrest in Pregnancy: A Scientific Statement from the American Heart Association. Circulation. 2015;132:1747–73.
8. Mogos MF, Salemi JL, Spooner KK et al. Differences in mortality between pregnant and non-pregnant women after cardiopulmonary resuscitation. Obstet. Gynecol. 2016; 128(4):880–888. DOI: https://doi.org/10.1097/AOG.0000000000001629
9. Maternal health | UNICEF India. Available from: https://www.unicef.org/india/what-we-do/maternal-health.
10. Carle C, Alexander P, Columb M, Johal J. Design and internal validation of an obstetric early warning score: secondary analysis of the intensive care National Audit and Research Centre case-mix program database. Anesthesia. 2013;68:354–67.
11. Paternina-Caicedo A, Miranda J, Bourjeily G, et al. Performance of the Obstetric Early Warning Score in critically ill patients for the prediction of maternal death. Am J Obstet Gynecol. 2017;216(58):e1-8.
12. Umar A, Manu A, Mathai M, Ameh C. Development and validation of an obstetric early warning system model for use in low resource settings. BMC Pregnancy Childbirth. 2020;20:531–40.
13. Payne BA, Hutcheon JA, Ansermino JM, et al. A risk prediction model for the assessment and triage of women with hypertensive disorders of pregnancy in low-resourced settings: the miniPIERS (pre-eclampsia integrated estimate of Risk) multi-country prospective cohort study. PLOS Med. 2014;11(1): e1001589. https://doi.org/10.1371/journal.pmed.1001589.
14. Holmes S, Kirkpatrick ID, Zelop CM, Jassal DS. MRI evaluation of maternal cardiac displacement in pregnancy: implications for cardiopulmonary resuscitation. Am J Obstet Gynecol. 2015;213:401. https://doi.org/10.1016/j.ajog.2015.05.018 (**Epub 2015**).
15. Lipman S, Cohen S, Einav S, et al. Management of cardiac arrest in pregnancy. The Society for Obstetric Anesthesia and Perinatology consensus statement on the management of cardiac arrest in pregnancy. Anesth Analg. 2014;118(5):1003–16. https://doi.org/10.1213/ANE.0000000000000171.
16. Neal JM, Woodward CM, Harrison TK. The American Society of regional anesthesia and pain medicine checklist for managing local anesthetic systemic toxicity: 2017 Version. Reg Anesth Pain Med. 2018;43:150.
17. Rose CH, Faksh A, Traynor KD, Cabrera D, Arendt KW, Brost BC. Challenging the 4- to 5-minute rule: from perimortem cesarean to resuscitative hysterotomy. Am J Obstet Gynecol. 2015;213:653–6. https://doi.org/10.1016/j.ajog.2015.07.019.
18. Einav S, Kaufman N, Sela HY. Maternal cardiac arrest and perimortem cesarean delivery: evidence or expert-based? Resuscitation. 2012;83:1191–200. https://doi.org/10.1016/j.resuscitation.2012.05.00.
19. Zelop CM, Einav S, Mhyre JM et al. Cardiac Arrest during pregnancy: Ongoing Clinical Conundrum. Am J Obstetr Gynecol [Internet]. 2018.Available from: http://linkinghub.elsevier.com/retrieve/pii/S00029378173280
20. Kapoor PM, Goyal S, Irpachi K, Smita B. Importance of transesophageal echocardiography in peripartum cardiomyopathy

undergoing lower section cesarean section under regional anesthesia. J Anaesthesiol Clin Pharmacol. 2014;30:427–9.
21. Sharma NS, Wille KM, Bellot SC, Diaz-Guzman E. Modern use of extracorporeal life support in pregnancy and postpartum. ASAIO J. 2015;61(1):110–4.
22. Gomes MS. Mariana Guimarães, Nuno Montenegro Thrombolysis in pregnancy: a literature review. J Matern Fetal Neonatal Med. 2019;32(14):2418–28. https://doi.org/10.1080/14767058.2018.1434141.
23. Chauhan A, Musunuru H, Donnino M, et al. The use of therapeutic hypothermia after cardiac arrest in a pregnant patient. Ann Emerg Med. 2012;60:786–9. https://doi.org/10.1016/j.annemergmed.2012.06.004.
24. Vencken PM, Hooff MHV, Weiden RMVD. Improved performance of maternal-fetal medicine staff after maternal cardiac arrest simulation-based training. Am J Obstetr Gynecol. 2012;206(4):e4.
25. Einav S, Mhyre JM, Martin S. Cardiac arrest during pregnancy: ongoing clinical conundrum. Am J Obstet Gynecol. 2018;219(1):52–61.

About the Author

Sadhana Kulkarni is a Professor and HOD of Emergency Medicine and in-charge Skill Development Unit, MGM Medical College, Aurangabad (M.S.), India. Constituent unit of MGMIHS, Navi Mumbai. She was a former Professor and Head of Department of Anesthesiology at Govt. Medical College, Aurangabad. She has 42 years of experience in Anesthesiology and 22 years in critical care and pain management. She is instructor for Basic and Advanced Cardiac Life Support courses of American Heart Association and Indian Resuscitation Council. She is a fellow of Academic college of Emergency Experts (ACEE). Her areas of interest are obstetric anesthesia, CPR, and skill laboratory.

Authors and Affiliations

Sadhana Kulkarni[1] · Savani S. Futane[2]

Savani S. Futane
savani_k@rediffmail.com

[1] Emergency Medicine, Constituent Unit of MGMIHS, MGM Medical College and Hospital Aurangabad, Navi Mumbai, Maharashtra, India

[2] Dr. Vasantarao Pawar Medical College, Hospital and Research Center, Nashik, India