



Systematic Review

Maternal cardiac arrest: Current resuscitation strategies and the emerging role of simulation-based training

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Abstract

Maternal resuscitation during the antenatal period represents a critical and complex clinical challenge, as it involves the simultaneous management of both maternal and foetal well-being. The rarity of maternal cardiac arrest (MCA) combined with physiological changes of pregnancy, such as altered haemodynamics and airway challenges, demands a rapid, coordinated, and skilled multidisciplinary response. Despite ongoing global efforts to reduce maternal mortality, the burden remains high, particularly in low- and middle-income countries. Preventable deaths due to maternal cardiac arrest (MCA) are frequently attributed to knowledge gaps and inadequate response times. In recognition of this, the American Heart Association (AHA) and other authorities have released pregnancy-specific resuscitation guidelines. Yet, adherence to these protocols in real-world practice remains uneven. Simulation-based training has emerged as a promising strategy to bridge this gap, offering clinicians the opportunity to practise rare, high-risk scenarios in a safe, controlled environment. This narrative review discusses the causes and pathophysiology of maternal cardiac arrest, evaluates existing resuscitation guidelines focusing on the AHA recommendations, and underscores the growing importance of simulation-based education in improving maternal and neonatal outcomes during cardiac emergencies in pregnancy.

Keywords: Pregnancy; Maternal mortality; Emergencies; Resuscitation; Cardiac arrest.

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1. Introduction

Maternal resuscitation during the antenatal period presents a complex and challenging scenario for healthcare professionals, as it necessitates the simultaneous management of two lives, the mother and the foetus. This complexity is further compounded by the limited experience many obstetric teams have in carrying out effective resuscitation strategies. In 2017, the global maternal mortality ratio was approximately 211 deaths per 100,000 live births.¹ In India, while there has been a notable decline—from 301 per 100,000 live births in 2003 to 167 in 2013—the rate remains substantially higher than in developed nations.^{1,2}

Evidence suggests that preventable deaths in cases of maternal cardiac arrest (MCA) are often due to knowledge deficits and inadequate medical responses.

MCA presents unique challenges owing to the anatomical and physiological changes associated with pregnancy, including altered haemodynamics, increased difficulty in airway management, and the potential compromise of foetal well-being. While organisations like the American Heart Association (AHA) have issued evidence-based guidelines for managing MCA,

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implementation remains inconsistent across clinical practice.³ There is a growing need for standardised training programmes focused on maternal resuscitation to address these challenges. Simulation-based training has proven to be an effective tool in improving the competence and confidence of healthcare providers in managing MCA scenarios.⁴

This narrative review aims to explore the current understanding of the causes of maternal cardiac arrest and the existing resuscitation guidelines, while highlighting the role of simulation training in enhancing clinical preparedness and improving maternal and foetal outcomes.

2. Methodology

A comprehensive literature search was performed across four major medical databases: PubMed, Cochrane Library, Ovid MEDLINE, and Google Scholar, covering publications from January 2000 to March 2025. Search terms included a combination of Medical Subject Headings (MeSH) and keywords: "maternal resuscitation," "maternal cardiac arrest," "AHA guidelines," "maternal collapse," "obstetric emergencies," "simulation training," "Obstetric Early Warning Score (OEWS)," and "maternal risk assessment."

Two independent reviewers screened titles and abstracts for relevance. Full-text articles were then assessed based on predefined inclusion criteria: (1) studies focusing on maternal cardiac arrest during pregnancy or postpartum; (2) articles describing or evaluating resuscitation protocols, including AHA or equivalent guidelines; and (3) studies investigating the impact of simulation-based training on clinical performance or outcomes. Both randomized controlled trials and observational studies were included. Articles not published in English, case reports, editorials, and conference abstracts without full data were excluded.

Data extracted included study design, population characteristics, setting, type of intervention or guideline assessed, simulation model (if applicable), outcomes measured, and key findings. Risk of bias was evaluated using the Cochrane Risk of Bias Tool for RCTs and the Newcastle-Ottawa Scale for observational studies. Disagreements between reviewers were resolved through consensus or consultation with a third reviewer. The findings from eligible studies were synthesized both qualitatively and quantitatively as narrative review.

3. Causes of Maternal Arrest

The causes of cardiac arrest during pregnancy are diverse and may arise from either obstetric or non-obstetric conditions (Figure 1, Table 1).

