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Resuscitative hysterotomy – current state of knowledge

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Abstract

Cardiac arrest in pregnant patients is an extremely rare situation in clinical practice. However, when encountered, immediate decision-making is required in order to preserve the life and health of the mother and newborn. The pregnant uterus causes pressure on the inferior vena cava and abdominal aorta, reducing venous return and, consequently, cardiac output. Current guidelines recommend initiating a rescue hysterotomy if the return of spontaneous circulation is not achieved within 4 minutes. Once ROSC is achieved, the patient requires anaesthesia and control of massive haemorrhage by pelvic packing and the use of tranexamic acid. Studies suggest a linear relationship between delivery time and maternal and neonatal survival. Cases of maternal survival beyond 14 minutes after cardiac arrest are rare, but neonates often still have a chance. Cases of successful RH performed in the pre-hospital setting have been described. Adequate team preparation is key, and it can be achieved through high-fidelity simulations, among other things. *Anestezjologia i Ratownictwo 2025; 19: 17-23. doi:10.53139/AIR.20251906*

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Introduction

The incidence of cardiac arrest in pregnant women

Maternal cardiac arrest is an uncommon situation in clinical practice; however, when it occurs, it is essential to make instant decisions, as they can have a significant impact on the health and lives of the mother and child/children [1,2]. The prevalence of this occurrence may appear in 1 in every 12 000 to 55 000 pregnancies; these values differ depending on the reference [3-5]. The survivability of fetuses in the case of maternal cardiopulmonary arrest oscillates between 61 and 80% which is higher than the survivability of the pregnant woman. Most infants do not present neurological deficits, but sometimes neonates are born with permanent nervous system consequences. The survival rate of pregnant women experiencing cardiac arrest is less prognostically favourable as around 31-83% of them die [4].

Aetiology of cardiac arrest in pregnant women

A review of the literature shows that the most common causes of maternal cardiac arrest are cardiovascular diseases, trauma, sepsis, eclampsia, amniotic fluid embolism, pulmonary thromboembolism, drug overdose, and hemorrhagic complications [3,6-8]. Among these, the top two causes of death during pregnancy are cardiac infarction and aortic dissection [7]. If the causes of maternal cardiac arrest are reversible, they should be removed as soon as possible to enhance the prognosis of the pregnant woman. For example, in the case of trauma, it is crucial to eliminate reversible causes such as hypoxia, hypovolemia, or pneumothorax [9].

Physiological modifications during pregnancy

Pregnancy is related to physiological changes in the female body that are connected with the development of the fetus. Knowing these changes allows for more efficient cardiopulmonary resuscitation (CPR). For example it is essential to know that shock can only occur if the mother has lost at least 40% of her circulating blood [10].

In pregnant women, cardiac output rises by 40% [11]. This occurrence is associated with a 40-45% increase in circulating blood volume, a decrease in systemic vascular resistance, and a rise in heart rate. During CPR of an adult, compressions of the sternum generate 30% of standard cardiac output, whereas in pregnant females it generates considerably less [12]. Therefore, there is a risk of fetal hypoxia because of supplying too little blood to the uterus [13]. Additionally, while the pregnant woman is lying on her back, the uterus constricts the inferior vena cava and abdominal aorta. As a result of this compression, venous blood return and consequently cardiac output decreases [3,12]. Therefore, there might be a need to change the pregnant woman's position from lying on her back to lying on her left side with her body angled to 30° [12].

Furthermore, oxygen uptake increases by 20% during pregnancy, and respiratory volume expands [11,12]. Pregnant women also experience respiratory alkalosis, which results in compensatory metabolic acidosis [11]. Therefore, oxygen saturation should be maintained at 95% so that oxygen administration may be necessary. Finally, pregnancy can result in oedema of the upper airways, which is associated with difficult intubation [12].

