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Case report

Challenges during cardiac arrest in pregnancy

*Korneel Berteloot**, *Marc Sabbe*

Abstract

A 36-year-old woman at 23 weeks and 3 days of gestation experienced a witnessed cardiopulmonary collapse. Bystander cardiopulmonary resuscitation (CPR) was initiated immediately. After advanced life support, she was transferred under mechanical CPR to a hospital for extracorporeal membrane oxygenation (ECMO). There, a delayed perimortem caesarean section (PMCS) was performed. Consideration to initiate ECMO following the PMCS was ultimately discontinued due to extensive intra-abdominal haemorrhage and the elapsed time of over one hour since the collapse. A full body computed tomography (CT) scan following ROSC revealed bilateral pulmonary embolisms and grade 4 liver laceration with active bleeding due to mechanical CPR. Despite the prolonged duration of cardiac arrest (69 min) and significant metabolic derangements, the patient had a favourable recovery and was discharged after 42 days with a good neurological outcome. This case illustrates the challenges of timely perimortem caesarean section in out-of-hospital cardiac arrest, where guidelines recommend performing the procedure within 4 min of maternal collapse. It also highlights the risks associated with mechanical chest compression devices.

Keywords: Pregnancy, Cardiac arrest, Perimortem section caesarean, Mechanical cardiorespiratory resuscitation, Extracorporeal cardiopulmonary resuscitation, Pulmonary embolism

Introduction

Cardiac arrest in pregnant women is rare, it occurs one in every 36 000 maternities. The most common causes are heart disease (23%), thromboembolism (16%), epilepsy and stroke (13%), sepsis (10%), mental health conditions (10%), bleeding (8%), cancer (4%) and pre-eclampsia (2%).[1]

Pregnancy is accompanied by some physiological changes. It causes an increase in cardiac output, blood volume, respiration and oxygen demand. After 20 weeks of gestation the enlarged uterus can press against the inferior vena cava and the aorta leading to reduced venous return and decrease in cardiac output. Additionally, the functional residual capacity decreases as the enlarging uterus elevates the diaphragm.[2,3] Treatment of a collapsed pregnant woman differs in several aspects from a normal resuscitation. This includes release of the aortocaval compression and making a decision regarding perimortem section delivery. Moreover, the primary difference is the responsibility for two patients: both foetus and mother.[1–3]

A key factor that improves survival is good quality cardiopulmonary resuscitation (CPR). This involves four aspects: a high compression rate (100 to 120 per minute), sufficient compression depth (5 cm in adults), full chest recoil, and minimal hands-off time.[1,2]

Cardiopulmonary resuscitation (CPR) can be performed manually or mechanically. Mechanical chest compression devices deliver consistent compressions, freeing paramedics from manual compressions and allowing focus on other aspects of patient care. There are two main types of mechanical chest compression devices: piston devices (e.g., LUCAS or Corpuls) and load-distributing band devices (e.g., AutoPulse). Piston devices use a piston mounted on a frame that encircles the patient's chest, driven by compressed air or an electric motor to compress the chest similarly to manual compressions. In contrast, load-distributing band devices like AutoPulse use a wide band that alternately shortens and lengthens around the chest, providing rhythmic compressions.[4]

The European Resuscitation Council (ERC) recommends extracorporeal cardiopulmonary resuscitation (eCPR) as a rescue strategy when standard advanced life support (ALS) measures fail. ECPR involves the use of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) during cardiac arrest.[1]

* Corresponding author at: Herestraat 49, 3000 Leuven, Belgium.
E-mail address: korneel.berteloot@student.kuleuven.be (K. Berteloot).

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Case presentation

Pre-hospital

A 36-year-old woman at 23 weeks and 3 days of gestation (G2P1) with no significant medical history called emergency services reporting "presyncope". Upon ambulance arrival, she was pale and complained of dorsal pain. Vital signs revealed sinus tachycardia at 124 beats per minute and hypotension (70/40 mmHg). Respiratory rate was 50 per minute and saturation was not measurable. Nine minutes later, the patient experienced a sudden cardiac arrest and bystander CPR (ambulance personnel) was promptly initiated.