Major obstetric haemorrhage is one of the leading causes, with an estimated incidence of 6 per 1,000 maternities, and was responsible for 13 maternal deaths between 2012 and 2014.⁵

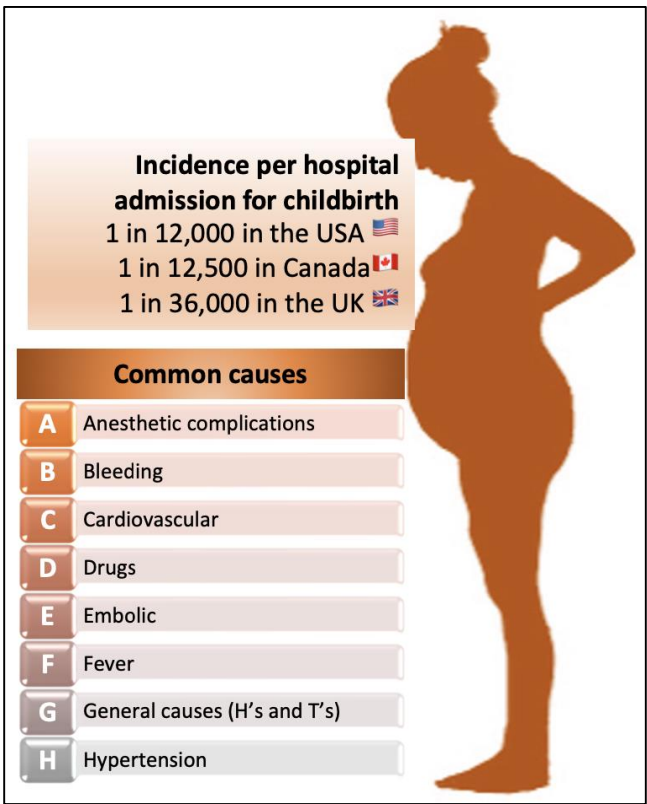


Figure 1: Incidence and common causes of maternal cardiac arrest

Thromboembolism is another major contributor and was identified as the most common cause of direct maternal death in the 2016 MBRRACE-UK report.⁶ Amniotic fluid embolism (AFE), although rare—occurring at a rate of 1.7 per 100,000 maternities in the UK—is often fatal and typically presents as a sudden collapse during labour or shortly after delivery.⁷ Cardiac disease remains the most frequent cause of indirect maternal death, accounting for 51 deaths between 2012 and 2014, and often manifests as sudden arrhythmic death.⁸ Other notable causes of maternal collapse include sepsis, eclampsia, intracranial haemorrhage, and anaphylaxis, with eclampsia being particularly common among women with pre-existing pre-eclampsia.

4. Identification of at-risk Patients

The Obstetric Early Warning Score (OEWS) is a standardised tool designed to identify and monitor pregnant women at risk of clinical deterioration, facilitating timely intervention and improving outcomes.⁹ Timely recognition and management of obstetric emergencies are essential for preventing adverse outcomes. The OEWS incorporates a range of clinical parameters, including blood pressure, heart rate, respiratory rate, oxygen saturation, temperature, and symptoms such as chest pain or shortness of breath. Each parameter is assigned a score based on its deviation from normal values or the presence of concerning symptoms. However, consistent adherence to OEWS guidelines can be challenging due to variations in clinical settings and gaps in healthcare provider knowledge, logistical issues, inadequate supervision, poor

healthcare worker -patient ratio in Low- and middle-income countries. Integrating technology-based systems that automatically calculate OEWS using electronic medical records can support more consistent implementation across diverse care environments.¹⁰ Evidence suggests that the use of early warning systems such as OEWS enhances the identification of women at risk of clinical deterioration during pregnancy or the postpartum period.¹¹ This facilitates

early intervention by activating appropriate resources, including rapid response teams and obstetric emergency protocols. Moreover, the OEWS promotes effective communication among healthcare providers by offering a shared framework for assessing maternal acuity. This common language supports timely decision-making regarding interventions and transfers to higher levels of care when necessary.

Table 1: Causes of maternal cardiac arrest

1. Obstetric Causes	- Preeclampsia/ Eclampsia - Placental Abruption - Placental Previa with massive haemorrhage - Postpartum haemorrhage, ex Uterine atony or Uterine rupture - Ruptured Ectopic Pregnancy - Amniotic Fluid Embolism
2. Cardiac Causes	- Arrhythmias, - Myocardial infarction - History of complex congenital heart disease (valvular heart disease, cardiomyopathy, coronary artery disease, connective tissue disorder) - Prior cardiac surgery - Pulmonary hypertension
3. Other Medical Causes	- Sepsis - Electrolyte Imbalance - 5 H & 5 T (Hypoxia, Hypotension, Hypo/Hyperkalaemia, Hypothermia, Thromboembolism (Cardiac, Pulmonary), Tamponade (cardiac), Tension Pneumothorax, Toxicity)
4. Drug related	- Anaphylaxis - Overdose- Magnesium, Oxytocin, Insulin, Opioid overdose, Benzodiazepine - Drug error
5. Trauma related Causes	- Motor vehicle accidents or other traumatic injuries - Blunt abdominal trauma in pregnancy
6. Anaesthesia Related Causes	- Adverse reactions to anaesthesia drugs - Complications during regional anaesthesia, High Neuraxial Block LAST, Drug Error - Loss of airway, aspiration, respiratory depression

