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LITERATURE REVIEW

Perimortem Cesarean Section : As Resuscitative Hysterotomy On Maternal Cardiac Arrest

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Abstract

Maternal cardiac arrest or maternal collapse is defined as an acute event involving the cardiorespiratory systems and/or brain, resulting in a reduced or absent consciousness level (and potentially death), at any stage in pregnancy and up to six weeks after delivery. Perimortem Cesarean Section (PCS) is performed either during maternal cardiac arrest or during impending maternal cardiac arrest to resuscitate mother and fetal. Current recommendations for maternal resuscitation include performance of the procedure following five minutes of unsuccessful cardiopulmonary resuscitation. The most common aetiology of maternal collapse was known as "4 H and 4 T" (Hypovolemia, Hypoxia, Hypo/Hyperkalemia, Hypothermia; Tromboembolism, Toxicity, Tension pneumothorax, Tamponade). Resuscitation in maternal cardiac arrest is mostly similar with non-pregnant patient resuscitation. There are several considerations need to be addressed in primary survey such as endotracheal tube I size smaller, supplemental O₂ regardless of peripheral saturation, aggressive volume resuscitation, and uterine displacement to relieve compression of the IVC.

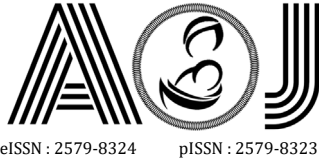
Keywords: Maternal cardiac arrest; non-pregnant patient resuscitation

INTRODUCTION

Maternal cardiac arrest or maternal collapse is a rare case during pregnancy and labor. The incidence between 1 in 30.000- 1 in 53.250 pregnancy. It 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 and up to six weeks after delivery. Either case is rare but very life threatening, most obstetricians may be confronted with this situation only once or twice, if ever, in their practice lifetime.^{1,2}

The most common aetiology of maternal collapse was known as "4 H and 4 T" (Hypovolemia, Hypoxia, Hypo/Hyperkalemia, Hypothermia; Tromboembolism, Toxicity, Tension pneumothorax, Tamponade).³

Perimortem Cesarean Section (PCS) has been resorted to as a rare event since ancient times. It is defined as cesarean section performed either during maternal cardiac arrest or during impending maternal cardiac arrest the primary goal of which is to increase the chance



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of successfully resuscitating the mother and potentially improving fetal survival.⁴ Historically a postmortem foetus extraction was described as early as 715 before Christ when the Roman King Numa Pompilius decreed that no child should be buried within his mother (for religious reasons) since some foetus was found still alive. One of the first positive case report of PMCS was described by De Pace and coworkers in 1982 where a woman developed cardiac arrest (CA) during fiberoscopy. After 20 minutes of CPR, PMCS was performed and ROSC was soon achieved in the mother while the baby recovered uneventfully. Both had a full long term neurological survival.⁵

Current recommendations for maternal resuscitation include performance of the procedure following five minutes of unsuccessful cardiopulmonary resuscitation. If accomplished in a timely manner, perimortem cesarean section can result in fetal salvage and is also critical for maternal resuscitation.^{6,7,8}

CASE ILLUSTRATION (LITERATURE REVIEW) ^{2,5,6,7,9}

| Identity | Problems | Interval cardiac arrest and PCS | Baby Outcome | Maternal Outcome |
|----------|--|------------------------------------|---|---|
| 31 years | Profuse bleeding caused by gunshot, BP 90/40, HR 140, GCS 6, uterine fundal palpated 6 cm above umbilical (26 weeks gestation). Resuscitation was failed BP down 60/p, plan to performed perimortem CS | Time since gushot to CS 55 minutes | - Born male baby - 710 gram - A/S 1/3/6 - neonatal resuscitation, NICU for 3 months - There is no neurology deficit when he was 5 years old | Died in ICU 14 hours post perimortem CS |
| 30 years | Gunshot on the head and chest, Unstable vital sign, Performed thoracotomy and open cardiac mass Uterine fundal was palpated 5 cm above umbilical (25 weeks of getation) | Interval arrest to CS : 9 minutes | - Born baby 770 gram, A/S 2/3/4 - Baby alive and no deficite neurology in the age of 5 years old | Mother was died slightly after CS |
| 36 years | Car accident, blunt truma to the thorax, head and abdomen, cardiac arrest, ECG PEA, then performed PCR | 12 Inutes | - Born baby 1500 gram,,A/S 3/6 | Mother died slightly after CS |



