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Resuscitation of Obstetric Patient

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Abstract

The number of cases of pregnant patients with cardiorespiratory arrest requiring resuscitation has increased worldwide, secondary to the main number of patients with high-risk pregnancies associated with chronic, especially cardiopulmonary, pathologies. The knowledge of the resuscitation algorithms by the health personnel responsible for the care of pregnant patients is mandatory, because due to different physiological and anatomical changes, there are particularities in the management and use of medications. In addition, a detailed description of the steps included in the resuscitation is necessary, where assessment of the airway, ventilation, circulation, and defibrillation determines a step in resuscitation. One of the determining and exclusive events in this type of patients is cesarea perimortem. That is why it includes a concrete description of the time and the indications for its realization. Finally, a list of medicines most used in resuscitation in pregnancy, with its dosage and safety range, is mentioned. The pregnant patient poses a challenge to resuscitation teams. This review refers to the recommendations for establishing “obstetric blue code” protocols at the institutional level.

Keywords: reanimation, maternal arrest, pregnancy, cardiopulmonary, perimortem caesarean

1. Introduction

The approach to resuscitation in pregnancy determines several conditions that go from the physiological, anatomical, and emotional point of view, as we face a catastrophic event and the challenge of restoring the health condition of two living beings as a mother [1]. Knowledge and training in resuscitation of the obstetric patient has had a great development in the last decade, with an increasing number of publications and special chapters in the international guides of resuscitation [2].

Although maternal mortality worldwide has declined by 44%, there has been a worrying increase in extreme maternal morbidity and mortality in developed countries around the world due to increased pregnancy age and comorbidities that determine a greater number of situations of cardiac arrest [3].

In the USA, the prevalence of events requiring cardiac resuscitation in hospitalized obstetric patients was $8.5 \times 100,000$, with a survival rate of only 59% in the mother [4].

We believe that the scope of this chapter includes the knowledge of the various groups responsible for mother–child resuscitation, such as emergency physicians, obstetricians, anesthesiologists, critical care physicians, and neonatologists, as well as nurses and midwives.

2. Changes physiologic in the mother

The physiological and anatomical changes of pregnancy require some modifications in the resuscitation protocols, these changes begin early in pregnancy, reach their peak during the second trimester, and then, remain relatively constant until delivery.

The major hemodynamic changes induced by pregnancy include an increase in cardiac output between 30 and 40% (as a result of increased stroke volume and to a lesser extent increased maternal heart rate 15–20 bpm) [5], plasma volume expansion is 10–15% at 6–12 weeks of gestation, and at the term, is 30–50% higher than non-pregnant women, increase in red cell volume [6] (a greater increase in intravascular volume than red cell mass, that results in the dilutional or physiologic anemia of pregnancy), reductions in systemic vascular resistance and systemic blood pressure [7].

Most of the increase in cardiac output is distributed in the placenta, kidneys, and skin so that the mechanical effects of the gravid uterus can decrease venous return from the inferior vena cava and obstruct blood flow through the abdominal aorta; all of above, contribute to unsuccessful cardiopulmonary resuscitation. Left lateral uterine displacement is necessary in the pregnant patient with fundal height at or above the umbilicus, to minimize aortocaval compression, to optimize venous return, and to generate adequate stroke volume during cardiopulmonary resuscitation [6].

During pregnancy, the anatomy of the upper respiratory airway undergoes numerous changes; upper airway, the pharynx and larynx edema occur as a result of hormonal effects and may reduce visualization during laryngoscopy and therefore, intubation in a pregnant woman can be difficult, and smaller endotracheal tubes may be needed [6, 8]. Therefore, progesterone relaxes gastroesophageal sphincters and prolongs transit times throughout the intestinal tract, predisposing the patient to aspiration of stomach contents [9].

Changes in the thorax and abdomen appear early in pregnancy; even before displacement from the enlarging uterus. In the first trimester, the subcostal angle changes from 68 to 103°, the diaphragm rises by up to 4 cm and the chest diameter increases by 2 cm or more, diaphragmatic excursion increases by up to 2 cm (the result is “barrel chested” appearance) [8].