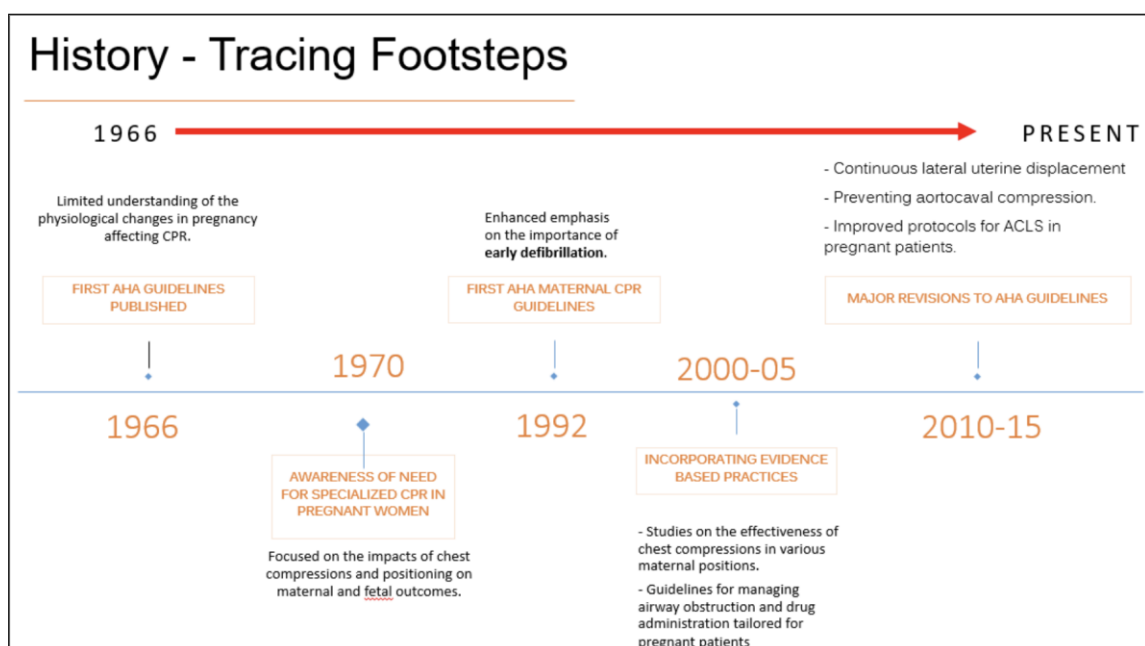


Figure 2: Evolution of AHA guidelines on maternal resuscitation

5. Cardiopulmonary Resuscitation

AHA guidelines on maternal resuscitation have evolved to emphasise pregnancy-specific modifications. (**Figure 2**, **Table 2**). A comparison of maternal resuscitation guidelines issued by AHA, RCOG- UK Green top guidelines and Association of Obstetric Anaesthesiologists, India- An Expert

Committee Consensus Statement and Recommendations has been in **Table 3**. Modifications done specific to pregnant patients include left uterine displacement, early airway management, intravenous access to be preferred at a site above the diaphragm, need for perimortem caesarean section, with a growing focus on team readiness and timely perimortem caesarean delivery (**Figure 3**).

