Cardiopulmonary Resuscitation in the Pregnant Patient – An Update

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CASE REPORT
A 35 year old, 38 weeks pregnant, apparently healthy woman was referred by her family physician urgently to our labor and delivery unit due to concern about her lack of appetite over the past week and her altered mood. Her 15 year old son confirmed that she appeared depressed and had not left the house for the past week. Her communication difficulties were attributed to her new immigrant status in Israel. She appeared exhausted with low mood. At this stage there was no specific diagnosis. Upon admission to the hospital her vital signs were stable: blood pressure 120/70 mmHg, heart rate 70 beats/minute and oxygen saturation 98% on room air. Fetal heart rate tracing was also normal. She was not in active labor and did not complain of pain. The on-duty anesthesiologist was asked to consult the patient regarding epidural analgesia once in active labor. The patient appeared confused and uncooperative, and approximately 10 minutes after the history-taking and examination had begun the patient’s trachea was intubated while receiving cardiac massage at a rate of 100/min, 10 breaths/ min and two intravenous boluses of 1 mg each of atropine and epinephrine. Spontaneous circulation and normal blood pressure resumed after 2 minutes of CPR, but the patient remained unconscious with both pupils dilated and unreactive to light. Approximately 5 minutes after the diagnosis of CA, an emergency cesarean delivery was performed in the operating room which was situated inside the delivery unit. The patient remained unresponsive (no movement, with unchanged heart rate and blood pressure) to the surgical

Some reasons for cardiac arrest in pregnancy are reversible and should be recognized and managed promptly

CA = cardiac arrest
CPR = cardiopulmonary resuscitation
stimulus. The patient received no anesthesia and only 100 µg IV fentanyl for analgesia, with no muscle relaxants. The baby was delivered with an Apgar score of 4/6 and a pH of 7 and his condition gradually improved during the following hours. Following the cesarean delivery the mother remained unresponsive, with a Glasgow Coma Scale of 3. A brain computed tomography scan revealed severe diffuse brain edema. She patient was treated with mild hyperventilation, mannitol, rest in a semi-recumbent position and oxygen to keep her oxygen saturation above 98%. Following resolution of some brain edema, a huge frontal herniated brain tumor was revealed. The tumor was considered inoperable and the patient died 5 days later.

This case emphasizes that CPR skills may be required unexpectedly in the labor ward and that management of cardiac arrest involves prompt initiation of the correct treatment, which could include cesarean delivery and treatment of the underlying cause of the CA [3,4].

PATHOPHYSIOLOGY OF CARDIAC ARREST IN PREGNANCY
In pregnant women, CA is complicated by the pathophysiological changes that occur during pregnancy, especially aortocaval compression. During CPR with closed chest massage in non-pregnant patients the maximal cardiac output approximates 30% of normal [5]. In patients ≥ 20 weeks pregnant lying in the supine position, the cardiac output is further decreased by 30–50% due to aortocaval compression [5]. This implies that if these patients suffer CA when placed in the supine position, there will be practically no cardiac output at all despite a correctly performed CPR.

Patients in advanced pregnancy also have a tendency for rapid development of hypoxemia and acidosis, a higher risk of pulmonary aspiration, and an increased incidence of difficult intubation as compared to the non-pregnant population. These changes are exaggerated by multiple pregnancy and obesity, all of which make the resuscitation more difficult.

ETIOLOGY AND DIFFERENTIAL DIAGNOSIS OF CARDIAC ARREST IN PREGNANCY
It is imperative to identify reversible causes of CA. The age of pregnancy should be quickly established in order to decide on fetal viability. Abdominal ultrasound examination is used for this purpose but it should not delay resuscitation procedures.

The etiology of CA in pregnancy can be classified into anesthesia-related causes and/or non-anesthesia-related causes [Tables 1 and 2]. Occasionally, the etiology is multifactorial, making the diagnosis and management more challenging.

ANESTHESIA-RELATED MATERNAL MORTALITY
The 1990-2003 USA closed claims data in obstetric anesthesia reported 69 cases of anesthesia-related death or severe brain injury; 18% (vs. 6.7% in the non-pregnant surgical population) were linked to airway problems. Airway catastrophes were also related to some poor fetal outcomes [8].

It is noteworthy that through the decades, a change in anesthesia-related maternal mortality trends has been observed. Around 40 years ago, the aspiration of gastric contents was the leading cause of anesthesia-related maternal death, but in the following 20 years the culprit was failed intubation. More recently, attention to airway loss during induction of anesthesia has led to a decrease in airway mortality during induction. However, mortality related to airway problems during extubation of the trachea has increased, as has spinal anesthesia-related mortality [9,10].

The last Confidential Enquiries into Maternal And Child Health (CEMACH) in the United Kingdom 2003–05 reported that in six cases maternal death was directly related to anesthesia, a similar figure to that reported in 2000–02. There were three cases of postoperative airway loss: all occurred in morbidly obese parturients [11]. Twenty-seven percent of all maternal deaths (directly or indirectly related to anesthesia) occurred among obese women (body mass index > 30), whereas 24% occurred among overweight women (BMI > 25). Two obese

### Table 1. Etiology, mechanism, characteristics and management of anesthesia-related CA in pregnancy

<table>
<thead>
<tr>
<th>Category</th>
<th>Mechanism</th>
<th>Characteristics</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anoxic/hypoxic</td>
<td>Failure to oxygenate due to failed intubation/ventilation and/or aspiration of gastric contents</td>
<td>• Obese patients&lt;br&gt;• Other reasons for difficult airway</td>
<td>Rescue airway procedures</td>
</tr>
<tr>
<td>Hemodynamic/</td>
<td>High/total spinal (see below: specific mechanisms)</td>
<td>• Local anesthetic overdose&lt;br&gt;&quot;Barbotage&quot; of the CSF&lt;br&gt;Unrelieved aortoacaval compression</td>
<td>Hemodynamic &amp; respiratory support</td>
</tr>
<tr>
<td>Respiratory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxicity</td>
<td>Local anesthetic toxicity (overdose or IV injection)</td>
<td>• Specific symptoms&lt;br&gt;• Neurologic signs&lt;br&gt;• Hemodynamic signs&lt;br&gt;• Respiratory arrest</td>
<td>Hemodynamic &amp; respiratory support, Intralipid® (Pharmacia &amp; Upjohn)</td>
</tr>
</tbody>
</table>
or if necessary endotracheal intubation can be performed with cricoid pressure.

