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REVIEW

Perimortem caesarean section: A review of the anaesthetist's nightmare

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SUMMARY

A perimortem caesarean section is a rare event, but is gaining more support as an essential part of maternal and foetal resuscitation during maternal cardiac arrest in late pregnancy. The anatomical and physiological changes occurring in pregnancy make resuscitation difficult and require key interventions to improve the outcome for both the mother and child. Specific obstetric resuscitation guidelines are required to raise awareness and for further training. Early recourse to perimortem caesarean section when resuscitation is failing may increase survival and requires a multidisciplinary team trained in maternal and neonatal resuscitation to make appropriate rapid decisions. Key interventions including left uterine displacement, early advanced airway control and perimortem caesarean section should be integral to maternal resuscitation for a good outcome. Simulation training based on specific obstetric resuscitation guidelines should be tailored and adopted by individual centres to facilitate rapid decisions for effective resuscitation, including the performance of a perimortem caesarean section.

1. Introduction

Maternal cardiac arrest is rare but its incidence appears to have increased from the previously quoted 1:30,000 to 1:20,000 pregnancies based on UK CEMACH data and about 14 cases every year in the USA, based on the National registry of CPR data.[1,2] A global incidence is however unknown due to the lack of reliable data and differing epidemiology and standards of perinatal care worldwide. The etiology of maternal cardiac arrest is multifactorial, with preventable causes like haemorrhage and sepsis contributing as the commonest causes of maternal death in developing countries.[3] However, cardiac disease has now become the most common overall cause of maternal cardiac arrest in developed countries like the United Kingdom, exceeding thromboembolism, sepsis and haemorrhage, caused mostly due to sudden adult death syndrome, myocardial infarction, aortic dissection and cardiomyopathy. Preventable lifestyle changes in recent decades like obesity, smoking, older age, diabetes and hypertension have contributed to a higher incidence of ischaemic heart disease leading to myocardial infarction.[4]

Many conditions lead to cardiac arrest during pregnancy and causes may be classified by etiology into: (1) direct causes like eclampsia, haemorrhage, thromboembolism, amniotic fluid embolism; (2) anaesthetic complications like airway disasters or local anaesthetic toxicity; and (3) indirect and unrelated conditions like cardiac disease, sepsis, malignancy and trauma. Diminished maternal reserve usually leads to rapid deterioration during pregnancy and the presence of the foetus may distract the caregiver from giving the mother more attention.

It is known that the management of cardiac arrest in pregnant women is more complicated than in non-pregnant patients due to the anatomical and physiological changes of pregnancy and the presence of a growing foetus and therefore requires a rapid, coordinated and multidisciplinary response to ensure a favourable outcome for both the mother and child. The management includes specific interventions like early airway control, left uterine displacement (LUD) and recourse to early perimortem caesarean section (PMCS).

PMCS refers to an operative delivery performed on a pregnant woman to aid foeto-maternal resuscitation in the event of maternal extremis or cardiac arrest. This is undertaken when cardiopulmonary resuscitation (CPR) has already been initiated and appears to be failing. Neonatal survival is a secondary outcome and is unlikely when the gestational age is less than 24 weeks. Conversely, the closer to term a PMCS is performed, the greater the likelihood of foetal survival.[4] This differs from a postmortem caesarean where the procedure is carried out after the death of the mother to attempt saving the foetus.[4] Timely PMCS has the potential to save the mother and the foetus. However, despite the increasing number of reports of successful maternal and foetal survival from cardiac arrest in literature, the overall survival remains poor, possibly due to the delay in initiating PMCS.

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PMCS is performed to relieve significant aortocaval compression occurring after 20 weeks of gestation. This is due to an increase in the uterine size, causing reduced venous return and consequently the cardiac output, especially in the supine position.[5] Emptying the uterus removes aortocaval compression, resulting in a 60–80% increase in cardiac output, thereby increasing the likelihood of maternal survival.[6] Radiographic studies have confirmed that once the uterus is emptied at caesarean delivery, the vena cava quickly returns to normal.[7]

2. Evidence for specialized obstetric resuscitation and PMCS

There is a lack of clinical trials evaluating the effect of specialized obstetric resuscitation versus standard care in outcomes like return of spontaneous circulation (ROSC) or survival of post-arrest pregnant women. The current advice for pregnancy specific interventions is based on studies in pregnant patients 'not in cardiac arrest'. These studies advocate that knowledge of anatomy, physiology and pharmacology during pregnancy and interventions like LUD and early PMCS play a role in maternal resuscitation.[8]

The relationship between PMCS and maternal outcome still remains unclear. Several case reports of unexpected, dramatic improvements in maternal haemodynamics and survival after PMCS have been reported. However, this may represent a selection bias as only survivals are reported. The quality of CPR also varies and effective CPR with return of palpable pulses may negate the need for a PMCS. Effective CPR with ROSC is underreported.[9]