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| | | | | |
|----------|--|-----------|--|---|
| | | | - No growth disorder on 4 years old girl, but have slow language disorder | |
| 41 years | dyspnea with high blood pressure reaching 200/110mmHg. Patient was diagnosed as G4P3 37 weeks of gestation with severe preeclampsia, acute lung edema. After given magnesium sulfate, the patient got severe dyspnea and out of consciousness. Resuscitation directly performed, after 4 minutes unresponsive, the obstetrician team and anesthesiologist performed cesarean section | 5 minutes | - Baby boy 3400gram was born with A/S 3/5 - given neonatal resuscitation - The baby is in good condition with the family | Patient fall into severe sepsis and septic shock, manage to survive only 6 days care in ICU |
| 35 years | Patient came to general ER with dyspnea, on G1 35 weeks gestational age, patient have history of fever and cough since 3 days before admission. She came with respiratory rate 35x/min, heart rate 130x/min, blood pressure and temperature was normal, no signs of labor. There were crackles at both lung fields. Patient was diagnosed as suspected community acquired pneumonia and given beta-2 agonist inhalation. Ten minutes afterwards patient got restless, then had spontaneous water broke followed by loss of consciousness and apnea with undetected pulse. Resuscitation was then performed in left lateral tilt position. At that time the fetal heart rate was reaching 70–80 pulses per minute. Due to the mother and fetal hypoxia condition the team decided to do perimortem cesarean section and B-lynch | | - born baby girl 2100gram A/S 1/0 - Baby was in good condition. | Died after 3 hours CS in ICU |
| 33 years | dyspnea, which was felt from 5hours before admission. She had to sleep with piles of cushion to comfort her | 5 minutes | - Born baby boy | After brief cesarean surgery, the |



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| | | | | |
|--|--|--|---|---|
| | <p>breath and had cough since 1 week ago. She came with respiratory rate was 24x/minutes, pulse 122bpm, BP 160/100mmHg and protein stick +2. She looks pale and both extremities were cold with the capillary refill time more than 3". The fetal heart rate was 132x/min. We assessed this patient as threatened respiratory failure due to acute lung edema on G1 term pregnancy singleton live head presentation, severe preeclampsia, not in labor and we plan to do emergency cesarean section. Under preparation for c-section, patient had seizure and fall in to apnea with no pulse. The blue code team was called, cardio pulmonary resuscitation immediately started by the anesthesiologist team in left lateral position. At that time the fetal heart rate was 109bpm. After 4 minutes resuscitation patient still cannot reach ROSC, we decided to do cesarean section immediately at place</p> | | <p>3200gram with AS 6/8 - The baby was taken home in good condition</p> | <p>resuscitation continued about 15 minutes, pulse detected at the monitor, patient came to ROSC and sent to ICU for further management. After one hour at the ICU, the patient had vaginal bleeding, decided to insert condom catheter, but within three hours later, profuse vaginal bleeding continued with signs of hypovolemic shock, uterine atonic was found and end up with subtotal hysterectomy. One day after, patient fell in to septic shock with multi organ failure, found Klebsiella pneumonia from sputum culture.</p> |
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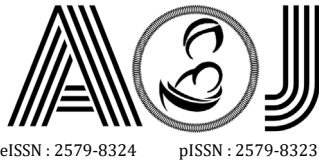
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| | | | | |
|----------|---|------------|--|-----------------------|
| 17 years | 17-year-old primigravid African American female with twin pregnancy and a history of preeclampsia arrived at ED, no pulse, no breathing. Paddle tracing demonstrated asystole. Full Advanced Cardiac Life Support (ACLS) was begun immediately and emergency activation of the obstetrics and pediatrics services was done. Upon endotracheal intubation, vomitus was found in the mouth. Fetal heart tones were not detected with stethoscope or Doppler. However, fetal movements were palpable. Emergency cesarean section | 12 minutes | <ul style="list-style-type: none"> - Baby boy 1 (BB1) 2500 gr was born in full CRA, with Apgar scores 1/3 Despite aggressive ACLS, the baby was - not resuscitated, and was declared - dead - Baby boy 2 (BB2) 2400 gr - was born with no spontaneous res- - pirations, with a heart rate of 100 - beats/min, cyanotic, and flaccid, - with Apgar scores 1/5. the baby was - not resuscitated, and was declared - dead | Died 4 hours after CS |
|----------|---|------------|--|-----------------------|

