

Peri-Mortem Caesarean Section Delivery: A Literature Review and Comprehensive Overview

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Abstract

Objective

To explain the pathophysiology, indications, techniques and medicolegal implications of perimortem caesarean section delivery (PMCS) and introduce criteria based standards for this operation to improve results.

Methods and Search Design

We conducted an Ovid MEDLINE search for the years 1950-2014 with the following key words: maternal mortality, cardiopulmonary resuscitation, maternal collapse, peri-mortem caesarean section, and cardiac arrest. Citations from bibliographies of identified publications were used as a secondary reference list.

Conclusion

A timely performed PMCS can save the life of a mother and her baby. Awareness of the physiological changes of pregnancy, new advances in resuscitation methods, and proper preparation for a timely surgery, the correct surgical technique, and understanding the medico legal implications are key issues to achieve the goal of maternal and fetal survival. Creation of international and national guidelines and establishment of international and national data base registry with standard improved documentation for these rare events should be considered in order to improve outcomes and provide a more accurate statistically relevant data and results.

Keywords Fetal-maternal survival; Maternal collapse; Perimortem caesarean section; Resuscitation

Synopsis Perimortem caesarean section is associated with high maternal and perinatal mortality and morbidity. Anticipation and timely performed surgery improve maternal and perinatal health and survival.

Introduction

Perimortem caesarean section delivery (PMCS) refers to abdominal delivery in a pregnant woman dying from cardiopulmonary arrest (1:30,000 - 1:53260) [1,2] or maternal collapse (14 to 600/100000 pregnancies) [3]. Either cause is so rare, most obstetricians may be confronted with this situation only once or twice, if ever, in their practice lifetime.

The main sources for currently available data derive from 237 case reports in the English language literature (226 cases reported between 1986 and 2004 [4] and 11 cases, ascertained by the authors between 2004-2014) or from the 151 cases reported between 1955-2008 in the UK confidential enquiries into maternal deaths (the largest population-based data set on PMCS) [5-9].

Neither source is ideal. Underreporting (ascertainment bias) plus publication and selection bias is inherent weakness of the evidence derived from case reports. The confidential enquiries report cases that did not survive and may not supply all relevant data. A national or international guideline for standard reporting does not exist. The opportunity for quality research or controlled trials is lacking, not possible or unethical.

PMCSO is associated with high maternal and perinatal mortality [2], which challenges attendant health care workers. Appropriately timed surgery combined with improvements in resuscitation techniques offer the potential to save both mother and baby. Recently the literature suggests a broader role for PMCSO than previously considered, the procedure may fulfil a more important role in the future [3,4].

Pertinent Definition

Cardiac Arrest

Sudden stop in effective blood circulation due to failure of the heart to contract effectively or at all. It is potentially reversible if treated early [10].

Maternal Collapse

Maternal collapse in a pregnant woman is defined as an acute event involving the cardiorespiratory systems and/or brain, resulting in a reduced or absent conscious level (and potentially death), at any stage in pregnancy [3].

Perimortem

The period of time immediately before death [11]. Interestingly, PMCSO was defined inconsistently in the different triennial UK Confidential Enquiries reports into maternal deaths. The first report (1955-57) used the term “ante-mortem” [5], other terms used in succeeding reports included “moribund”, “in extremis” (1959-1960), “terminal stages of fatal illness” (1961-1966), which changed to “perimortem” in the 1985-87 report [6]. The 2000-2008 reports defined perimortem as “Carried out in extremis while the mother is undergoing active resuscitation” [7-9].

In contrast, case reports generally used “perimortem” without qualification. These inconsistent variations in terminology impede review of the literature and complicate future analyses. The need for an internationally accepted definition is obvious.

Maternal Pathophysiology at or Near Term

Pregnancy induces physiological and physical changes in many systems, which may require modification of the resuscitation technique to be able to deal with the effect of these changes on collapsing pregnant women. All involved in maternal resuscitation, including paramedics and emergency room staff should be made aware of these changes, its impact and challenges to resuscitation [3].

The Cardio-Vascular System

From 20 weeks of gestation onwards, pressure by the gravid uterus on the inferior vena cava reduces cardiac output by about 25% in the supine position. The compromised venous return and reduced cardiac output by the pressure of the gravid uterus limits the effectiveness of chest compressions [12]. Left lateral tilt increases stroke volume by at least 30-40% and delivery improves cardiac output by 30-80% [1].

Respiratory System

During late pregnancy or near term, residual volume and functional capacity decreases by 25%, while maternal oxygen demand increases by 20%, leading to a rapid decrease of arterial and venous oxygen tension during periods of hypoxia. Maternal hypoxia is associated with increased pO_2 and decreased pCO_2 and bicarbonate, all of which predispose to hypoxaemia and acidemia [1,3]. Pregnant women become hypoxic more quickly.