If, at the onset of CPR, a pregnant woman presents with hypoxia, hypercarbia, or acidosis, there is a possibility of aspiration of gastric contents, which can be one reason for inefficient CPR [14]. Uterine constriction of abdominal vessels and progesterone-related relaxation of the gastropharyngeal sphincter also conduce to aspiration of gastric contents [12].

Resuscitative hysterotomy (RH) is explained as a cesarean section that accompanies cardiopulmonary resuscitation (CPR) during maternal cardiac arrest [1,12]. As mentioned previously, uterine compression on abdominal vessels may lead to ineffective CPR. Therefore, performing RH is beneficial for the mother because it decreases the constriction of the uterus by evacuating the infant(s) [8,11].

Among the indications for RH are no return of spontaneous circulation after 4 minutes of appropriate CPR, gestational age greater or equal to 24 weeks, and a short time from the start of maternal cardiac arrest to the RH procedure [6,9]. All of these aspects must be present.

Contradictions to RH are gestational age shorter than 24 weeks, maternal cardiac arrest lasting less than 4 minutes, and obtaining ROSC in a short time after initiatory CPR. It is not strongly advised to perform RH several minutes after the onset of the mother's cardiac arrest as there is no unambiguous evidence of its effectiveness in this situation [6,9]. Some case reports confirm the survivability of the pregnant woman and delivery of the baby without neurological deficits despite performing delayed RH [15]. However, more research is required on this issue.

Resuscitative hysterotomy should be carried out where the maternal cardiac arrest started. In the case of out-of-hospital maternal cardiac arrest, it might not be possible to maintain sterile conditions as RH is an urgent procedure without the accessibility of high-tech equipment [3,15]. During the resuscitative hysterotomy, there is a necessity to look out for the urinary bladder and avoid harming the neonate. Additionally, chest compressions must be done during the RH procedure without taking a break for longer than 10 seconds [16].

Aim of the work

This study aimed to summarise current data on resuscitative hysterotomy (RH). The literature review was performed between the 25th and 29th of November 2024, covering papers published between 2014 and 2024. International literature was accessed through the Pubmed database. The following keywords and descriptors from the MeSH (Medical Subject Headings)

thesaurus were used: "perimortem cesarean section". "perimortem cesarean delivery", "cardiopulmonary resuscitation", "Cesarean Section", "out-of-hospital cardiac arrest".

Current knowledge

Current guidelines

Based on the guidelines of the American Heart Association, Society for Obstetric Anesthesia and Perinatology, and European Resuscitation Council, the following steps for the management of maternal cardiac arrest have been developed [4]:

1 Rapid gestational age assessment based on the uterine fundus' height. If the uterus is palpable at or above the level of the umbilicus, the estimated gestational age is above 20 weeks and may cause aortocaval compression.
2. Manual displacement of the gravid uterus to the left side to relieve aortocaval compression.
3. Immediately initiate basic life support and implement advanced life support as soon as trained personnel are available.
4. Carry out RH if ROSC is not obtained within 4 minutes of the cardiac arrest, resulting in delivery within 5 minutes. In in-hospital cases, the patient should not be transported to the block; RH should be performed at the scene. The team does not need to wait for surgical equipment; a scalpel is sufficient [7]. Before starting RH, reversible causes of cardiac arrest should be ruled out, including controlling massive haemorrhage, maintaining airway patency, and ruling out pneumothorax and cardiac tamponade. RH should be performed by the surgeon with the most experience [2]. RH should be performed by a vertical midline laparotomy incision. A study showed that even trauma surgeons took more time to do RH through a lower transverse abdominal incision [17]. Providers familiar with the Pfannenstiel incision can use it if it ensures expeditious delivery [11]. RH is used in an emergency and in the patient's best interest and, therefore, does not require informed consent [9].
5. Once ROSC is achieved, the patient will require anaesthesia, minimal surgical closure, or packing of the abdomen. Massive haemorrhage is a possible complication of RH - hemostatic drugs such as TXA should be used. Studies recommend administering 1-2g of TXA in a bolus per minute and administering a uterotonic agent such as 10 units of oxytocin intramuscularly. The patient also requires transport to a centre providing emergent surgical care.