Since the first trimester of pregnancy, a relative hyperventilation occurs, with minute ventilation rise by 50% at term, mediated by the elevated serum progesterone levels. This produces a mild respiratory alkalosis with compensatory renal excretion of bicarbonate [8].

The functional residual capacity decreases approximately 20% due to the upward shift in the diaphragm as the uterus enlarges, while oxygen consumption increases by 20% during pregnancy to meet the increased oxygen demands of the placenta, fetus and maternal organs. These two factors are responsible for hypoventilation in the pregnant woman [5, 9].

Forced expiratory volume (FEV1) does not change during pregnancy, but expiratory reserve volume and residual volume decrease, inspiratory capacity is mildly increased, resulting in a minimal drop in the total lung capacity from 4.2 to 4 l, In addition, there is a decrease in arterial carbon dioxide (PaCO₂) levels from 40 mmHg in non-pregnant to 27–32 mmHg during pregnancy, so that, the resultant arterial pH is normal to slightly alkalotic (between 7.40 and 7.45). The decrease in PaCO₂ helps the fetus to eliminate carbon dioxide across the placenta [9].

3. Etiology

It is necessary to know the possible etiology of cardiac arrest in pregnant women to identify and treat correctly the causal factors and therefore give the mother and the fetus a better chance of survival. The cause of maternal cardiac arrest can often be multifactorial, and in many cases it is associated with chronic health problems that exist before pregnancy, so women with comorbidities should have multidisciplinary follow-up. Even so, it must be taken into account that cardiorespiratory arrest (CRA) in pregnant women occurs frequently in previously healthy woman in relation to hemorrhage or embolism (non-arrhythmogenic causes, unlike non-pregnant women). This refers to the non-pulsed electrical activity algorithm (AESP) in which the modified 5H and 5T must be remembered (see **Table 1**) [4, 10–15].

5H	5T
1. <i>Hypoxia</i> : particular predisposition that the pregnant woman has due to the high consumption of oxygen by the developing fetus	1. Toxics/tablets
2. <i>Hypovolemia</i> : uterine atony, placental abruption, placenta previa, placenta accreta, subcapsular hepatic hematoma, ectopic pregnancy, uterine rupture, retained products of conception	2. <i>Thrombosis</i> : pulmonary thrombosis and Coronary thrombosis
3. <i>Hydroelectrolitic</i> : hypermagnesemia. Treatment of threatened preterm or preeclampsia, particularly in renal failure, hyperkalemia/hypokalemia	3. <i>Tension</i> : pneumothorax tension
4. Hydrogenions-acidosis	4. <i>Tamponade</i> : cardiac tamponade.
5. Hypothermia	5. Trauma

Table 1. Etiologies of maternal arrest (5H-5T) [11–15].

The main causes of CRA in pregnant women include bleeding, heart failure, sepsis, and amniotic fluid embolism, and the main causes of mortality in this population are the cardiac disease, sepsis, preeclampsia/eclampsia, hemorrhage, cerebrovascular events, amniotic fluid embolism, complications from anesthesia, and thrombosis/thromboembolism [4, 10]. A way to remember those causes is the mnemonic of the American Heart Association (AHA), because the obstetrics' CRA causes are different from the general population [5] (see **Table 2**).

Letter	Meaning	Etiology
A	Anesthetic Accidents	High neuraxial block Hypotension Loss of airway Aspiration Respiratory depression Local anesthetic systemic toxicity Trauma Suicide
B	Bleeding	Coagulopathy Uterine atony Placenta accreta Placental abruption Placenta previa Retained products of conception Uterine rupture Surgical Transfusion reaction
C	Cardiovascular	Myocardial infarction Aortic dissection Cardiomyopathy Arrhythmias Valve disease Congenital heart disease
D	Drugs	Oxytocin-magnesium-opioids-insulin Drug error Illicit drugs Anaphylaxis
E	Embolic	Amniotic fluid embolus Pulmonary embolus Cerebrovascular event Venous air embolism
F	Fever	Infection/sepsis
G	General	H's and T's (Table 1)
H	Hypertension	Preeclampsia-eclampsia HELLP syndrome Intracranial bleed

Table 2. Etiologies of maternal arrest (A to H's mnemonic) [5].