A normal arterial pCO_2 of 40 in the non-pregnant woman causes alarm during pregnancy, it indicates poor ventilation and respiratory acidosis leading to fetal distress [1]. Superimposed on these changes, the increased weight of the breasts and diaphragmatic elevation makes it difficult to maintain a clear airway and perform intubation. Delivery improves thoracic compliance and the ability to incubate and ventilate the lungs.

Neurological Damage

Brief hypoxia leads to global ischaemia and heterogeneous injury to the brain. Ischemia and hypoxia causes neuronal injury and necrotic and apoptotic cell death. Brain injury is likely to happen if cardiac arrest goes untreated for more than five minutes [13]. In a series of 1476 cases of cardiac arrest, 89% had normal brain function or mild neurological disability, 8.5% had moderate impairment, and 2% suffered major neurological disability [14]. In another population based study of 332 long term survivals of out of hospital cardiac arrest, 85% were functionally independent [15].

The same process affects the baby's brain. If resuscitation starts within the critical 4 minute limit, a good prognosis is expected [16].

Gastrointestinal System

Decreased gastric motility and relaxation of the oesophageal sphincter may predispose to aspiration of gastric contents during resuscitation. If aspiration occurs, the increased gastric acidity increases pulmonary damage.

Laboratory Values

In interpreting laboratory results, normal reference values specific for pregnancy should be observed [17].

Fetal Pathophysiology

In conditions of hypoxia, fetal protective measures redistribute blood to vital organs, (brain and kidney) protecting them from severe damage. If the maternal oxygen saturation remains above 60 mm Hg, the fetus is able to compensate for hypoxia; below that level, fetal oxygen saturation falls dramatically [1].

Causes of Maternal Collapse or Cardiopulmonary Arrest

The commonest reversible causes of maternal collapse or cardiopulmonary arrest include pulmonary and amniotic fluid embolism, haemorrhage / hypovolaemia and eclampsia. Other causes include sepsis, anaphylaxis, heart disease, cerebral accidents, hypothermia, hyper- or hypokalaemia, myocardial infarction, metabolic acidosis, and iatrogenic factors such as trauma, medications or anaesthesia, domestic or road traffic accidents. An exhaustive list is beyond the scope of this article.

Clinical Considerations when Assessing a Patient for a Possible PMCS

Fetal Survival for the Estimated Gestational Age

Delivery before 23 weeks generally results in neonatal death. In ideal circumstances, fetal survivals range from 10% at 23 to 85% at 26-28 weeks [18]. Long term neurological sequelae following delivery between 24 to 28 weeks declines from 70% to 20%, respectively [19]. Until 23 weeks, delivery will not improve fetal survival [1], the main intervention aims at maternal survival. The nearer to term, the greater the chances of fetal survival [9].

Fetal Survival and Time from Maternal Arrest to Delivery

Irreversible fetal brain damage occurs within 4-6 minutes of inadequate cerebral perfusion [1]; the ideal time for PMCS is within 4 minutes after maternal cardiac arrest [3,16]. The best survival rate for infants >24 to 25 weeks in gestation occurs when the delivery of the infant occurs no more than 5 minutes after the mother's heart stops beating. This requires beginning PMCS about 4 minutes after cardiac arrest.

In one report of 38 cases (25-42 weeks gestation) reported from 1986 to 2004 [20], 34 infants survived. Of 20 perimortem caesarean deliveries with potentially resuscitation able causes, only 12 infants (48%) were delivered within 5 minutes; of these, 8 (66%) were normal after 18 months follow up. Among the 13 delivered after more than 5 minutes, only 6 (56%) were normal at 18 months. Because of the small number of cases, it is not possible to draw statistically significant conclusions. Fetal survivals have also been reported at 30, 45 and 47 minutes after cardiac arrest [21,22,23]. Based on these reports, physicians may be entitled to operate if there are signs that the fetus is alive or if the baby is deemed to have a reasonable chance of survival. The presence of fetal heart rate before PMCS is an important pre-requisite if the surgery is carried out for fetal survival.

Maternal Health

A mother with existing medical disorders (e.g. cardiac disease or diabetes) or a past or current obstetric risk factor (hypertensive disorders, ante-partum haemorrhage...etc.) may not provide optimal intrauterine nourishment to the fetus which may lead to a worse prognosis for fetal survival or survival with an intact neurological system.