It should be noted that there are no reported cases in the literature that a physician was prosecuted for performing RH, but there has been legal action against a doctor who did not perform RH [18].

4 - minute rule - discussion

The "delivery by five minutes" rule was proposed by Katz in 1986 based on observations of fetal survival [2]. The pathophysiological basis for recognising this rule is to minimise neurological damage in the mother caused by central nervous system hypoxia [11]. One study associated RH performed within 5 minutes with a 95% fetal survival rate [16]. When examining maternal and infant survival, discontinuous survival rates before and after 5 minutes were not proven. Studies suggest that the relationship between survival and delivery time is more linear [20].

The moment of cardiac arrest, understood as the loss of signs of life and central pulses, is not always the same as the moment at which circulation stops. In hypovolemia or haemorrhage, very low cardiac output may be preserved. This phenomenon may have resulted in some of the more prolonged successful resuscitations following RH, which makes it worth considering RH well after the 4-5 minute time window [9]. Cases have been described of neonatal survival in RH undertaken 13, 14, and 21 minutes after cardiac arrest, significantly beyond the proposed 4 minutes [17]. In the CAPS study, maternal survival depended on the time from cardiac arrest to the start of RH. All surviving mothers had RH performed in under 12 minutes [17]. Although maternal survival above 14 minutes is rare, there is still a chance for the newborn and no further risk for the mother [17].

Impact of resuscitative hysterotomy on the survival and subsequent health state of the mother

The authors of the medical articles emphasise that the survivability of the fetus is not the prime objective. The foremost purpose is to increase the effectiveness of CPR in the pregnant woman [3,9,10].

Reanimation of pregnant women might be negatively affected by some factors. As mentioned previously, aorto-caval uterine constriction and reduced cardiac

output generated by sternum compressions are crucial aspects that should be discussed. There is a necessity to perform RH if there is no decrease in uterine compression after placing the pregnant woman on the left side with her body inclined at an angle of 30 degrees. Evacuating the uterus has a significant influence on the efficacy of CPR due to the rise of maternal pulmonary compliance because of a decrease of pressure in the abdominal cavity [3,15].

The systematic review indicates that the resuscitation efforts on pregnant women with cardiac arrest can be successfully continued for a long time. Prolonged CPR seems to not have an impact on the mother's survivability and subsequent neurological losses [19]. Data exists stating that efficacious reanimation performed even after 47 minutes from a mother's cardiopulmonary arrest may lead to ROSC and no brain damage [20].

Additionally, there is no sufficient evidence showing a connection between gestational age and the survival rate of the pregnant woman [2]. It is important to perform RH in a short time after the onset of maternal cardiac arrest [21].

Impact of resuscitative hysterotomy on the survival and subsequent health state of the neonate

The survival rate of neonates born from resuscitative hysterotomy is not high and may be as low as 30%, depending on the study [1]. The fetus responds to subtle decreases in maternal oxygen supply, and despite compensatory mechanisms, fetal complications associated with hypoxia can occur [2,6]. In addition, other factors may have an impact on the survivability of the fetus, such as the mother's general condition, previous low blood pressure or hypoxia of the pregnant woman, and also the length of the period between the onset of maternal cardiac arrest and the RH procedure [2].