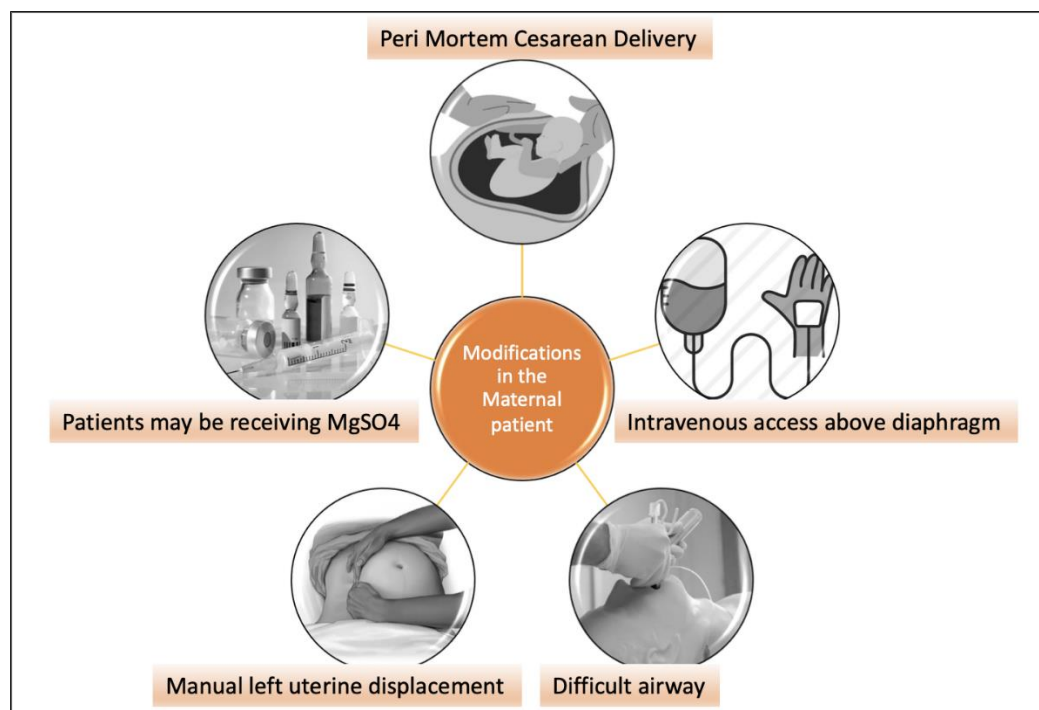


Figure 3: Modifications in Maternal Resuscitation. Key considerations during maternal resuscitation include peri-mortem caesarean delivery, intravenous access above the diaphragm, airway management, manual left uterine displacement, ongoing magnesium therapy, and adjustments for pregnancy-related physiological changes.

Table 2: Comparison of AHA 2015 vs 2020 guidelines: Cardiac arrest in pregnancy

Component	AHA 2015 Guidelines	AHA 2020 Guidelines	Remarks
Manual Left Uterine Displacement	Strongly recommended to relieve aortocaval compression during resuscitation	Continues to be strongly recommended	No change
Airway Management	Emphasized early airway control, as aspiration risk is high in pregnancy	Further emphasized; importance of skilled provider for difficult airway acknowledged	Reinforcement with focus on difficult airway risk
IV Access	Recommended upper extremity IV access above diaphragm	Reinforced recommendation	No change
Perimortem Caesarean Delivery (PMCD)	Recommended if no ROSC by 4 minutes; perform delivery by 5 minutes	Recommendation unchanged; reinforced importance of early PMCD	Emphasis on time-critical action remains unchanged
Use of Magnesium Sulfate	Not specifically addressed	Acknowledge use in preeclampsia/eclampsia; monitor for toxicity	New consideration based on obstetric practice
Foetal Monitoring During Arrest	Not addressed	Explicitly not recommended during cardiac arrest	New addition to avoid distractions from maternal care

Table 2 Continued...			
Targeted Temperature Management (TTM)	Not specified for pregnant women	Pregnant patients should receive TTM as per non-pregnant protocols	New specific recommendation
Multidisciplinary Approach	Encouraged	Reinforced with importance of obstetric and neonatal consults	Stronger emphasis on coordinated care
Post-ROSC Care	Limited guidance	Emphasis on maternal stabilization and individualized neonatal considerations	Expanded post-arrest management guidance
Foetal Consideration Post-ROSC	Not detailed	Continuous foetal monitoring and individualized delivery planning during TTM encouraged	New focus on foetal well-being post-ROSC
Resuscitation Team Training	Recommended interdisciplinary training	Continued recommendation with emphasis on simulation-based training	Stronger push for training and preparedness

AHA: American Heart Association, IV: Intravenous, ROSC: Return of spontaneous circulation

Table 3: Comparison of maternal resuscitation guidelines issued by AHA, RCOG and AOA

Aspect	AHA (2020)	RCOG-UK (2011, updated 2019)	AOA India (2022)
Primary Reference	AHA 2020 CPR and ECC guidelines	Green-top Guideline No. 56	Association of Obstetric Anesthesiologists, India- An Expert Committee Consensus Statement and Recommendations for the Management of Maternal Cardiac Arrest (2022)
Uterine displacement	Manual left uterine displacement (LUD) recommended from >20 weeks	Tilt or LUD mandatory >20 weeks	LUD emphasized as critical; tilt not preferred
Chest compression modification	Standard hand position; perform compressions as per non-pregnant guidelines	Same as non-pregnant, with early LUD	Same as standard; importance of LUD
Defibrillation	Standard energy doses; no modification	No change in defibrillation energy	No change in defibrillation; rapid deployment encouraged
Airway management	Early intubation by experienced provider. Provide endotracheal intubation or Supraglottic advanced airway. Anticipate difficult airway	Early airway control emphasized; difficult airway protocols	Early airway control. Experienced anaesthetist should perform intubation. Smaller size tube should be preferred.
Perimortem Caesarean delivery (PMCD)/Resuscitative Hysterotomy (RH)	If no ROSC in 5 min, consider immediate PMCD	Uses term “Perimortem caesarean section (PMCS).” If there is no response to CPR within 4 min, consider RH. Ideally, this should be achieved within 5 minutes of the collapse.	Uses term PMCS or RH or Resuscitative uterine intervention (RUI). 5-min rule, but stress on team readiness & role allocation
ECMO/advanced support	ECMO may be considered in specialized centre	Not mentioned	Recommends ECMO consideration in high-resource settings

Table 3 Continued...

