

Management of pregnancy and obstetric complications in prehospital trauma care: prehospital resuscitative hysterotomy/perimortem caesarean section

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ABSTRACT

The need for prehospital resuscitative hysterotomy/perimortem caesarean section is rare. The procedures can be daunting and clinically challenging for practitioners. Maternal death can be averted by swift and decisive action. This guideline serves to inform prehospital practitioners about conducting maternal resuscitation following cardiac arrest, provides an evidence-based framework to support decision making and highlights areas for improvement in prehospital care.

INTRODUCTION

Performing ‘resuscitative hysterotomy/perimortem caesarean section’ (RH/PMCS) can be a daunting prospect for any healthcare professional, including experienced obstetricians. Success may save a family, yet failure or failure to act may mean the loss of two lives. The rarity of maternal cardiac arrest, 1 in 30 000 pregnancies,^{1,2} means the likelihood of encountering such a case is limited to once in a career. Yet the speed of decision making is likely to be critical in determining the outcome.

There are historical descriptions of perimortem fetal extractions, thought to be dated as early as 715 BC, when Roman King Numa Pompilius decreed ‘no child should be buried within its mother’.³ In 1982, the neurologically intact survival of a mother and child after caesarean section following 20 min of cardiopulmonary resuscitation (CPR) during an inhospital cardiac arrest was the first recorded case in modern literature.⁴

Worldwide, especially from North American literature, trauma is reported as the leading cause of indirect maternal mortality and of fetal demise.⁵ Traumatic cardiac arrest is associated with poor clinical outcome, and unfortunately survival rates remain very low.^{6,7}

Indirect maternal mortality causes in the UK, as listed in the Confidential Enquiry into Maternal Death and Morbidity, have repeatedly been identified to be cardiac disease, followed by psychiatric causes and influenza.⁸ However, the UK trauma registry information demonstrates 1% of female patients with trauma of childbearing age are pregnant at the time of injury and have a higher mortality rate.⁹

Resuscitation algorithms during cardiac arrest are the same in many respects for pregnant and non-pregnant patients. The anatomical and

physiological modifications of late-term pregnant women mean a heightened need for protection of the airway from aspiration of gastric contents and to relieve uterine caval compression.

CPR, through precordial compressions, in pregnant patients only generates 10%–30% of normal cardiac output, and it can be very difficult to achieve perfusion of vital organs.^{10,11}

CPR has the potential to be significantly more effective following emptying of the gravid uterus. Profound changes in cardiovascular physiology occur during pregnancy. In particular, uterine blood flow, as a percentage of cardiac output, increases from 2% in the non-pregnant state to 18% during the third trimester.^{12,13} Emptying of the uterus following normal delivery results in a 60%–80% decrease in the cardiac output requirement of the uterus, but following caesarean section this is closer to a 30% decrease. Emptying the uterus also serves to relieve the deleterious effects of caval compression. Therefore, an increased likelihood of maternal survival is achieved from the improved vital circulatory volume and increased cardiac output following delivery of the baby.¹⁴

‘Resuscitative hysterotomy’ (RH) is the term used for the procedure throughout this document to highlight the integral nature of the procedure following maternal cardiac arrest, akin to resuscitative thoracotomy for penetrating thoracic injury. RH is synonymous with the term ‘perimortem caesarean section’ (PMCS). The procedure is intended for maternal benefit only following maternal cardiac arrest.

There is limited evidence pertaining to the specific management of pregnant patients during cardiac arrest. Therefore, scrutiny and distillation of available literature, together with expert opinion, have been used to develop these recommendations for prehospital environment to serve as a guide in the rare but stressful event of traumatic cardiac arrest during pregnancy.

Definition of pregnancy in prehospital trauma care

When encountering a female patient with trauma between the ages of 10 and 55 years old, the potential of pregnancy must be considered. If pregnancy has been confirmed, the gestational age should be sought and relayed in further communications. Pregnancy greater than 20 weeks' gestation will considerably alter trauma care management.



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Table 1 Levels of evidence

Level of evidence	Type of evidence
Ia	Evidence from systematic reviews or meta-analysis of randomised controlled trials
Ib	Evidence from at least one randomised controlled trial
IIa	Evidence from at least one controlled study without randomisation
IIb	Evidence from at least one other type of quasi-experimental study
III	Evidence from non-experimental descriptive studies such as comparative studies, correlation studies and case-control studies
IV	Evidence from expert committee reports or opinions and/or clinical experience of respected authorities

Applicability of recommendations in prehospital trauma care

Due to the varying levels of healthcare personnel delivering prehospital care services,¹⁵ this set of recommendations should not serve to contravene practitioners' qualifications or scope of practice. A number of recommendations pertain to invasive or advanced procedures and may only be applicable to higher level practitioners. Yet all practitioners should be aware of these recommendations and understand the implications for management, in particular when senior support is required or when care should be expedited. Practitioners, irrespective of level, should endeavour to achieve best practice within their scope of practice and should be able to justify actions, if they should be contrary to the agreed recommendations.