A review of the medical literature shows that the majority of authors comply with the fact that the best benefits are obtained when RH is performed no longer than 10 minutes after the onset of maternal cardiac arrest [22]. Some data suggests that only after 20 minutes of hypoxia can maternal cardiac arrest cause congenital disabilities or, at worst, fetal death [17]. However, some case reports describe delayed out-of-hospital RH procedures, for example 27 minutes after the onset of maternal cardiac arrest. In this situation mentioned above, the infant survived but unfortunately developed cerebral palsy and gastroesophageal reflux. The mother of the newborn was diagnosed with disseminated intravascular coagulation (DIC) and died a few hours after the delivery [22]. As a result a conclusion can be stated that the risk of neurological deficits is higher the longer the time between the onset of maternal cardiac arrest and the resuscitative hysterotomy is. Nevertheless, delayed RH is more often associated with two other situations: survival of the newborn without any brain damage or lack of the neonate survival [2].

Based on medical articles, there is a strong correlation between the neonatal survival rate born from the RH procedure and gestational age [2]. Examining the pregnant woman is necessary in this case, including determining the uterine fundus height. The RH procedure is not recommended if the gestational age is shorter than 24 weeks.

Resuscitative hysterotomy in the out-of-hospital setting

In prehospital medicine, a small percentage of patients are pregnant women – in the analysis performed by Helicopter Emergency Medical Services in the Netherlands, less than 1% of all calls were for pregnant women [17]. Hence, the phenomenon of RH in the out--of-hospital setting happens even less frequently. Only two studies investigated the incidence of cardiac arrest in pregnant women in the out-of-hospital setting [17].

Current American Heart Association guidelines indicate that if there is no ROSC within 5 minutes, immediate RH should be considered while also suggesting that 'In cases of prehospital maternal arrest, rapid transport [...] provides the best chance for a successful outcome' [23]. On the contrary, in 2019, the Paris Brigade Cardiac Arrest Group reported that prehospital RH may increase maternal chances of survival, demonstrating the controversy between specialists [17].

In the prehospital setting, the time needed to arrive at a hospital is often more than the recommended 5 minutes to deliver [17]. As mentioned in the previous paragraphs, the 4-minute rule was mainly based on case studies and presumed physiology [24]. Among prehospital cases, there is a description of RH performed 27 minutes after the onset of maternal cardiac arrest, resulting in both maternal and neonatal ROSC and neonatal survival. However, the neonate was born with a neurological injury [22].

Previous AHA guidelines indicated the need to transport the patient due to the lack of adequately trained personnel at the scene [23]. At the same time,

there is evidence that maternal survival doubled among women who were not transported for RH [17]. In an in-hospital simulation study, only 14% of teams transporting patients to the maternity ward managed to start PMCD within 5 minutes, compared with 57% when RH was undertaken at the site of cardiac arrest [2]. Transport also worsened the quality of chest compressions and increased compression pauses [2]. The CAPS study showed that delays in RH were associated with increased maternal mortality [25]. In another study, researchers concluded that delays created by transporting patients could be eliminated by the presence of a prehospital practitioner able to undertake RH at the scene [18]. However, if transport can be accomplished within 4-5 minutes of cardiac arrest, consideration should be given to delaying PMCS until arrival at a site where obstetric and neonatal support is available [24].

Additional interventions that can improve survival rates

Most often, patients in sudden cardiac arrest will be cared for by hospital emergency department staff, so they must be adequately trained. At the same time, a procedure should be prepared to alert the multidisciplinary team - neonatal team, midwife, obstetrician, and intensivist. Roles in the team should be clearly defined, including, among others, an individual responsible for airway patency, an individual dedicated to maintaining left uterine displacement, a reader whose role is to reduce errors by reading the checklist out loud, or a timer who will ensure the start time of the RH procedure [2]. The equipment needed to perform RH should be kept accessible and well-described. A neonatal resuscitation kit should also be available [2,8]. Depending on the sources, the contents of the RH kit vary. A scalpel and two cord clamps are listed as fundamental. In addition, the kit should include a skin sterilising solution, surgical mask with eye protection, gloves and gown, surgical forceps, and a pair of large surgical scissors, retractors, large sterile gauze swabs, and a urinary catheter.