Reversible causes focus	Standard 5Hs & 5Ts, plus pregnancy-specific causes	Emphasis on haemorrhage, preeclampsia/eclampsia, sepsis	Detailed pregnancy-specific reversible causes included
Team approach	Multidisciplinary team, code blue obstetric team suggested	Obstetric emergency team; early escalation	Pre-defined maternal code team recommended
Training	Strongly encouraged	Strongly encouraged, Small-group multidisciplinary interactive practical training,	Emphasis In-hospital mock drills, repeated practice at workshop
Transport & location of resuscitation	Resuscitate in place, move only after ROSC or PMCD	Similar; prompt transfer to appropriate place only after ROSC following PMCS.	Do not delay RH for transfer to OR; bedside RH encouraged
Medications	Same ACLS drug doses	Same as ACLS drug recommendations	Same as ACLS drug recommendations.

AHA: American Heart Association, RCOG-UK: Royal College of Obstetrician

5.1. Chest compressions

Ideally, a dedicated “maternal code blue” team should be activated, comprising adult resuscitation, obstetric, and neonatal teams.¹² In the event of cardiac arrest, immediate chest compressions should be initiated at a rate of 100–120 per minute, with a depth of at least 5 cm.¹³ The latest RCOG guidelines recommend following an ABCDE approach to maternal collapse.¹⁴ The person performing compressions should be rotated every two minutes to prevent fatigue.¹³ Previously, the Society of Obstetric Anaesthesia and Perinatology (SOAP) recommended placing hands 2–3 cm higher on the sternum, based on the theory that the gravid uterus shifts the thoracic cavity upwards.¹⁵ However, recent American Heart Association (AHA) and Indian guidelines now advise using the same hand position as in non-pregnant patients, on the lower half of the sternum.

5.2. Airway and ventilation

Supplemental oxygen must be provided immediately upon recognising maternal collapse. For patients without an advanced airway, ventilation should be delivered via face mask with two breaths for every 30 chest compressions. Nasopharyngeal airways are best avoided due to the increased risk of epistaxis in pregnant women.¹⁶ Pregnant patients are considered at higher risk of difficult airway due to anatomical and physiological changes in pregnancy, with the incidence of difficult intubation estimated at 1 in 250 cases.¹⁷ A cuffed endotracheal tube is preferred due to the heightened risk of aspiration. The Society of Obstetric Anaesthesia and Perinatology recommends using a video laryngoscope at the first intubation attempt.¹⁸ Cricoid pressure is no longer deemed essential despite the increased aspiration risk.¹⁵ According to the latest Difficult Airway Society (DAS) guidelines, prompt oxygenation is paramount, achievable with a face mask or a supraglottic airway device. If necessary, this may be followed by front-of-neck access. The recent UK-based NAP4 study concluded that surgical tracheostomy is more effective than cannula cricothyrotomy; hence, resuscitation providers should be proficient in surgical airway techniques.¹⁹ Involvement of a skilled, senior

anaesthetist at an early stage is strongly recommended.¹⁴ Waveform capnography should be used to confirm endotracheal tube placement and assess chest compressions' quality. An end-tidal CO₂ (ETCO₂) level exceeding 10 mmHg or a rapid, sustained rise can suggest ROSC. Once an advanced airway is secured, the recommended ventilation rate is one breath every six seconds (i.e., 10 breaths per minute) while chest compressions are continued.¹³

5.3. Left uterine displacement (LUD)

The enlarged uterus can compress the aorta and vena cava, leading to decreased venous return and cardiac output, which diminishes the effectiveness of chest compressions. To mitigate this, left uterine displacement is advised in maternal cardiac arrest when the gestational age is beyond 20 weeks.³ However, it is essential to note that LUD should be provided for any gravid uterus that is clinically large enough to cause aortocaval compression, not strictly based on gestational age.¹⁵ Manual displacement is preferred over tilting the bed, as the latter can interfere with effective chest compressions. The ‘up, off, and over’ technique is recommended, wherein the provider stands on the mother's right side, placing one hand underneath the uterus and the other to push it upwards and to the left.²⁰ Alternatively, the provider can displace the uterus by pushing it from the right side towards the left. If manual displacement is not feasible, a left lateral tilt of 15–30 degrees may be used, provided the patient is on a firm surface.²⁰ Simulation studies suggest that using a backboard reduces mattress compression and enhances chest wall recoil during compressions.²¹ Nevertheless, studies have shown that initiation of LUD is often overlooked in maternal resuscitation.¹⁵

5.4. Defibrillation

Defibrillation in pregnancy follows the same protocols and energy settings as for non-pregnant patients. The “peri-shock pause” should be kept to a minimum—ideally under five seconds.¹⁵ Chest compressions should resume immediately after shock delivery without pausing to check for a pulse. Paddle placement should be such that one is placed above the

right breast and the other below the left breast.¹² An automated external defibrillator (AED) is also encouraged where available.¹⁵ Any foetal monitoring devices, whether internal or external, should be removed or disconnected before shock delivery, due to the theoretical risk of shock transmission to the foetus. However, time should not be wasted on removing these devices if it delays defibrillation.¹⁵

5.5. Miscellaneous

Caution is advised during aggressive fluid resuscitation, particularly in patients with pre-existing pre-eclampsia, where fluid overload can lead to further complications.²²