DISCUSSION**Physiological Changes in Late Pregnancy⁴**

- Blood volume and cardiac output increase by 30-40% above the nonpregnant state by 28 weeks
 - ✓ This hypervolemic state is protective for the mother, as fewer red cells are lost during hemorrhage
 - ✓ Clinical signs of maternal shock manifest only after 40% of maternal blood volume lost
- Late pregnancy is very susceptible to hypotension from compression of the inferior vena cava (IVC) in the supine position by the enlarged uterus



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- The enlarged uterus causes elevation of the diaphragm by about 4 cm, and results in a decrease in the functional residual capacity by about 20%

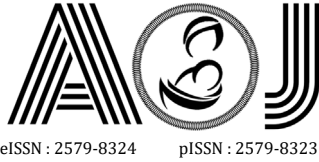
Table 1. Physiological and physical changes in pregnancy

| | Changes in pregnancy | Impact on resuscitation |
|------------------------------|---|---|
| Cardiovascular system | | |
| Plasma volume | Increased by up to 50% | Dilutional anaemia Reduced oxygen-carrying capacity |
| Heart rate | Increased by 15–20 bpm | Increased CPR circulation demands |
| Cardiac output | Increased by 40% Significantly reduced by pressure of gravid uterus on IVC | Increased CPR circulation demands |
| Uterine blood flow | 10% of cardiac output at term | Potential for rapid massive haemorrhage |
| Systemic vascular resistance | Decreased | Sequesters blood during CPR |
| Arterial blood pressure | Decreased by 10–15 mmHg | Decreased reserve |
| Venous return | Decreased by pressure of gravid uterus on IVC | Increased CPR circulation demands Decreased reserve |
| Respiratory system | | |
| Respiratory rate | Increased | Decreased buffering capacity, acidosis more likely |
| Oxygen consumption | Increased by 20% | Hypoxia develops more quickly |
| Residual capacity | Decreased by 25% | Decreased buffering capacity, acidosis more likely |
| Arterial PCO ₂ | Decreased | Decreased buffering capacity, acidosis more likely |
| Laryngeal oedema | Increased | Difficult intubation |
| Other changes | | |
| Gastric motility | Decreased | Increased risk of aspiration |
| Lower oesophageal sphincter | Relaxed | Increased risk of aspiration |
| Uterus | Enlarged | Diaphragmatic splinting reduces residual capacity and makes ventilation more difficult Aortocaval compression causes supine hypotension, reduces venous return and significantly impairs CPR |
| Weight | Increases | Large breasts may interfere with intubation Makes ventilation more difficult |

CPR = cardiopulmonary resuscitation; IVC = inferior vena cava; PCO₂ = partial pressure of carbon dioxide