**CARDIAC ARREST IN PREGNANCY – ADVANCED CARDIAC LIFE SUPPORT GUIDELINES**

The following are updated guidelines [5] for which there are several modifications for pregnant women, taking into account the lives of both mother and fetus since fetal survival depends on maternal survival.

**Key interventions for managing cardiac arrest in pregnant women:**

- Ventilate the patient with 100% oxygen
- Establish IV access and give a fluid bolus
- Consider the possible cause of cardiac arrest to ease targeted management

1. **Left lateral position**

Place the patient on a hard surface in 15°-30° left lateral tilt position or pull the uterus to the side. The left tilt can be
achieved manually or with a rolled blanket under the right hip and lumbar area.

2. **Airway and breathing**
Apply continuous cricoid pressure during ventilation and intubation due to the risk of regurgitation. Consider the possibility of airway edema especially in parturients with gestational hypertension which can make endotracheal intubation difficult. Start with two rescue breaths of one second each. Bag-mask ventilate at a rate of 8-10 breaths/min and a tidal volume large enough to raise the chest, during pauses of compressions (synchronization). Synchronization between chest compressions and ventilation is not necessary with an advanced airway (endotracheal tube) in place. It must be noted that hyperventilation is harmful and should be avoided.

3. **Circulation**
Chest compressions are performed higher than in non-pregnant patients, slightly above the center of the sternum due to the elevated diaphragm and abdominal contents. Chest compressions should be performed with the patient lying on a hard surface. “Push fast and hard”! Place the heel of one hand on the center of the chest. Place the other hand on top. Interlock the fingers and compress the chest at a rate of 100/min, a depth of 4-5 cm and equal compression:relaxation times. It is recommended that the CPR operator be changed every 2 minutes. Although vasopressors (epinephrine, vasopressin) reduce blood flow to the uterus, current recommendations advise using standard drugs in standard adult ACLS doses. A single dose of vasopressin 40 units is an alternative to repeated epinephrine injection. Amiodarone 300 mg IV has replaced lidocaine for treatment of ventricular arrhythmias.

4. **Compression-ventilation (C-V) ratio**
A C-V ratio of 30:2 is recommended. With two or more rescuers switch the compressor every 2 minutes or every five cycles of C-V. In the newborn give two ventilations after 15 compressions (C-V ratio of 15:2).

5. **Defibrillation**
Standard ACLS defibrillation doses should be used. Survival rates are highest with immediate CPR and defibrillation within 3 to 5 minutes of a witnessed pulseless ventricular tachycardia or fibrillation. Defibrillation is administered at the following doses:
- **Biphasic – truncated exponential waveform** 150-200 J
- **Biphasic – rectilinear waveform**: 120 J
- **Newborn** – 2 J/kg for the first attempt and 4 J/kg for subsequent attempts
- The ACLS guidelines emphasize the importance of availability of automated external defibrillators.

Electric cardioversion during pregnancy has been described in the literature and appears to be safe for the fetus [12].

In pregnant women a secondary reassessment of the airway and breathing is critical to consider early intubation owing to the risk of aspiration. The endotracheal tube size should be half a size smaller and the correct position should be confirmed with capnography. Incorrectly applied cardiac compressions in pregnant patients with CA may be complicated with liver laceration, uterine rupture, hemothorax and hemopericardium.

**EMERGENCY DELIVERY**
If cardiac arrest is not immediately (4-5 minutes) reversed by basic and advanced life support, emergency hysterotomy (or cesarean delivery) should be performed at > 20 pregnancy weeks. The best survival rate for an infant is at age > 24 or 25 weeks if delivered < 5 minutes after CA [13]. Gestational age may not always be known and ultrasonography can be used if time permits. It is important to recognize that a promptly performed cesarean delivery may save the mother and her infant.

Timely hysterotomy delivers the fetus, empties the uterus, restores venous return and aortic flow and, in addition, allows newborn resuscitation. Cesarean section might be necessary to accomplish a successful resuscitation even if the fetus has died.

Immediately following the diagnosis of CA, a well-trained team comprising a gynecologist, anesthesiologist, neonatologist and midwives should activate the departmental hysterotomy protocol, in parallel with the CPR efforts. This requires preparation of the operating room for an emergency hysterotomy which ideally should be performed no longer than 4-5 minutes after initiation of CPR. If CPR fails following hysterotomy, open cardiac massage and cardiopulmonary bypass should be considered.

**CONCLUSIONS**
Cardiac arrest is a rare, unexpected and devastating event for pregnant patients and those treating them. Early anticipation and treatment may prevent CA, for example following high spinal block. Multidisciplinary teams should be familiar with the ACLS guidelines and their special modifications for pregnant women. In addition, there should be a well-conceived
hysterotomy protocol in delivery rooms, which should be fully equipped for both resuscitation and emergency hysterotomy within 4-5 minutes.

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