Four minutes post-cardiac arrest, the mobile emergency unit arrived and advanced life support (ALS) was started. Initial rhythm assessment demonstrated pulseless electrical activity (PEA). A total of four doses of intravenous adrenaline were administered. Airway management was secured following endotracheal intubation. A perimortem caesarean section was not performed prehospitally due to limited experience and concerns about the procedure's feasibility in an unsuitable environment. To reduce aortocaval compression, a left lateral tilt was utilized. During prehospital resuscitation, the patient briefly regained cardiac output twice for less than 2 min. Manual chest compressions were transitioned to mechanical compressions when prolonged CPR and hospital transfer for potential ECMO was required. Following horizontal evacuation by the fire department, resulting in prolonged transport, she was transferred under mechanical CPR provided by the CORPULS device. The position of the CORPULS was verified both pre-hospital and at arrival, confirming correct placement.

In-hospital

Upon arrival, 58 min post-collapse a perimortem caesarean section (PMCS) was immediately performed by the obstetrician through a vertical xiphopubic incision, as recommended by the ERC. Significant intra-abdominal bleeding was noted. Unfortunately, the foetus was stillborn three minutes after hospital arrival. No neonatal life support (NLS) was provided due to a gestational age of less than 24 weeks and prolonged CPR.

The consideration to initiate ECMO following the perimortem caesarean section was ultimately discontinued due to extensive haemorrhage and the elapsed time of over one hour since the collapse. Initial transesophageal echocardiography (TEE) did not indicate a pulmonary embolism, as no D-shaping of the right ventricle was observed. The working diagnosis was haemorrhagic shock, treated according standard of care. In total, 4 units of blood, 2 units of plasma, and 1 unit of platelet concentrate were administered. Also, 1 g of tranexamic acid IV, 10 IU of oxytocin IV, 5 IU of oxytocin intrauterine, and 1 g of calcium chloride for hypocalcemia correction due to massive transfusion was given. Abdominal exploration revealed a liver laceration in the right lobe, for which a 4-quadrant abdominal packing was performed by the abdominal surgeon in the emergency department.

Despite the patient's critical status, with a blood gas showing an unmeasurably low pH (pH < 6.8), severe hypercapnia (pCO_2 71.8 mmHg), and lactate levels of 19 mmol/L, resuscitation efforts were continued. Capnography readings remained high (>50 mmHg) despite low flow, indicating respiratory acidosis. Following delivery, ALS was resumed as no rhythm check was performed due to the consideration of initiating extracorporeal cardiopulmonary resuscitation (ECPR). Initial rhythm was again PEA, but following two doses of adrenaline, return of spontaneous circulation (ROSC) was achieved at 69 min following collapse.

Post-resuscitation and further management

A full-body computed tomography (CT) scan performed post-ROSC identified bilateral pulmonary embolisms, which were not initially suspected. Additionally, the scan revealed a grade IV liver laceration near segments 7/8 with active bleeding in the right subphrenic region. A surgical revision in the operating room was performed to manage hemodynamic instability despite vasopressors. This included liver hemostasis, abdominal packing, and packing of the Retzius space. The uterus was closed as no bleeding focus was identified. The patient was subsequently transferred to the intensive care unit (ICU) for continued care. Pulmonary emboli were initially treated with low molecular weight heparin (LMWH), with dosing adjusted based on anti-Xa levels, and later switched to a new oral anticoagulant (NOAC) in the second stage. Despite prolonged cardiac arrest and severe metabolic disturbances, she had a favorable recovery and was discharged after 42 days with a good neurological outcome.

Discussion

In this case, no pre-hospital resuscitative caesarean section was performed, despite that ERC guidelines recommend to be carried out within 4 min of collapse. A British study demonstrated that a shorter time interval between collapse and performing a perimortem caesarean section was associated with improved survival. The time between collapse and delivery was 7 min in the survival group compared to 16 min in the maternal death group. An important factor was the location of the out of hospital cardiac arrest (OHCA), with cardiac arrest occurring at home being linked to higher mortality. Other reasons for delayed PMCS include lack of experience or knowledge, fear of performing the procedure in an unsuitable environment, concerns about medicolegal consequences, and the misconception that PMCS is only performed for foetal benefit.[5] A French cohort study, on the other hand, noted that performing a PMCS within 5 min of collapse in the pre-hospital setting is nearly impossible, primarily due to response times alone.[6]

The overall survival rate following cardiac arrest in pregnant women is approximately 60%.[2,5] However, in the subgroup of out-of-hospital cardiac arrest (OHCA), survival drops to around 15%.[6] Despite the well-documented positive impact of bystander CPR on survival, its implementation remains limited. A French study reported that, although 72.7% of out-of-hospital cardiac arrests in pregnant women were witnessed, CPR was initiated in only 38.2%. Increasing public education on recognising cardiac arrests and perform basic life support (BLS), including techniques such as left uterine displacement during pregnancy, could enhance maternal survival outcomes.[6] Moreover, healthcare providers also need additional training due to the rarity and complexity of cardiac arrest during pregnancy. This training should focus on obstetric-specific procedures, effective communication, and coordinated multidisciplinary teamwork.[5]

To the best of our knowledge, this case represents the longest time from collapse to ROSC resulting in maternal survival with good neurological outcome, particularly considering the delayed PMCS. A possible explanation includes the immediate initiation of bystander CPR, as well as a potentially prolonged period of low-flow circulation

rather than no-flow, as suggested by the high capnography values and the brief ROSC achieved twice.