In the past, there have been conflicting and non-specific resuscitation guidelines for managing cardiac arrest in pregnancy. Newer guidelines and training recommendations for managing cardiac arrest in pregnancy have emerged in recent years, based largely on expert opinion rather than on scientific evidence. Nolan et al., in their recommendations regarding cardiac arrest in pregnancy have commented that 'there exists insufficient evidence to support or refute the use of specialized obstetric resuscitation techniques in maternal cardiac arrest' but they recognized that the treatment should be guided by understanding the physiological changes occurring in pregnancy, increased risk for hypovolaemia, optimal positioning for compressions, releasing aortocaval compression with early recourse to PMCS.[10] The American Heart Association (AHA), European Resuscitation Council (ERC) and training bodies like Major Obstetric Emergencies & Trauma (MOET) and Advanced Life Support In Obstetrics (ALSO) now recommend pregnancy-specific interventions during maternal CPR and include the use of PMCS based on the '4-min rule.' This implies that if no ROSC is evident within 4 min of a cardiac arrest despite ongoing resuscitative efforts, immediate PMCS should be considered, aiming for delivery within 5 min of a cardiac arrest.[1,11,10] CPR should be continued during PMCS.

Einav et al. reviewed all the reported pre-delivery maternal cardiac arrests between 1980 and 2010 and found that a clear maternal benefit was evident in 31.7% of cases that had undergone PMCS. However, they noted that the likelihood of maternal survival despite resuscitation was significantly decreased beyond 10 min of a cardiac arrest. They also found that despite the 4-min rule advocated for PMCS not being met in 93% of the cases, neonatal survival still benefitted in 50% of cases, even in deliveries beyond 10 min of an arrest.[12]

3. Management of cardiac arrest: effects of anatomical and physiological changes of pregnancy on CPR and the role of pregnancy specific interventions

Cardiovascular and respiratory changes in maternal physiology during pregnancy have been shown to influence resuscitation.[13] Resuscitation using BLS and ACLS algorithms should be tailored to the physiological changes of pregnancy.[14]

Active CPR should be in conjunction with a conscious search for reversible causes of maternal collapse. The acronym BEAU-CHOPS (bleeding, embolism, anaesthetic complications, uterine atony, cardiac disease, hypertension, others, placental causes, sepsis) should be considered in the absence of an obvious cause.[1] Simultaneous management of an established cause should be carried out where possible.

In late pregnancy, the growing baby and the uterus splint the diaphragm, with a reduction of around 20% in the FRC, with closing volume encroaching upon normal tidal ventilation, reducing the oxygen reserve. Oxygen consumption is increased by about 20%. Carbon dioxide production is also increased due to a higher metabolic rate of the mother and from the foetus. A compensatory increase in tidal volume, respiratory rate and consequently minute ventilation of almost 50% occurs. Additionally, there may be upper airway oedema, causing airway narrowing. Due to weight gain and breast engorgement, the chest wall becomes heavier and less compliant. Early advanced airway management with endotracheal intubation using cricoid pressure is being recommended in maternal cardiac arrest, as rapid desaturation and hypercarbia occur with alveolar hypoventilation or apnoea. Senior clinicians should be involved in intubation as these patients are also more difficult to ventilate and intubate. Regurgitation and pulmonary aspiration is a significant risk if airway is not quickly secured.

Pregnancy is a high cardiac-output state, primarily because of the demands of the growing foetus, with an almost 50% increase in cardiac output above non-pregnant values. The uterus receives up to 30% of cardiac output at term, compared to 2–3% in a non-pregnant state. This is achieved by a reduction in systemic vascular resistance, with increased resting heart rate, venous return and stroke volume. Maternal blood pressures are also reduced in pregnancy, with SBP 10–15 mmHg lower than pre-pregnancy values. These changes can mask acute blood loss in pregnancy, especially since cardiovascular decompensation is delayed due to increased plasma volume. A loss of 35% blood volume may occur before signs of haemodynamic instability are identified.[15]

Also, supine hypotension syndrome due to aortocaval compression starts to become significant beyond the 20-week gestation, with cardiac output reduced by 30–40% in the supine position by term. This may be worsened due to multiple pregnancy or polyhydramnios; venous return and forward flow are both reduced. In the event of a cardiac arrest, unresolved aortocaval compression may prevent restoration of the cardiac output despite adequate CPR. During CPR, cardiac output is produced by mechanical means with adequate thoracic compression. In the best of circumstances, with the patient supine, cardiopulmonary resuscitation produces a cardiac output 30% of normal.[16] Also, in a term parturient lying supine, the stroke volume is only 30% of a non-parturient due to aortocaval compression.[17] To circumvent aortocaval compression during resuscitation, LUD using a Cardiff Resuscitation Wedge or by other means is recommended.[13] The resuscitative force required for chest compressions varies with the angle of inclination.[18] Rees et al. showed that at a tilt of 27°, the maximum resuscitative force drops to 80% of when supine and at >30° body roll is produced, possibly making chest compressions less effective.[19] A wedge is not easily obtained during cardiac arrest, especially in non acute-care areas. Tilting by other means is grossly underestimated and unreliable.[20] Use of manual uterine displacement has also been recommended and may actually be superior to LUD. The best compromise for CPR and optimal venous return is in the supine position with manual displacement of the uterus to the left.[21]

Chest compressions should follow standard ACLS guidelines, but flared ribs, raised diaphragm, obesity and breast hypertrophy seen