METHODS

A review of the literature was undertaken prior to the consensus meeting, and information was distributed to panel members. Literature was compiled from searches of the Medline database, PubMed and Google Scholar, along with reference to international guideline documents. Search terms included: *Pregnancy, Obstetrics, Trauma, Injury, Fracture, Haemorrhage, Peri-mortem Caesarean Section and Resuscitative Hysterotomy*.

Hierarchy of evidence¹⁶ is applied to the level of recommendations and the underlying literature justifying each statement, in accordance with the information displayed in tables 1 and 2.

RECOMMENDATIONS

1. *RH/PMCS should only be performed following maternal cardiac arrest in pregnancy of gestational age assessed greater than 20 weeks (grade D).*

The potential physiological and haemodynamic benefits conferred by emptying the uterus, outlined above, are only clinically relevant for pregnancies of gestational age greater than 20 weeks. There has not been shown to be an association between gestation age and maternal survival following maternal cardiac arrest¹⁷ (level III). Management of the pregnant patient with

trauma should only be altered when the gestation is evaluated to be greater than 20 weeks. Uterine fundal height at or above the level of the umbilicus should be used to determine gestation of a pregnancy greater than 20 weeks, in the absence of a confirmed history. Further guidance regarding management of pregnant patients with trauma can be found in the accompanying article 'Management of Pregnancy and Obstetric Complications in Pre-Hospital Trauma Care'¹⁹ (level IV). Pregnancy <20 weeks should be treated as per local guidelines or standard operating procedures (SOPs).

2. *RH/PMCS should only be performed following maternal cardiac arrest when resuscitation efforts are deemed appropriate (grade D).*

Despite the ability of the prehospital practitioner to arrive on the scene fast, performing highly invasive procedures on a patient without signs of life for an undetermined period may be deemed inappropriate. Should the cause of maternal cardiac arrest be determined to be irreversible or ongoing resuscitation considered futile, RH/PMCS is not recommended.

The procedure is not without risks because of the physical hazards of needle stick/sharp injury and of the psychological impact on practitioners and bystanders. Also, consideration must be given for the dignity of the patient. If no clinical benefit can potentially be gained or a poor outcome is likely, following return of spontaneous circulation (ROSC) after RH/PMCS, these risks must be considered (level IV). Extreme care is required when RH/PMCS is to be performed with simultaneous closed chest cardiac compressions due to the risk of iatrogenic injury to the patient or prehospital practitioners.

3. *RH/PMCS should only be performed after the correction of the causes of maternal cardiac arrest, treatable in prehospital care (grade D).*

This recommendation recognises the limitations within the prehospital setting for the definitive correction of all causes of cardiac arrest, traumatic or non-traumatic. A primary survey should be completed rapidly prior to performing RH/PMCS. Vascular access should be rapidly achieved, as per Faculty of Pre-Hospital Care recommendations for pregnant patients, prior to RH/PMCS, as this will be essential in the event of ROSC.

Following traumatic maternal cardiac arrest, RH/PMCS should be considered as part of the circulatory system assessment and correction of hypovolaemia. RH/PMCS should therefore be performed after; catastrophic haemorrhage is controlled, and airway patency is established, plus tension pneumothorax and cardiac tamponade are excluded (see Management algorithm section).

Following non-traumatic maternal cardiac arrest, advanced life support should be commenced as appropriate and RH/PMCS completed urgently, if advanced life support has not achieved ROSC after 4 min (see below for further details regarding timing).

4. *RH/PMCS should only be performed by a practitioner with requisite equipment, competence and confidence to carry out the procedure appropriately (grade D).*

The need for appropriate equipment, including personal protective equipment (PPE), and adequately trained personnel is mandatory. Organisations and individual practitioners are recommended to carry, and be familiar with the use of, equipment to perform RH/PMCS. Procedural training is recommended for those involved with prehospital care. Also, practitioners' discretion is very important when deciding whether or not to perform RH/PMCS. Although the potential for increased survival from maternal cardiac arrest is theorised, evidential support is limited. If practitioners should feel unable to

Table 2 Grades of evidence

Grade of recommendation	Type of evidence
A	Based on hierarchy I evidence
B	Based on hierarchy II evidence or extrapolated from hierarchy I evidence
C	Based on hierarchy III evidence or extrapolated from hierarchy I or II evidence
D	Directly based on hierarchy IV evidence or extrapolated from hierarchy I, II or III evidence

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perform RH/PMCS, they should be supported in their decision and endeavour to continue resuscitative efforts. Taking into account significant biases, confounding factors and the authors' self-described tendency towards conservatism, higher maternal mortality is observed in those patients in whom RH/PMCS had been performed¹⁷ (level III). The true relationship between RH/PMCS and maternal survival remains unclear.