6. Peri-mortem Caesarean Delivery (PMCD)/ Resuscitative Hysterotomy (RH)

PMCD term has been renamed as resuscitative hysterotomy (RH), which, as the name implies, is a resuscitative surgical manoeuvre on the uterus to deliver the fetus.²³ According to the latest American Heart Association (AHA) guidelines, there is a Class I recommendation to perform a RH in pregnant patients who experience cardiac arrest and do not achieve return of spontaneous circulation (ROSC), particularly when the fundal height is at or above the level of the umbilicus.¹³ The literature reported 188 cases up to 1986, with an additional 38 cases between 1986 and 2004 and 94 cases identified between 1980 and 2010 in another review.^{23,24} Maternal survival rates following RH range from 43% to 54%, while foetal survival varies between 0% and 89%.²⁴ Notably, no published reports have documented a deterioration in maternal condition as a direct result of RH.³

RH necessitates a coordinated, multidisciplinary approach involving resuscitation, obstetric, and neonatal teams. Removing the foetus can improve maternal cardiac output by up to 60% by alleviating aortocaval compression.²⁵

Additionally, it facilitates more effective chest compressions and enhances respiratory mechanics.

From a foetal perspective, RH reduces the risk of anoxic brain injury, which can occur within 4 to 6 minutes of circulatory arrest.³ Importantly, RH should be both mother- and baby-centred; both outcomes should be considered. In line with this approach, the term resuscitative hysterotomy is increasingly being used in place of RH to reflect the dual focus. The fundamental steps of RH are illustrated in the accompanying figure. Ideally, RH should be performed by an experienced obstetrician. While informed consent is preferable, the doctrine of the patient's 'best interest' applies in an emergency. There are no known reports in the United States of legal action taken against a physician for performing RH without consent in such scenarios.²⁵ For in-hospital cardiac arrests, time should not be wasted transferring the patient to an operating theatre. Instead, the procedure should be carried out at the site of collapse. Evidence suggests that on-site RH is associated with a maternal survival rate of 72%, compared to 36% when the patient is transferred before delivery.¹² Regarding surgical technique, either a midline vertical or a suprapubic transverse incision may be used, depending on the operator's expertise. Guidelines emphasise that no additional time should be spent on creating a sterile field before commencing the procedure.¹³ If necessary, an antiseptic solution can be poured over the abdomen. Following RH, oxytocin, if administered, should be used cautiously due to its potential adverse haemodynamic effects.³

7. Resuscitative Drugs and Equipment for Cardio-Pulmonary Resuscitation

Commonly used drugs in maternal cardiac arrest resuscitation are listed in **Table 4**.

Table 4: Pharmacologic agents in maternal cardiac arrest management

Drug	Indication	Dosage & Key Notes
Epinephrine	Cardiac arrest during pregnancy	1 mg IV/IO every 3–5 minutes. Use IV access above diaphragm to avoid aortocaval compression. If IV not possible, use IO (e.g., proximal humerus).
Amiodarone	Shockable rhythm unresponsive to defibrillation	300 mg IV bolus, followed by 150 mg IV if needed.
Naloxone	Suspected opioid overdose	0.4–0.8 mg IV, repeat every 2–3 minutes as needed.
Tranexamic Acid	Maternal collapse due to massive haemorrhage	1 g IV. Proven to reduce bleeding-related mortality (WOMAN trial). No adverse effects noted.
Calcium Gluconate	Magnesium toxicity (seen with MgSO ₄ use in pre-eclampsia)	10 ml of calcium gluconate or calcium chloride IV. Treats ECG changes, muscle weakness, or respiratory depression.
Intralipid 20%	Local anaesthetic systemic toxicity (LAST)	Initial bolus: 1.5 ml/kg IV. Continuous infusion: 0.25 ml/kg/min. If no response, consider ECMO or cardiopulmonary bypass. Should be part of obstetric emergency drug kits.
Uterotonics	To manage postpartum uterine atony	Use oxytocin with caution in haemodynamically unstable patients—may cause tachycardia and hypotension.

7.1. Equipments

A dedicated set of equipment essential for managing maternal collapse and resuscitation should always be readily available in areas identified as high-risk. This equipment should include items necessary for maternal resuscitative efforts and obstetric interventions (**Figure 4**)