Etiology of Maternal Cardiac Arrest⁶

| Reversible cause | Cause in pregnancy |
|---|--|
| 4 H's | |
| Hypovolaemia | Bleeding (may be concealed) (obstetric/other) or relative hypovolaemia of dense spinal block; septic or neurogenic shock |
| Hypoxia | Pregnant patients can become hypoxic more quickly Cardiac events: peripartum cardiomyopathy, myocardial infarction, aortic dissection, large-vessel aneurysms |
| Hypo/hyperkalaemia and other electrolyte disturbances | No more likely |
| Hypothermia | No more likely |
| 4 T's | |
| Thromboembolism | Amniotic fluid embolus, pulmonary embolus, air embolus, myocardial infarction |
| Toxicity | Local anaesthetic, magnesium, other |
| Tension pneumothorax | Following trauma/suicide attempt |
| Tamponade (cardiac) | Following trauma/suicide attempt |
| Eclampsia and pre-eclampsia | Includes intracranial haemorrhage |



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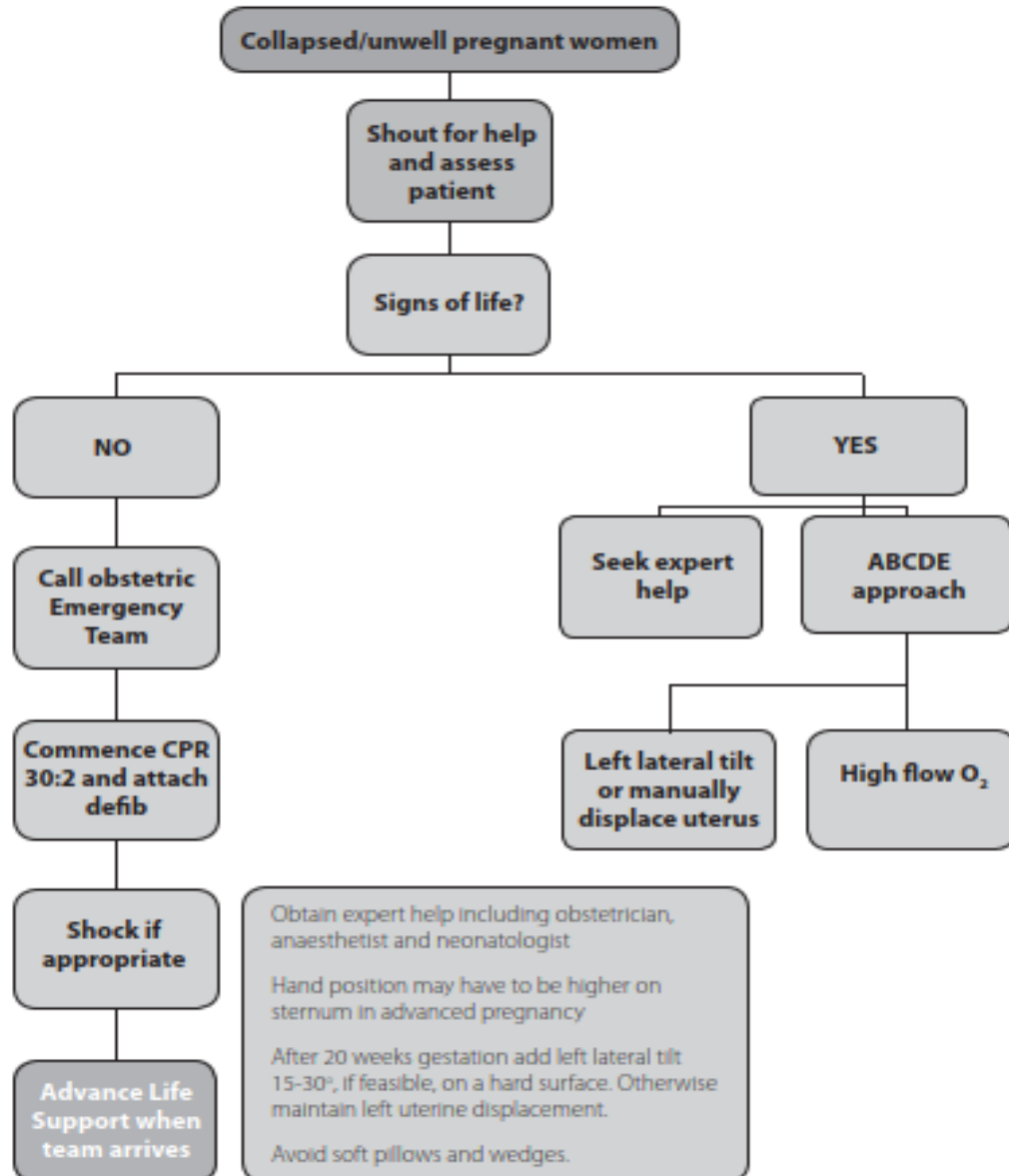
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Resuscitation of Maternal Cardiac Arrest