5. RH/PMCS should only be performed if a chain of survival exists for definitive management of the patient (grade D).

Should ROSC be achieved, the patient will require prehospital anaesthesia and a minimum surgical closure or packing of the abdomen. Major haemorrhage is likely as a result of RH/PMCS following ROSC. Haemostatic dressings and tranexamic acid (TXA) should be administered as appropriate. Emergent surgical care will be required as part of the definitive management and rapid transportation to an appropriate facility is required immediately. If this level of care cannot be reasonably provided, the futility of RH/PMCS and associated risks must be considered prior to performing the procedure (level IV).

6. Whenever possible, RH/PMCS should be performed after maternal cardiac arrest if there is no ROSC following 4 min of active CPR. Emptying the uterus may still be helpful beyond this time and should be performed as long as resuscitation attempts are continuing following cardiac arrest (grade D).

Maternal survival is associated with the timing of RH/PMCS¹⁷ (level III). To maximise the benefit of the procedure, the recommendation is given for resuscitation efforts to be initiated immediately following maternal cardiac arrest and the order to 'prepare for RH/PMCS' to be given. The optimal time period has been difficult to determine, but the long-held '4 min rule' has been the goalpost for the duration between arrest and initiation of RH/PMCS. This is based on the physiological tolerance of cerebral hypoperfusion to minimise poor outcomes. Ideally, RH/PMCS should be completed within 5 min from maternal cardiac arrest and should not be unduly delayed.¹⁸ Yet this time frame has been shown to be difficult to achieve, and a very small proportion of cases are completed in this time frame¹⁷ (level III). In the majority of reported cases achieving ROSC, RH/PMCS was performed 10 min after the time of arrest, but have occurred even up to 60 min. Also, the majority of reported cases occur inhospital and were rarely following traumatic cardiac arrest¹⁷ (level III). The ideal time target does not reflect the diagnostic and logistic challenges of prehospital trauma care¹⁷ (level III). Therefore, RH/PMCS should be completed as soon as possible and should not be unduly delayed, except to confirm the appropriateness here outlined.

Following cardiac arrest, few maternal survivors have been recorded after 15 min of resuscitation in the prehospital setting, with or without RH/PMCS¹⁷ (level III). Evaluation must be made on an individual case basis in the prehospital environment regarding the rapidity with which to perform the procedure. If strong clinical indication to continue the resuscitation effort is ongoing, beyond 15 min from maternal cardiac arrest, RH/PMCS should be completed to optimise cardiovascular physiology, but caution is given.

7. RH/PMCS is recommended to be performed through a vertical midline laparotomy incision (grade D).

The use of a vertical midline laparotomy incision will maximise exposure and allow the greatest access to facilitate the procedure⁸ (level IV). Care should be taken not to injure the bladder or the bowel. Once the uterus is exposed, a 15 cm anterior incision of the upper segment of the uterus vertically will minimise the risk of iatrogenic fetal injury. The procedure can be completed with the use of a scalpel only¹⁹ (level IV), or

if readily available scissors can be used to complete the uterine incision superiorly and allow the fetus to be extracted⁸ (level IV). The fetus should be delivered from the uterus, either by the hips or the head and shoulders. Avoid attempting to deliver the fetus by the arm or the leg. Once the fetus is extracted, the cord should be dually clamped and divided. The placenta should be left in situ and the abdomen packed, with manual pressure applied, if possible. ROSC is most likely to occur immediately following fetal delivery, as maximal physiological response is seen with emptying of the uterus. Internal cardiac massage or aortic compression/cross-clamping may also be achieved through a vertical midline laparotomy incision.

If ROSC is achieved, administration of sedation/anaesthesia and the management of postpartum haemorrhage will be required, including the administration of uterotonic agents.

8. RH/PMCS should be fully recorded in the medical records and in organisational governance infrastructure (grade A).

Good medical practice dictates the level of documentation for medical practitioners, and reciprocal guidance is provided for allied health professionals. Poor documentation confers potential medicolegal implications, yet contemporaneous record keeping can be difficult and individuals should endeavour to make notes as soon as possible after the event.²⁰ Further to the medicolegal aspects of care, the additional research benefits are imperative to pioneer evidence bases for prehospital care.²¹ It is recommended that organisations produce SOP guidance to aid for prehospital personnel. It is mandatory for all organisations to have in place a formal clinical governance review proceeding to evaluate all cases of RH/PMCS. Organisations should submit information to national governance bodies to aid research efforts in prehospital care.