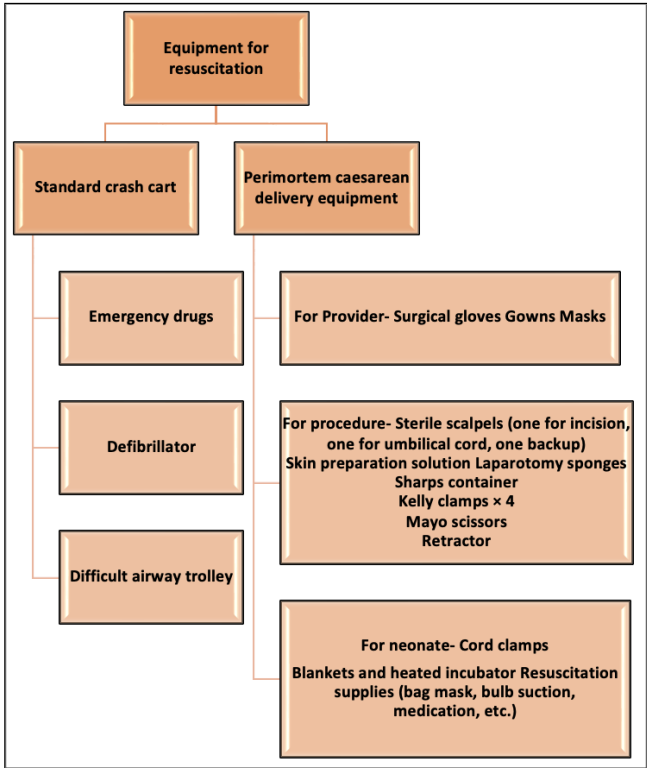


Figure 4: Equipment Required for Maternal Resuscitation and Perimortem Caesarean Delivery. This diagram outlines essential resuscitation equipment, including a standard crash cart with emergency drugs, defibrillator, difficult airway trolley, and specific tools for perimortem caesarean

7.2. Role of point of care ultrasound (POCUS)

POCUS serves as a valuable tool in evaluating potentially reversible causes of cardiac arrest, including hypovolaemia, pulmonary embolism, unrecognised cardiac disease, pericardial effusion, myocardial infarction, and cardiomyopathy.²⁵ When positioned on the chest, the ultrasound transducer can help identify the optimal cardiac window before briefly pausing chest compressions. POCUS can also be effectively integrated into the management of maternal cardiac arrest, enabling more targeted interventions. For instance, the presence of abdominal free fluid on ultrasound may indicate a ruptured ectopic pregnancy or uterine rupture, thereby guiding clinical decisions if ROSC is achieved. Additionally, POCUS may assist in assessing the diameter of the inferior vena cava to evaluate fluid status in postpartum haemorrhage (PPH) or estimate intracranial pressure (ICP) in cases of eclampsia by measuring the optic nerve sheath diameter. However, it is crucial to use the correct technique and ensure that imaging does not delay life-saving chest compressions. Several POCUS protocols have

been developed specifically for cardiac arrest scenarios, including Cardiac Arrest Sonographic Assessment (CASA), Cardiac Arrest Ultrasound Examination (CAUSE), and Core Ultrasound in Resuscitation (CURE).²⁸

Similarly, transoesophageal echocardiography (TEE) may assist in identifying major pathologies such as coronary artery dissection, regional wall motion abnormalities, aortic dissection, pericardial or pleural effusions, pulmonary embolism, and ventricular thrombi. It may also support the accurate placement of cannula for extracorporeal membrane oxygenation (ECMO).²⁹

7.3. Role of ECMO

Extracorporeal Membrane Oxygenation (ECMO) is a rescue treatment that plays a vital role in maternal resuscitation. It can offer life-saving cardiac and/or respiratory support in patients suffering from conditions such as ARDS, cardiac arrest, or amniotic fluid embolism.³⁰ Indications may vary during antenatal and postpartum phases. An experienced multidisciplinary team approach (including obstetricians, maternal fetal medicine specialists, neonatologists, anaesthesiologists, intensivists, cardiothoracic surgeons, perfusionists, and specialized nurses) is crucial. While ECMO has proven to improve maternal survival by up to 75–88% and also favourable fetal outcomes (65–84%), concerns include bleeding, thromboembolism, and premature birth. Management requires careful adjustments according to pregnancy physiology and multidisciplinary planning to optimize uteroplacental perfusion and minimize complications.³¹

Maternal resuscitation algorithm incorporating POCUS and ECMO/ECPR, highlighting immediate actions, obstetric tasks and escalation to ECMO if arrest persists has been shown in **Figure 5**.

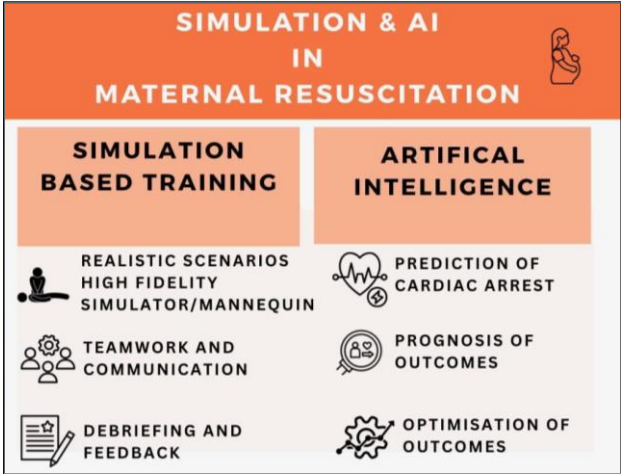


Figure 5: Simulation and AI integration in maternal cardiac arrest management: Enhancing team preparedness, decision-making, and real-time clinical support through predictive modelling and immersive training environments