4. Management

The management of CRA in pregnant women should ideally be performed by trained individuals, with knowledge of the physiological changes in pregnancy, in the centers where the equipments necessary for cesarean perimortem and for neonatal resuscitation are available. The most important pillar in the management of CRA in pregnant women is prevention [5], guaranteeing adequate oxygenation, and circulatory volume, so it is recommended to place the patient in a position of complete left lateral decubitus to relieve the aortocava compression, administration of 100% oxygen by face mask to treat or prevent hypoxemia, establish intravenous access above the diaphragm to ensure intravenous therapy is not obstructed by the pregnant uterus and to investigate and treat precipitating factors [11]. In the CRA there is basic and advanced management, first the basic management of pregnant women in CRA and then the advanced management will be discussed, emphasizing the changes with respect to the CRA of the non-pregnant adult.

4.1. Basic cardiovascular life support

the basic life support (BLS), the first responders must initiate usual resuscitation measures, including board placement, and provision of chest compressions and appropriate airway management, defibrillation where appropriate, and manual left uterine displacement [12] (algorithm N1). A minimum of four responders must be present to carry out all tasks effectively (**Figure 1**).

4.1.1. Circulation

Thoracic compressions: the patient should be placed supine for chest compressions (chest compressions performed with the patient in a tilt could be significantly less effective than those performed with the patient in the usual supine position, and this could have a major impact on the chance of successful resuscitation), which must be effective at least 5 cm deep, are performed 3 cm above the traditional sternal point, frequently at least 100 per min and with a sequentiality of 30 chest compressions: 2 artificial ventilation, deviation of the uterus to the left manually, it is recommended to allow complete thoracic expansion after each compression and to minimize interruptions in chest compressions. Once a device has been placed the compressions can be continuous and not alternate with the ventilation [10–12]. There is no literature examining the use of mechanical chest compressions in pregnancy, and this is not advised at this time. Previous guidelines recommended placing the hands slightly higher on the sternum in the pregnant patient, but there are no scientific data to support this recommendation.

4.1.2. Airway

After placing the pregnant woman in a suitable position, the opening of the airway is performed, head extension maneuver is performed, neck flexion and chin elevation (except in patients with a history of cervical trauma, in which if only the lower jaw is raised), if there is