There is no evidence that mechanical CPR provides superior survival outcomes over manual CPR. Nevertheless, mechanical devices can be helpful to deliver chest compressions where manual CPR is difficult or impossible, such as during ambulance transport or may be used as a bridge to advanced treatments such as ECMO.[4] Several studies have shown a higher incidence of CPR-related injuries with mechanical CPR, ranging from rib fractures to severe complications such as bleeding, pneumothorax, liver lacerations, and mediastinal hematomas.[7,8] These injuries are often attributed to the deeper compressions provided by mechanical devices, particularly during prolonged use. Incorrect device application or misalignment further increases the risk of iatrogenic injuries.[7,8] Additional, a *meta*-analysis found that mechanical CPR causes more compression-induced injuries than manual CPR, with no difference in life-threatening injuries. The piston devices, in particular, are associated with a higher risk of skeletal and visceral injuries, including fractures, cardiac and liver lesions, and haemothorax, compared to manual CPR.[9]

Limited evidence exists regarding the use of mechanical chest compression devices in pregnant patients. Consequently, their use is not recommended by the American Heart Association (AHA) or the ERC.[1,2] A study by Sung et al. describes the development of a new mechanical CPR device, named Mechelper, that can be safely applied to the pregnant population. Further research will be needed to confirm its effectiveness and safety[10]

Liver injury during CPR is rare, but mechanical chest compressions are associated with a five-fold higher risk of liver laceration compared to manual compressions.[8] A congested liver is more prone to injury, and pulmonary embolism can contribute to this by causing acute right ventricular failure and retrograde flow in the hepatic veins.[11] Pregnancy-related physiological changes, including hepatic congestion and diaphragm elevation, may increase the risk of liver injury during CPR as well. The enlarged uterus and reduced abdominal space can compress the liver capsule, while increased intravascular volume and hepatic congestion enhance susceptibility to injury. Cox et al. found that 43% of pregnant patients who survived CPR had a liver laceration, significantly higher than the 0.6–2.1% incidence observed in the general population.[12]

Extracorporeal life support (ECLS) is increasingly used to improve survival rates in pregnant patients, with common indications including acute respiratory distress syndrome (ARDS, 49.4%), cardiac failure (18.7%), and cardiac arrest (15.9%). The 30-day maternal survival rate following ECLS is 75.4%, with survival following cardiac arrest reaching 87.7%, significantly higher than standard CPR (~60%).[13,14] Intact neurological survival is reported at 78.9%. These favorable outcomes may be attributed to the younger, healthier patient population and the higher prevalence of reversible conditions, although publication bias should be considered. Fetal survival following ECLS is 67.4%, though data on long-term outcomes is limited. Maternal complications are rare, with bleeding, deep vein thrombosis (DVT), and vascular issues being most common.[14] Current evidence on ECLS use in pregnancy is primarily based on case series, case reports, and select systematic reviews since 2015. Despite this, ECLS is considered a viable rescue therapy for pregnant patients in cardiac arrest, offering favorable maternal and fetal outcomes with low complication risks.[14] A multidisciplinary consultation is essential prior to initiating ECLS, and decisions should be made on a case-by-case basis.[15] In this case, the decision not to proceed with ECLS was made after a multidisciplinary discussion, considering the late hospital presentation (>1 h post-collapse), ongoing bleeding, and lack of other reversible causes, in line with current guidelines.

Conclusions

This case highlights the challenges of performing a PMCS within the critical four-minute window in clinical practice. It also demonstrates caution when using mechanical CPR devices due to their association with iatrogenic injuries, though they can be useful in certain situations, such as during transport. This case emphasizes that decisions regarding the termination of CPR or the potential initiation of eCPR should be made on a case-by-case basis, with a multidisciplinary consultation.

CRediT authorship contribution statement

Korneel Berteloot: Writing – original draft, Resources, Investigation, Conceptualization. **Marc Sabbe:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100855.

Author details

Department of Emergency Medicine, University Hospital Gasthuisberg, Leuven, Belgium

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