8. Neonatal Outcomes

Neonatal outcomes following maternal collapse depend on several factors, including the underlying cause of the collapse, gestational age, and the timeliness and quality of emergency care. Survival rates are notably poorer when maternal collapse occurs outside the hospital setting.³² Due to the scarcity of large-scale population data, accurately predicting neonatal outcomes in such cases remains challenging. A review of maternal cardiac arrest and RH highlighted that shorter intervals between cardiac arrest and delivery are associated with improved neonatal survival.³¹ Notably, neonatal survival was observed only in cases where maternal cardiac arrest occurred in hospital. However, there have been reports of neonatal survival even when RH was performed as late as 30 minutes after the maternal arrest.³³

In rare cases of maternal brain death, prolonged somatic support has been shown to facilitate positive neonatal outcomes. A systematic review of 35 cases of maternal brain death at an average gestational age of 20 weeks found that somatic support continued for an average of seven weeks, resulting in 77% of neonates being born alive, with 85% of those infants demonstrating normal development at 20 months.³⁴ Even in out-of-hospital cardiac arrests, favourable neonatal outcomes are possible if maternal collapse is recognised early and resuscitative efforts are initiated promptly.³⁵ However, the extreme rarity and unpredictability of cardiopulmonary arrest during pregnancy make it difficult to establish definitive patterns or prognostic indicators for neonatal outcomes in these scenarios.

9. Simulation and AI in Maternal Resuscitation: Enhancing Preparedness for Critical Events

MCA is an uncommon yet highly critical emergency where every second counts. Given its rarity, many healthcare professionals, particularly trainees, may never encounter such events during routine clinical practice.³⁶ Simulation-based education & training has emerged as an essential tool to prepare clinicians for this high-stakes scenario.⁴

Simulation-based training, primarily when high-fidelity mannequins and realistic scenarios are employed, allows teams to practice life-saving interventions in a controlled environment.² It promotes familiarity with measures such as perimortem cesarean delivery, chest compressions, and advanced airway management in pregnant patients. Shields and colleagues validated an obstetric life support curriculum and found that participants showed considerable knowledge, skill proficiency, and self-confidence improvements. The course also achieved a pass rate of over 96% on structured resuscitation assessments.³⁷

Key elements of simulation-based training are realistic scenarios, teamwork & communication, and the main focus is on debriefing & feedback. Zhang et al. demonstrated that training with the SimMan intelligent platform led to faster response times, improved chest compression continuity, and

better overall coordination among team members.³⁸ Structured scenarios encourage learners to practice rapid decision-making, clear role assignment, and synchronized effort—key elements for successful maternal resuscitation.

Simulation also promotes and strengthens conceptual understanding. A study by Alimena et al. showed that after just one session, trainees were markedly more accurate in identifying the correct gestational age for resuscitative cesarean (≥ 20 weeks) and the appropriate setting for performing it (bedside rather than operating room). Participants also reported a significant increase in confidence levels and expressed strong support for making such training a regular part of residency education.⁴

Moreover, simulation-based training can fulfil a crucial educational gap in the resuscitation of a pregnant patient. Despite the increasing prevalence of complicated pregnancies, many residency programs may lack structured training in the management of maternal cardiac arrest.^{39,40} Simulation offers a reliable way to prepare a multidisciplinary team of obstetricians, anaesthesiologists, emergency physicians, and intensivists—without compromising patient safety.^{37,41}

Artificial Intelligence (AI) adds a new dimension to the resuscitation I. AI technologies have shown promise in identifying early warning signs of cardiac arrest, optimizing dispatch decisions, and predicting post-resuscitation outcomes. In a large scoping review, AI-driven systems outperformed traditional tools in detecting life-threatening arrhythmias, guiding the deployment of defibrillators via drones, and supporting clinical decision-making based on real-time physiological data.⁴²

Together, simulation and AI provide a powerful combination. Simulation prepares clinicians to respond effectively in real-time, while AI enhances early detection, streamlines logistics, and supports outcome-based decisions. Integrating both into obstetric emergency preparedness has the potential to significantly improve survival rates and neurological outcomes for both mothers and newborns.

10. Conclusion

Maternal resuscitation in the antenatal phase is a critical process that necessitates specialised knowledge, skills, and coordinated teamwork to ensure the survival of both the mother and the fetus. Despite improvement in guidelines and training, gaps in preparedness and inconsistent application of the knowledge persist. Highlighting the importance of standardised, simulation-based training programs can greatly enhance the skills and confidence of healthcare providers, consequently improving outcomes. Ongoing research, education, and commitment to evidence-based protocols are crucial to reduce preventable maternal deaths and also optimise care in these critical situations.

11. Source of Funding

None.

12. Conflict of Interest

None.

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