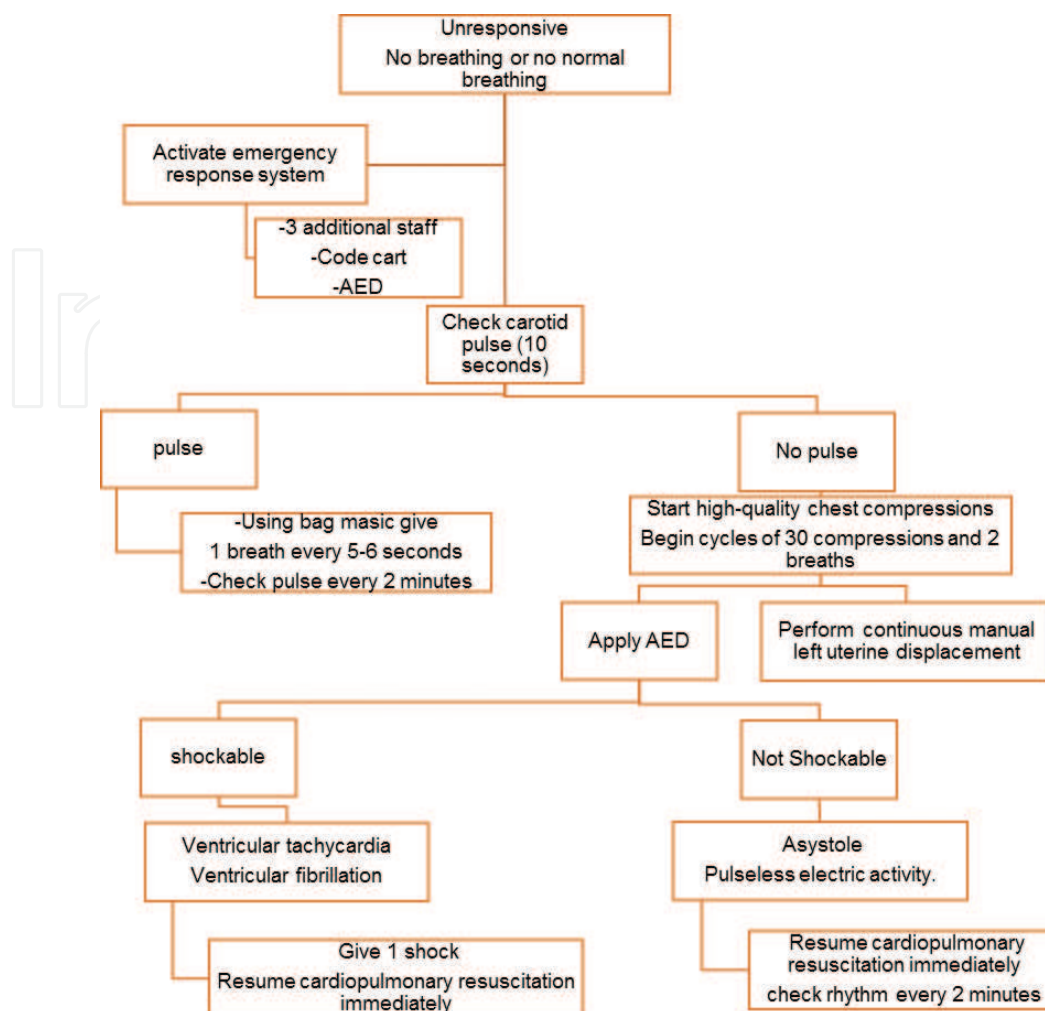


Figure 1. Basic life support (BLS)—cardiac arrest in pregnancy.

no response, be prepared to ensure the airway definitively, initiate with pre-oxygenation of the patient with 100% FiO₂, due to the complications in the pregnant patient because of the physiological changes of the pregnancy. It is recommended to perform this procedure with personnel having greater training in airways, it is recommended to have the “STUBBY” (short-handled) laryngoscope for mammary hypertrophy, and to have on hand a difficult airway equipment with elements such as mask Laryngeal in case conventional intubation is not possible. It is recommended to make only one attempt and ask for help from the most qualified personnel, if you are in second or third level of care, request help from the anesthesiology group.

4.1.3. Defibrillation

Identify the defibrillator of your workplace and identify if it is biphasic or monophasic. In the absence of a biphasic defibrillator, it is acceptable to use a single-phase, so far has not shown any injury to the fetus by defibrillation. Defibrillary Cardiopulmonary Arrest (CPA) Rates: We recommend the administration of 200 J by a biphasic defibrillator or 360 J by a single-phase defibrillator in ventricular fibrillation and non-pulse ventricular tachycardia, alternating with

the administration of the following drugs: Adrenaline 1 mg IV every 3 min [10–14]. The energy required for defibrillation during cardiac arrest in pregnancy would be the same as the most current recommendations for the non-pregnant patient.

5. Advanced cardiovascular life support

Although current guidelines for management of CPA adults say that chest compressions should not be interrupted initially for ventilation or airway placement. The pregnant patient has a very limited oxygen reserve and requires early attention to airways and ventilation.

In the advanced cardiovascular life support (ACLS), it is recommended that endotracheal intubation should be performed by an experienced laryngoscopist (not more than two laryngoscopy attempts should be made and prolonged intubation attempts should be avoided to prevent deoxygenation, prolonged interruption in chest compressions, airway trauma, and bleeding), and starting with an endotracheal tube with a 6.0–7.0 mm inner diameter is recommended, because the glottis in pregnancy is often smaller for edema. The cricoid pressure is not routinely recommended, but, continuous waveform capnography, in addition to clinical assessment, is recommended as the most reliable method of confirming and monitoring correct placement of the endotracheal tube (**Figure 2**).

If attempts at airway control fail and mask ventilation is not possible, current guidelines for emergency invasive airway should be followed.