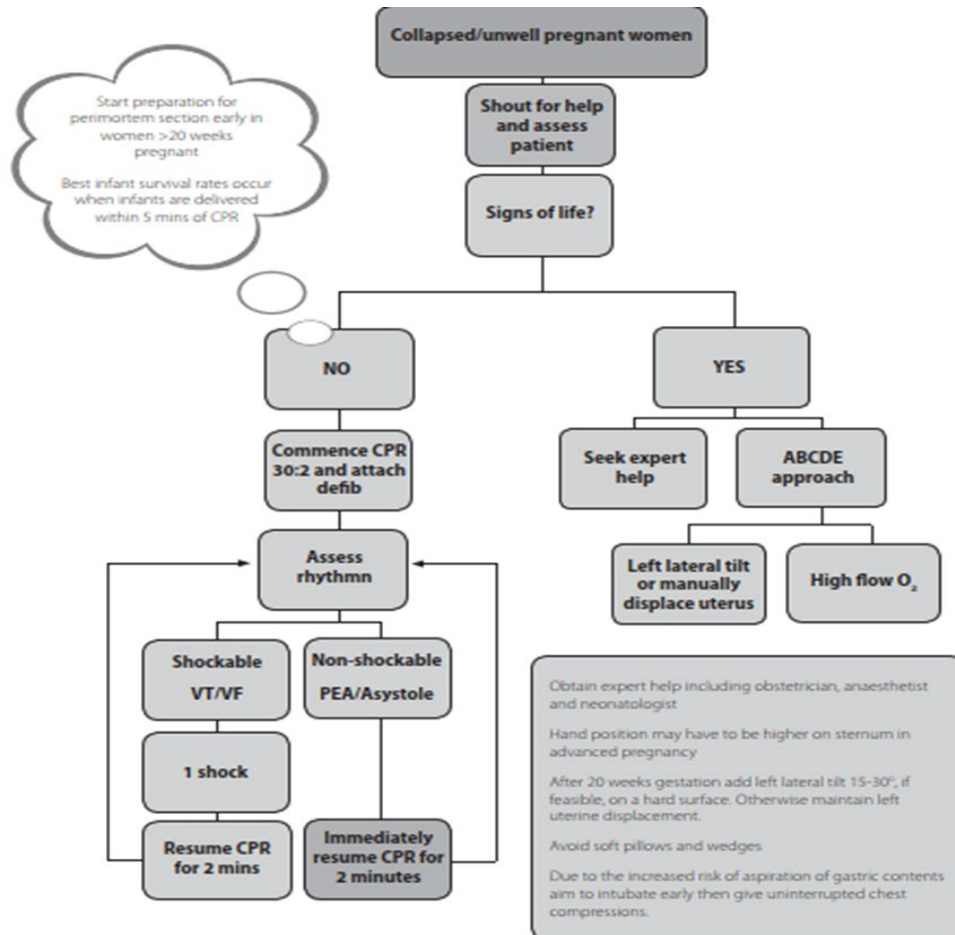
Overall same general approach as in non-pregnant patients. Focus must always be on resuscitating the mother, not the fetus. Special considerations in primary survey.^{3,5}

