

Accepted Manuscript

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PII: S0300-9572(18)31099-2
DOI: <https://doi.org/10.1016/j.resuscitation.2018.11.021>
Reference: RESUS 7822

To appear in: *Resuscitation*

Received date: 22 November 2018

Please cite this article as: Hillman SL, Cooper NC, Siassakos D. Born to Survive: A critical review of out-of-hospital maternal cardiac arrests and pre-hospital perimortem caesarean section. *Resuscitation* (2018), <https://doi.org/10.1016/j.resuscitation.2018.11.021>

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Title Born to Survive: A critical review of out-of-hospital maternal cardiac arrests and pre-hospital perimortem caesarean section.

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Word Count 1100

Poor survival rates for out of hospital cardiac arrest during pregnancy may be improved if first emergency responders could perform a perimortem caesarean section (PMCS) followed by temporary analgesia and rapid hospital transfer.

Maternal cardiac arrest is a fortunately rare but often fatal occurrence, with additional challenges for survivors e.g. organ injuries (1). Papers evaluating in-hospital cardiac arrest in pregnant women suggest that odds of survival are higher when compared with non-pregnant controls (2) as long as teams are trained and led well (3,4). Effective resuscitation approaches are, therefore, critical to optimise survival for pregnant women. Less is known about out of hospital maternal cardiac arrests, hereafter referred to as OHCAP. The study by Maurin et al., 2018 (5) adds significant information.

This 5-year retrospective observational study identified OHCAP in 16 of 19,515 patients seen by a two-tiered emergency response system in Paris. 14/16 pregnant women had a cardiac arrest at home and 4/16 were unwitnessed. Overall, only two women were alive at 30 days post-arrest and both had first trimester pregnancies not needing PMCS. This paper provides records of the key features in the chain of survival. Importantly, it highlights the challenge of deciding between rapid transfer to the hospital setting versus prompt PMCS at 4 minutes. In all cases in their study, PMCS occurred after transfer to hospital and outside of the recommended timeframe. The authors acknowledge as limitations of their study the small sample size, inconsistency in aetiology of OHCAP, and variation in time to commencement of CPR. Their study does, however, highlight the challenges of prioritising decision making in OHCAP: resuscitate on the spot, deliver, or transfer immediately?

The findings by Maurin et al. are similar to a Canadian study that also found poor outcomes in six cases with OHCAP. In three women return of spontaneous circulation (ROSC) occurred, but only one (16.7%) woman survived to discharge. The majority of arrests took place in private locations, were associated with non-shockable rhythms, and most women did not receive bystander CPR. PMCS occurred in all cases but with mean time of more than 30 minutes (6). In a UK obstetric surveillance study of 66 maternal cardiac arrests, 16 women collapsed in the community and only two survived. Overall, time to PMCS, often the only way to achieve ROSC, was strongly associated with survival. Time to ROSC was 6 minutes (IQR 4–21) in survivors compared with 50 minutes (IQR 32–57) in women who died ($P < 0.01$) (7).

These studies highlight the challenges with OHCAP. A gravid uterus compresses the aorta and vena cava causing reduction in cardiac output, pronounced at later gestations (8). Although left lateral tilt used to be recognised as a means of overcoming the effects of a gravid uterus, studies have shown poor accuracy in applying a tilt (9). It is important that manual displacement of the uterus, used in preference in pregnant women with uterus at the level of the umbilicus or higher, forms part of BLS training for healthcare providers and members of the public to improve initial resuscitation efforts. However, it is rarely sufficient and a PMCS is often the only way to resuscitate effectively. Re-termining PMCS 'resuscitative hysterotomy' has been recommended to promote the psychology of performing the procedure promptly in maternal best interests.

The 4-minute rule was first introduced in 1987 largely based on a review of existing cases and presumed physiology (10). Subsequent investigation of this central tenet of maternal resuscitation efforts have supported its role in ROSC and improved survival. A 2005 review of 38 cases of PMCS reported ROSC in 14 (8 PMCS done within 5 minutes) of which 13 women were discharged home in good condition (survival rate 34%). Delay was almost universal in cases of OHCAP (11). A subsequent review of all reported cases (n=94) of maternal cardiac arrest between 1980 and 2012 has borne out improved survival, with ROSC in 60% and PMCS in the majority of viable pregnancies (87.2%, 76/86). However, an average time to delivery of 17 minutes was noted, with only 4 cases performed in the first 4-minutes (12). Maurin et al. identified time delay as an adverse factor with the median transfer time to hospital 94 minutes in their study.

Given poor compliance of the 4-minute rule even in the hospital setting, and the recognised time delays in OHCAP, attention must focus on improved access to PMCS. Better awareness for resuscitation teams about the benefit of performing a PMCS as soon as an OHCAP reaches a hospital setting, and improved multidisciplinary and simulated training, are both essential (13). The MOET course teaches about maternal cardiac arrest and PMCS. Data from the Netherlands showed that introduction of this training resulted in a fourfold increase in the rates of PMCS done on pregnant women (n=12) with 2 maternal (17%) and 5 neonatal survivors (14).

For the pre-hospital setting, there are several considerations to implementation of out-of-hospital PMCS. If transport can be completed (e.g. by helicopter) within 4-5 minutes of maternal arrest strong consideration should be made to delaying PMCS until arrival at an environment with obstetric and neonatal support available. In the

field, PMCS have been performed (15) although not routinely recommended. However, with appropriate training for emergency first responders becoming increasingly available (16) it might be time pre-hospital PMCS are revisited. A 2016 statement from MOET emphasized that all professionals with sufficient skills can perform PMCS and 'cannot be criticized for attempting the procedure' (17). The current UK College of Paramedics training syllabus includes maternity care, trauma in pregnancy and resuscitation in pregnancy (18). Analgesia is important upon ROSC, but there are options for providing temporary relief during rapid transfer, for example ketamine and midazolam (19). The aftermath also needs to be addressed and includes complications like postpartum hemorrhage, co-morbidities, and, crucially, consideration to the newborn. If the uterus is at the level of the umbilicus or above, emergency response should include, from the outset, specialised neonatal transfer ambulances.

In summary, we believe the only way to resuscitate effectively pregnant women is by early recognition of cardiac arrest in a woman with a uterus at the umbilicus or above, and resuscitation with manual displacement of the uterus followed by prompt PMCS by a trained paramedic, if immediate transfer to hospital is not possible. Additional guidelines for analgesia, post-ROSC sequelae, as well as the newborn, need to be in place before further consideration of pre-hospital PMCS becomes a routine recommendation. Current evidence supports its role in improving maternal outcomes in OHCAP settings where survival rates are extremely poor. It is time to rethink our approach to out-of-hospital maternal cardiac arrest.

Conflicts of interest

None

Acknowledgments

None

Funding

None

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