Given the lethality of cardiopulmonary arrest, the benefits from use outweigh any possible fetal risks. All medications at the same doses for treatment of cardiopulmonary arrest in the non-pregnant patient are used for the pregnant patient (**Table 3**).

5.1. Arrhythmia-specific therapy during cardiac arrest

5.1.1. *Cardiopulmonary non-defibrillation rhythms*

In case of asystole and pulseless electrical activity, focus on chest compressions as well as drug administration. Other potentially lethal arrhythmias that should be treated.

5.1.2. *Ventricular tachycardia with pulse*

Stable monomorphic VT with adult pulse responds well to biphasic or monophasic (synchronized) cardioversion discharges at initial doses of 100 J. If there is no adequate response after the first discharge, it is reasonable to increase the dose in a staggered manner.

5.1.3. *Supraventricular paroxysmal tachycardia*

In addition to synchronous cardioversion, adenosine is also recommended as a safe and potentially effective drug. There are no data yet on pregnancy. The recommended initial

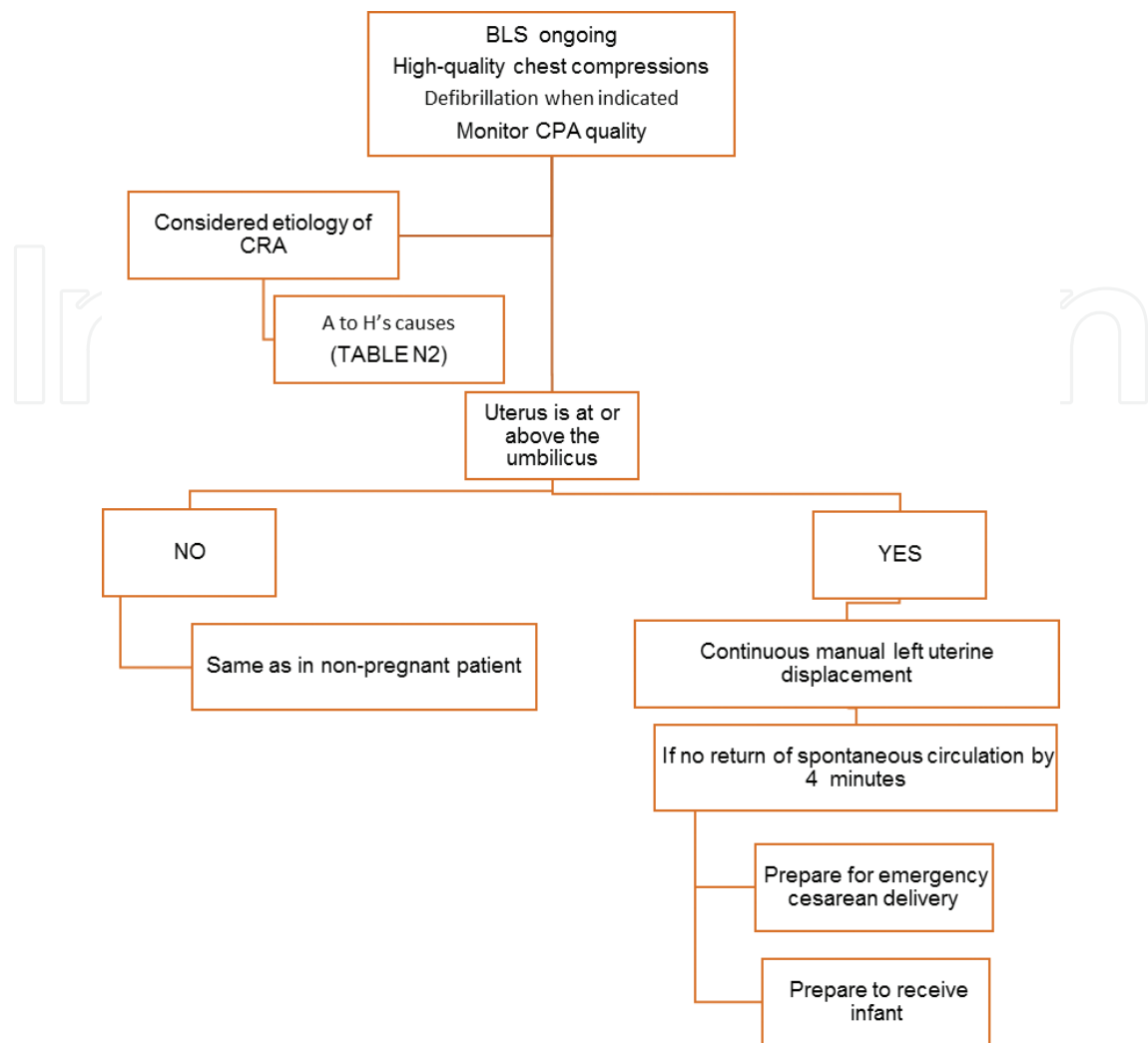


Figure 2. Advanced cardiovascular life support (ACLS)—cardiac arrest in pregnancy.

Medications	Use	Adverse effects	Observations	Dose
Epinephrine	If VF or VT persists after at least one attempt at defibrillation and 2 min of CPA	Reduce uterine blood flow through alpha-adrenergic-mediated blood vessel vasoconstriction	Is superior	1 mg IV every 3–5 min
Vasopressin	Was removed from the treatment algorithm for CPA	Uterine contractions	Is not clearly superior to epinephrine	Is not recommended
Magnesium sulfate Pregnancy	<ul style="list-style-type: none">Prevention of eclamptic seizuresFetal neuroprotection before preterm delivery	Magnesium toxicity	Should be discontinued Calcium chloride (10 mL of a 10% solution) or calcium gluconate (30 mL of a 10% solution) intravenously or intraosseously	4 or 6 g IV, followed by a maintenance 1–2 g IV/h

Medications	Use	Adverse effects	Observations	Dose
CPA	<ul style="list-style-type: none"> Polymorphic VT consistent with torsade de pointes 		Is not recommended for routine use in adult cardiac arrest patients	2 g IV, followed by a maintenance infusion