In some patients, the cause of cardiac arrest may be potentially reversible. If the return of spontaneous circulation is not achieved after RH, extracorporeal membrane oxygenation [3]. should be considered to stabilise the circulation. Potentially reversible causes during extracorporeal therapy include local anaesthetic toxicity, drug overdose, respiratory failure, and acute respiratory distress syndrome or amniotic fluid embolism [11]. The number for the ECMO centre should be listed in the checklist [3].

Tomoyuki Iwai et al. described a successful case of RH with excellent outcomes of the mother and baby. ROSC was achieved ten minutes after RH, and the patient received hypothermic cerebral protection for four days. Seven months later, her only problem was short-term memory loss, which did not limit her daily functioning. The use of therapeutic hypothermia in patients after RH has not been thoroughly investigated to date. Clinicians should follow the latest recommendations for the general population [26].

Healthcare personnel knowledge and how to improve it

In 2020, Leonardsen et al. created and validated the Competence in cardiac arrest and CPR in pregnancy questionnaire (ComCa-P), providing an opportunity to examine the competence of healthcare professionals in cardiac arrest and CPR in pregnancy [5]. Hardeland et al. in 2022, using the ComCa-P questionnaire, examined the knowledge of healthcare personnel from the maternity and gynaecology ward, emergency department, intensive care unit, post anaesthetic care unit, ward of cardiac monitoring, and department of anaesthesiology. Self-assessed competence varied in terms of different respondents' backgrounds. Implementation of the new guideline helped improve this. The authors indicate a need for repetitive education and training in this rare incident [27]. Without repetitive training, retention of skills is poor [2].

Simulation-based education is an effective interprofessional teaching and learning method without the risk of adverse consequences and patient harm [28]. Studies indicate that high-fidelity simulations have a strong educational effect on psychomotor skills [27]. Simulation can be used to ensure emergency preparedness, improve the care system, and foster collaborative communication [11]. However, an objective conclusion is hard to draw, and the ultimate effect of RH training in reducing morbidity and mortality remains to be properly evaluated in future research [29].

Priorities should emphasise clear communication, high-quality chest compressions, ensuring manual dislocation of the uterus, and performing emergency cesarean section within 5 minutes [30]. With the introduction of Managing Obstetric Emergencies and Trauma (MOET) courses in the Netherlands, there has been a 4-fold increase in the rate of undertaking RH

and a decrease in the time from the onset of cardiac arrest to the start of RH [2].

In 2018, Lee et al. described a high-fidelity simulation scenario conducted at New York Presbyterian Morgan Stanley Children's Hospital. Each scenario involved the participation of physicians and nurses. They received feedback from participants wishing that the simulation exercises would occur more often. From the anonymous survey, authors concluded that sessions were effective in meeting the learning objectives and identifying systems issues, resulting in important system changes geared towards improving patient safety [30].

High-fidelity simulations are effective but require resources, including equipment. O'Dea et al. described a portable 3-D printed model of a gravid uterus in the abdomen, both cost-effective and attainable [28]. Palm et al. described two low-cost, high-fidelity RH models [31]. Alfalasi et al. described a method for creating human cadavers, providing the opportunity to practice this extremely rare but potentially life-saving procedure for two lives [32].

Summary

The need for a rescue hysterotomy is extremely rare, but it can happen in any situation. It is important to remember that if ROSC is not obtained within 4 minutes, RH is the only intervention that can increase the mother's and neonate's chance of survival. It is important to assess whether there are indications for the procedure as well as aiming to perform it as soon as possible. The overriding goal should be to save the mother, and the RH procedure itself requires performing effective CPR. This procedure performed according to the relevant guidelines allows for a greater chance of a healthy neonate to be born without neurological complications. Therefore, medical staff should be regularly trained in performing emergency caesarean sections and practice the procedure using simulation methods. Monitoring data on hospital and prehospital cardiac arrests in pregnant patients should be considered to develop evidence-based guidelines.

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Conflict of interest
None

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