- Airway: There is physiologic narrowing of the upper airways in the third trimester
 - ✓ Use an endotracheal tube 1 size smaller.
 - ✓ Intubation medications are the same.
- Breathing: Pregnant patients are predisposed to rapid falls in PaO₂ during apnea
 - ✓ Supplemental O₂ should be provided for any pregnant patient being resuscitated regardless of saturation.
- Circulation: Hypovolemia should be suspected before clinical signs of hypotension in patients, as the state of hypervolemia and resulting hemodilution may mask underlying significant blood loss.
 - ✓ Aggressive volume resuscitation is encouraged regardless of blood pressure.
 - ✓ Resuscitation of the pregnant patient should include uterine displacement to relieve compression of the IVC and thus improve cardiac output and restore circulation. Perform in any patient in whom the uterus could potentially cause compression regardless of gestational age or lack of knowledge of gestational age. Traditional teaching: This can be done by tilting the backboard up a 30 degree angle to the left, but may be difficult to perform effective chest compressions while patient tilted. New model: It is more effective to manually move the uterus to the patient's left with one or two hands during ongoing chest compressions, while patient remains flat on their back

Basic Life support Algorithm ¹

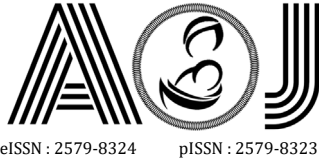


Advance Life Support Algorhythm ¹



Consideration of Perimortem Caesarean Section ⁸

| Indications for perimortem caesarean section |
|--|
| <ul style="list-style-type: none"> • Estimated gestational age > 20 weeks • Person able to perform procedure* • Resources to allow post-operative care of mother (and ideally child, although of secondary importance) • Peri-mortem caesarean section should be considered at the earliest stage unless there is return of spontaneous circulation |
| <p>*This does not need to be an obstetrician</p> |



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In other literature indication of PCS : ⁵

- 24 week gestation, because before 24 weeks gestation, the fetus is small and anivable
- On palpation examination, the abdomen is large, specifically if fundal height is above umbilicus
- If baby looks big on ultrasound (may not have time to measure biparietal diameter, but can get a general sense of the size of the fetus). It has become clear that cardio-pulmonary resuscitation remains significantly impaired by the gravid uterus after around 22-24 weeks gestation, despite the above management. Accordingly, surgical evacuation of the uterus has preceded many successful resuscitation attempts. Therefore if cardiopulmonary resuscitation is unsuccessful, delivery of the baby by perimortem section ('resuscitative hysterotomy') should be accomplished within 5 minutes. ^{5,6}
- PCS was dicide as soon as 4 minutes after maternal cardiac arrest, the place to performed is in recucitation room of emergency department or PONEK which means in ED should available the PCS tray.

The current literature describes indications for performing an emergency cesarean section based on both fetal and maternal prognostic factors once maternal cardiac arrest

has occurred. These factors include time elapsed from maternal cardiac arrest to fetal extraction, timing and quality of cardiorespiratory resuscitation, potential for fetal viability, and cause of maternal death. The general consensus appears to be that the earlier the cesarean section is peformed after maternal cardiac arrest, the better the prognosis for the fetus. The optimal time in performing the procedure has been established at 4 to 6 minutes after maternal cardiac arrest, since irreversible brain and tissue damage due to hypoxia occurs at or beyond that period.⁵ In a study done by Katz et al., this time range yielded the highest percentages of normal infants (70%).⁹

However, it is also well recognized that aggressive and early resuscitation can provide approximately 30–40% of cardiac output, which may contribute enough maternal and fetal oxygenation to prolong fetal viability. Supportive of this concept is a case reported by Hsin-Fu et al., where fetal monitoring was done maternal cardiac arrest while ACLS was ongoing. They ob-served that fetal tachycardia was maintained while the mother remained critically ill (with episodes of ventricular tachycardia/ventricular fibrillation) for approximately 19 minutes. Even after complete maternal cardiac arrest, the fetus was able to maintain a heart rate around 100 beats/min, yielding a completely normal neonate after 17 minutes of maternal CRA (26 minutes after the maternal condition deteriorated). Other studies have also reported good fetal outcomes after long periods of ACLS for the mother, with the longest estimated to be 22–29 minutes.⁹



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Website:<http://jurnalobgin.fk.unand.ac.id/index.php/JOE>**Outcome of baby delivered by perimortem Cesarean Section :**