Sodium bicarbonate	Correction of maternal acidosis	May worsen fetal acidosis Since crosses the placenta, overcorrection of maternal acidosis will lead to pooling of carbon dioxide in the fetal compartment	Guidelines do not recommend routine use Useful in life-threatening hyperkalemia or tricyclic antidepressant overdose	1–2 mEq/kg IV
Amiodarone	Primary drug in the arrhythmia treatment algorithm VF or VT unresponsive to defibrillation, CPA, and epinephrine	<ul style="list-style-type: none"> Hypothyroidism or hyperthyroidism in the mother or fetus because of the iodine in amiodarone Fetal bradycardia Fetal QT interval prolongation Premature labor Low birth weight 	Neonates of mothers taking amiodarone should have complete thyroid function tests and developmental follow-up	300 mg IV with a repeat dose of 150 mg IV as indicated

Table 3. Medications used in CPA and its consequences in pregnancy.

biphasic energy dose for synchronous cardioversion of atrial fibrillation is 120–200 J. The initial monophasic dose for synchronous cardioversion of atrial fibrillation is 200 J. In general, atrial flutter cardioversion and other supraventricular rhythms require less energy. An initial energy of 50–100 J with a single-phase or biphasic device is usually sufficient. If the first discharge of the cardioversion fails, the dose should be increased stepwise.

6. Modifications of the basic support and advanced cardiac life support in pregnancy

The three major modifications during the pregnant patient CPR are given in below sections.

6.1. Shift of the uterus to the left at 15–30° and upward during chest compressions

To improve placental perfusion and enable a perimortem cesarean, it has been described that thoracic compressions in non-pregnant patients produce 30% of the CG, to which 25% more is added by applying the lateralization of the uterus to the left. For this purpose, a blanket can be placed under the right hip or the Cardiff resuscitation wedge, which maintains the patient in the left dorsal decubitus position at 27° since an inclination greater than 30° has been associated with a significant decrease in force generation during chest compression.