Further considerations

Fetal Care

Following RH/PMCS, the delivery of a live infant may occur and a clinical decision must be made regarding the resources available.

Fetal survival following RH/PMCS is unfortunately poor. Obstetric literature demonstrates only a 30% survival rate of infants born by RH/PMCS.⁸ The vast majority of which are performed inhospital, not prehospital, and with neonatal resuscitation support. Fetal survival falls to 25% in gestations earlier than 37 weeks and even less in gestations earlier than 32 weeks.⁸ Severe neurological impairment has been reported with fetal survival following maternal cardiac arrest. Positive fetal outcomes can be attained with the practice of RH/PMCS; however, the procedure is intended for maternal benefit only.

If neonatal care can be performed without compromising maternal resuscitation efforts, then it should be conducted as appropriate. If there are insufficient resources or expertise to manage neonatal resuscitation, preservation of dignity is an important achievable aim of neonatal care.

MANAGEMENT ALGORITHM

Figure 1 describes the management algorithm.

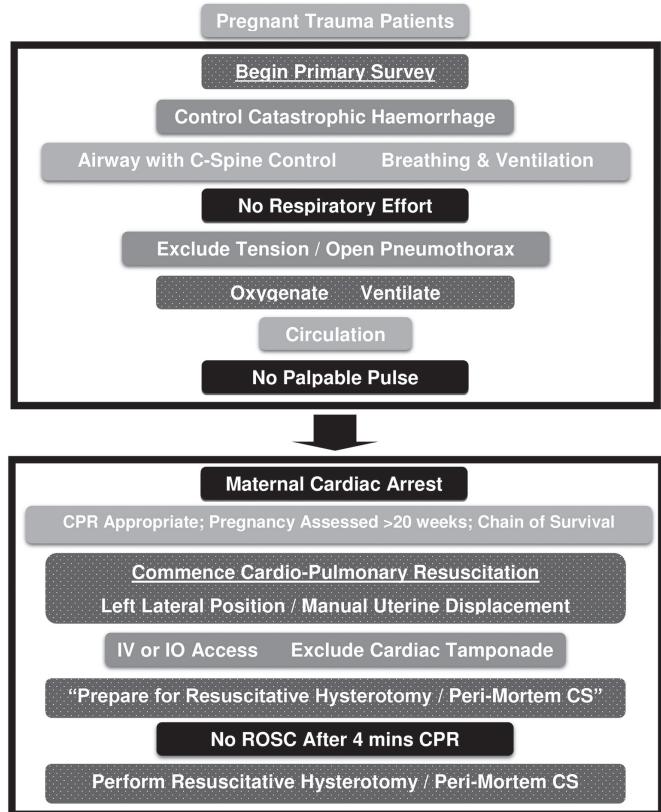
SUMMARY OF RECOMMENDATIONS

For RH/PMCS recommendations, see table 3.

CPR, cardiopulmonary resuscitation; RH/PMCS, resuscitative hysterotomy/perimortem caesarean section.

LIMITATIONS

This guideline is based on the best available evidence concerning prehospital obstetric care. However, a guideline can never be a

**Figure 1** Management algorithm.

substitute for clinical judgement, and there may be cases where it is appropriate for clinicians to be guided according to the needs of individual patients. Furthermore, the responsibility for the care of individual patients rests with the clinician in charge of the patient's

care, and the advice offered in this guideline must, of necessity, be of a general nature and should not be relied on as the only source of advice in the treatment of patients. Literature is limited, with no high evidence level articles available, not requiring extrapolation to draw plausible conclusions or outcomes.

FURTHER RESEARCH

Two main aspects of research are drawn to the front following evaluation of this topic. The primary aspect is for the establishment and maintenance of accurate prehospital registry systems to record such events. As prehospital emergency medicine grows as a specialty, the need for evidence-based practice is essential. The literature to date is awash with singular case reports or series, with elements of vital information often missing, rendering meta-analysis fruitless. Without high level evidence, improvement of practice is hindered in the modern setting. Second, the level of training/preparation for performing RH/PMCS procedures should be evaluated and the merits of simulation explored, with respect to the potential clinical benefits provided.

SUMMARY

The need for prehospital RH/PMCS is rare. The procedures can be daunting for practitioners and clinically challenging. Maternal death can be averted by swift and decisive action. This guideline serves to inform prehospital practitioners about conducting maternal resuscitation following cardiac arrest, provides an evidence-based framework to support decision making and highlights areas for improvement in prehospital care.

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Concepts

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