Fetal Survival, the Evidence

The existing case report data (<300), derived over many years from different parts of the world, lack consistency in the method of reporting, bias cannot be excluded and makes it difficult to construct fetal survival rates. In contrast, reports from the UK Confidential Enquiries into Maternal Deaths (1955-2008) are more reliable and consistent. These reports describe 151 PMCS in whom the mothers died, with a high perinatal mortality rate (95 perinatal deaths, 629/1000 live births) [6,7,8,9], demonstrating the importance of extensive efforts to improve fetal survival in this group of pregnant women with collapse or cardiopulmonary arrest. In a recent publication from Netherlands, Neonatal case fatality rate was 58% [2].

Maternal Survival, the Evidence

It is not possible to estimate maternal survival rates from the case reports, and the UK confidential enquiries does not report cases who survive. In the report of 38 cases cited above, no instance of deterioration of maternal condition due to PMCS was described. Notably, a profound positive effect occurred after PMCS in 12 patients in 22 cases [20]. In the 20 cases in which the reason for cardiac arrest was reversible, the maternal survival rate was 65%. In the above recent retrospective cohort study from Netherlands, the maternal case fatality rate for PMCS ranged from 75% to 83% [2].

Indications for PMCS

Cardiopulmonary arrest or collapse in a pregnant woman with gestational age >20 weeks with no response after left lateral tilting (15° or greater) and brief resuscitation (4-5 minutes) [1,2,3,24]. Maternal resuscitation should include perimortem caesarean section if there is no response to cardiac resuscitation within 5 minutes [25].

Risks and Complications of PMCS

- Theoretical medico-legal issues.
- Delivering an infant who may develop neurological damage.
- Fetal injury from the surgical intervention.
- Maternal complications (bowel, bladder injury, bleeding, infection and or thromboembolic complications) due to the surgery itself.
- Surgical intervention when the cause of maternal collapse or cardiopulmonary arrest may have not been diagnosed.

Technique for PMCS Anticipation and Preparations

If the emergency department is informed that a seriously ill or injured pregnant woman who is more than 20 weeks pregnant is in-route to hospital, the emergency team along with the obstetric and paediatric support staff is called in case PMCS is required. The consultant obstetrician and consultant obstetric anaesthetist should be summoned at the time of the cardiopulmonary arrest call [3].

Equipment for PMCS should be available and ready for immediate use in all resuscitation trolleys in the accident and emergency departments, the delivery suite and areas where maternal collapse may occur e.g. antenatal wards.

General Considerations

- PMCS can be carried out any place. Time should not be wasted moving the patient to the operating theatre.
- If full resuscitation does not produce improvement within 4 minutes, PMCS should not be delayed.
- If resuscitation results in restoration of sinus rhythm, the decision to deliver may be reversed.
- The emergency nature of the procedure may not allow optimal conditions (assessment of fetal heartbeats, placement of a urinary catheter, or preparing the patients' abdomen).

- If possible, consultation with the resuscitation, trauma, obstetric and paediatric teams should be initiated to decide the exact time to start the surgery.
- During surgery, continuous resuscitation including endotracheal intubation and chest compressions maximizes uteroplacental perfusion [26].
- Delivery of the fetus and placenta allows transabdominal open cardiac massage if necessary [26].
- If there is a penetrating chest trauma, a concurrent resuscitative thoracotomy may be required [26].
- The most experienced obstetrician available should perform the procedure.
- Salvaging the mother is the priority. The most important aim is to aid maternal resuscitation and save the mother's life even if the fetus is already dead or if there is a possibility of a severely damaged surviving child [3].
- When the mother cannot be saved, there may be hope for the fetus.
- The doctrine of "the best interest for the patient" should apply. Consent is not necessary.
- If resuscitation and PMCSO is successful, a consultant intensivist should be involved as soon as possible [3] and the mother is moved to a high dependency critical care area for optimal management.
- Outside hospital settings, if an obstetrician is available, it may be possible to perform PMCSO on site without waiting for hospital transfer.

Anaesthesia

Anaesthesiologists are frequently available when a patient has collapsed or arrested. In many cases, with no circulation, anaesthesia may not be required to start the procedure. However, administration of high flow 100% oxygen ensures optimal oxygen delivery and should be administered as soon as possible. Bag and mask ventilation should be undertaken until intubation can be achieved. Endotracheal intubation if possible, ensures good oxygen delivery and protects against aspiration of stomach contents. The resuscitation team should consider the medication risks to the fetus according to the U.S. Food and Drug Administration classification of medications used for resuscitation. Resuscitation techniques and methods are outside the merits of this publication.

Equipment

Minimum requirements include; tape measure for symphysis fundal height to estimate gestational age and a hand held Doppler to assess fetal life. A number # 10 scalpel, haemostats, suction, blunt and sharp scissors, needle holders, gauze sponges, one bladder retractor, 2 cord clamps, and sutures for wound closure. In emergency, a scalpel alone will enable delivery of the fetus and placenta and cutting the cord [3].