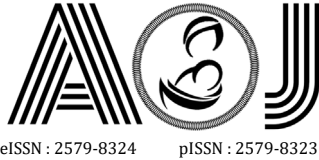
| Time (min) | No. Patients | No. Normal | No. Neurologic Sequelae |
|------------|--------------|------------|-------------------------|
| 0-5 | 42 (69%) | 42 | 0 |
| 6-10 | 8 (13%) | 7 | 1 (mild) |
| 11-15 | 7 (11%) | 6 | 1 (severe) |
| 16-20 | 1 (2%) | 0 | 1 (severe) |
| 21-25 | 3 (5%) | 1 | 2 (severe) |

Technic of Perimortem Caesarean Section³

- Make a vertical incision from xiphoid to the pubis using a scalpel
- Cut through subcutaneous tissue to get to peritoneal wall
- Use fingers to bluntly dissect to the peritoneum
- Cut through peritoneum vertically (ideally with scissors or use a scalpel to initiate an opening inferiorly)
- Deliver the uterus, then cut into the lower half of the uterus vertically to avoid the placenta and then use scissors to extend the incision upwards until you reach the baby
- Deliver the baby (neonate will likely need resuscitation)
- Clamp and cut the umbilical cord
- Place packing/towels in the opened uterus and abdomen
- Consider of B-lynch procedure or ligation of uterine artery to prevent the high risk of post partum haemorrhage

Multidisciplinary team involvement^{1,9}

Effective management of obstetric emergencies relies heavily on the skills and support of several individuals and services. Adequate planning, preparation and rehearsal of emergency drills are crucial to this process. Many hospitals will have protocols and activation pathways to ensure that these services are rapidly engaged in the event of an emergency. Daily tasks involve checking of equipment, drugs and communication systems. Longer term tasks involve training, audit, service development, case review and risk management. If unsuccessful, the decision to terminate CPR should be agreed by the entire resuscitation team. It is unlikely to be appropriate to stop if the patient is in VT or VF, however prolonged asystole without the identification of a reversible cause should prompt discussions about stopping resuscitation attempts. Thorough records should be kept throughout and following the resuscitation, noting times of drugs, decisions, interventions and transfers.



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Services involved in effective obstetric emergency plan

- Obstetricians
- Midwives
- Anaesthetist
- Critical Care
- Haematology
- Ancillary (theatre staff, porters etc.)

RCOG recommendation team that have include to PCS at least : ⁶

- Senior midwife
- Senior resident of obgyn
- Senior resident of anaesthesia
- Neonatal team

Post resuscitation care

Following successful resuscitation, meticulous attention must be paid to on-going support and treatment of the mother, ideally in a high dependency or intensive care environment. Less immediate complications of obstetric emergencies, such as myocardial damage from post-partum haemorrhage¹², renal failure and pulmonary thrombo-embolic disease¹³, may be underestimated contributors to mortality and morbidity. ^{9,10}

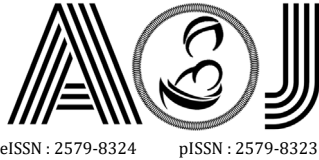
It is good practice that senior staff members take responsibility for informing the family of key progress and outcomes throughout. Additionally, a team debrief should be carried out whether the resuscitation is successful or not. ^{9,10}

CONCLUSION

1. PCS as a resuscitative hysterotomy primarily aimed at saving the life of the mother
2. PCS will improve maternal resuscitation, act quickly to start and complete the procedure
3. The optimal surgical approach for a PCS is via a large vertical incision.
4. Need multidisciplinary team to complete 4-6 minutes PCS
5. Outcomes of PCS depend on interval time of maternal cardiac arrest and baby extraction, quality of CPR, viability of the fetus, and cause of maternal death

ADVICE TO OUR INSTITUTION

M Djamil central general hospital as type A hospital and central of referral hospital in Sumatra should have prepared PONEK to be able to activate Perimortem Caesarean Section (PCS) as resuscitative hysterotomy to salvage mother and baby



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