6.2. Early endotracheal intubation

Waive ventilation with bag-mask and proceed directly to endotracheal intubation by the most experienced person, as the physiological changes of pregnancy increase 10 times the risk of complications they put. It is life-threatening mainly because of decreased functional residual capacity (CRF) by compression of the pregnant uterus, resulting in rapid desaturation, as well as edema (often thin tubes are used) and hyperaemia of the upper airway which cause frequent bleeding and make it difficult to visualize the vocal cords, especially in the presence of preeclampsia. In addition, decreased gastric motility and relaxation of esophageal sphincter tone increase the risk of aspiration. For all of the above, it is also recommended the use of muscle relaxants and rapid intubation sequence (SIR), as well as nasogastric tube placement (SNG) [12–14].

6.3. Cesarean perimortem

Cesarean perimortem is defined as the birth of the fetus after maternal cardiac arrest. Birth is almost always accomplished through cesarean delivery, but assisted vaginal delivery is appropriate if the cervix is fully dilated and the neonate is at a low station and can be delivered within 5 min of maternal cardiorespiratory collapse [15]. A review of published cases up to 2010 has showed that the cesarean perimortem led to a clear maternal survival benefit 31.7% [16].

The purpose of the cesarean perimortem is twofold. The first is facilitation of resuscitation, relieving aortocaval compression by emptying the uterus significantly improves resuscitative efforts. Second, early delivery of the baby, is accomplished with a decreased risk of permanent neurological damage from anoxia.

It is contemplated within the “four-five rule” of obstetric stop, which consists of starting the cesarean section 4 min after the maternal cardiac arrest so that he drinks be born within 5 min after the arrest spontaneous circulation and not later, especially when the cause is irreversible (e.g. abrupt), which in turn improves the maternal GC by 30% with autotransfusion of 500 ml. It is the most important consideration in the OP. According to Katz, 71% of babies surviving maternal cardiorespiratory arrest with good neurologic outcome were removed in 5 min or less. Therefore, fetal extraction is considered as the “D” of cardiopulmonary resuscitation in the pregnant woman.

Sudden substantial improvement in hemodynamics with a return of pulse and blood pressure immediately after perimortem cesarean delivery has been observed.

There are three pathophysiological states (in relation to the uterus and navel): O Pregnancy < 20 weeks, AU below navel: impaired hemodynamic compromise for the mother by the uterus, non-viable baby. No benefit of cesarean perimortem.

Or pregnancy of 20–23 weeks, AU up to 3 cm above the navel: possible hemodynamic involvement of the mother by the uterus, probably not viable baby. Consider cesarean perimortem to save the life of the mother.

O pregnancy \geq 24 weeks, AU at 4 cm above the navel: possible hemodynamic compromise exerted by the uterus, cesarean section perimortem is indicated during cardiopulmonary arrest to benefit the mother as well as the fetus. Consider not closing the abdominal incision

if cesarean section was necessary, to bind blood vessels as well as reduce the possibility of an abdominal compartment syndrome [2, 3, 6–10].

If the cesarean perimortem could not be performed by the 5-min mark, it was still advisable to prepare to evacuate the uterus while the resuscitation continued, infant survival has been seen even when delivery occurred > 5 min from the onset of maternal cardiac arrest. Neonatal survival was documented even when delivery occurred up to 30 min after the onset of maternal cardiac arrest [17]. The procedure should be performed at the site of the maternal resuscitation. Time should not be wasted in moving the patient or waiting for surgical equipment or doing abdominal preparation [18]. The only equipment needed to start is a scalpel [5].

7. Other considerations

- Regarding the drugs used in a cardiorespiratory arrest, these do not differ in the pregnant patient, although it is recognized that the vasopressors could decrease the uterine blood flow, remember that the best possibility for the survival of the fetus is the survival of the mother.
- Regarding the energy used for defibrillation/cardioversion, pregnancy does not significantly alter the electrical impedance of the chest wall and no deleterious effect of maternal defibrillation/cardioversion has been reported in newborns.
- Oxytocin and prostaglandins may be considered to correct uterine atony.
- In summary, an Obstetric Code (OC) is a situation in which a doctor can save two lives as long as resources are available and procedures are performed in less than 5 min [15, 19, 20].

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