Surgical Steps

- Entry into the abdomen is best through a longitudinal midline abdominal incision along the linea alba.
- A sufficiently long abdominal wall incision allows quick entry and may extend from the xiphoid to the pubis, particularly in obese patients or with a large uterus [26].
- The bladder is retracted caudad to prevent injury, particularly if there has not been time to insert a Foley's catheter [26].

- After correction of uterine dextrorotation, a classical longitudinal uterine incision 12-15 cm long with a #10 blade scalpel speeds delivery. If a transverse incision is used, a lower segment uterine incision may still achieve quick delivery of the fetus.

In a cohort study by Blair J et al., new-born extraction was statistically significantly swifter after a vertical incision, even in centers that performed the majority of emergency deliveries by transverse incision [27]. However, if the obstetrician is not familiar with this classical Caesarean section approach, the transverse skin incision can still achieve quick delivery. In a retrospective cohort study of 773 singleton caesarean deliveries, there was no difference in uterine Incision-to-Delivery interval and neonatal complications between vertical and transverse incision [28]. The surgeon should use the best approach he is comfortable with [3].

- Care should be taken to protect the bowel in case the mother survives.
- The fetus is protected against cut injuries by the surgeon's free hand [26].
- If an anterior placenta is encountered, it is best to cut through to allow rapid delivery.
- If available, cord blood gas evaluation is advisable.
- The fetus is immediately handed to the neonatal resuscitation team.
- If maternal resuscitation is successful, the placenta should be removed.
- Rapid adequate packing is quick to address any uterine or non-uterine bleeding until the maternal vital signs are reassessed.
- If bleeding is excessive because of an atonic uterus, appropriate management may include uterine tonics, uterine balloon catheter, compression sutures or a timely performed subtotal hysterectomy [29].
- If the maternal condition is hopeful, adequate surgical haemostasis is performed and the incisions closed. If it seems hopeless, the skin incision is still closed for aesthetic reasons.
- Blood and blood products should be used as appropriate.
- Women who survive should receive appropriate post operative care (intensive therapy, high dependency unit care, adequate antibiotic and antithrombotic prophylaxis).
- Resuscitation methods and techniques are outside the merits of this publication.

Medicolegal Considerations and Consent

PMCSO has not been the subject of court actions. Contrarily, one was reported in the 18th century for not performing the procedure [4]. An operation to save the life of the infant and possibly the mother is not considered a "criminal intent" [30], and the doctrine of emergency exception (delay of treatment may cause harm or injury) to a consent is applied [31]. Consent from a family member is not relevant [32]. A physician performing a PMCSO would not be penalized regardless of the outcome [33,34]. Consent from the next-of-kin is only required if a brain dead ventilator-dependent patient is kept alive solely as a nursery until better fetal survival [35].

Comments and Recommendations

- To avoid controversies in the definition, we propose a standard terminology and definition: "*Perimortem Caesarean Section Delivery (PMCSO): caesarean section delivery carried out during maternal collapse, a maternal dying state or maternal cardiopulmonary arrest*".

- International and national health authorities should establish rules and guidelines for a standard procedure.
- Different aspects of maternal resuscitation should be regularly audited e.g. the availability and use of equipment, resuscitation drugs, resuscitation decisions and outcomes.
- All staff involved in resuscitation and obstetric care (paramedics, emergency departments staff, midwives, anaesthetists and the obstetric team) should be trained with clear guidelines for resuscitation of pregnant women.
- Equipment for PMCSO should be readily available in all areas involved in obstetric resuscitation.
- Where possible include the obstetric and paediatric staff in the emergency medical team if maternal collapse or cardiopulmonary arrest occurs outside a hospital setting.
- To improve reporting and future realistic conclusion of maternal and fetal mortality and morbidity data, a formal national or international data base registry for all PMCSO with improved standardised documentation [36,37] should be established to collect the following:
 - Accurate information of maternal health status.
 - Accurate documentation of the resuscitation techniques utilised.
 - Estimated gestational age and fetal weight
 - Length of cardiac arrest before delivery
 - APGAR score and result of cord blood sampling
 - Short and long term condition of the baby
 - Postoperative condition of the mother

Conclusion

PMCSO is a rare event associated with a high maternal and perinatal mortality and morbidity. Anticipation, awareness and understanding the different aspects of PMCSO, timely intervention, training, progress in resuscitation and guidelines improves the outcomes for mother and baby. Establishment and standardization of documentation and recording of the chronology of events, the maternal and fetal assessment, and the management and outcome for mother and baby offers great potential for further accurate studies.

Declaration of Interest

The authors report no financial or any other conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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- Adel Elkady proposed the topic, did the literature search and wrote the paper. Louis Keith and Prabha Sinha supplied relevant references, reviewed the text and proposed appropriate changes for further improvements.
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