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Clinical paper

Analysis of prehospital perimortem caesarean deliveries performed by Helicopter Emergency Medical Services in the Netherlands and recommendations for the future

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Abstract

Background: Prehospital perimortem caesarean delivery (PCD) is a rarely performed procedure. In this study, we aimed to examine all PCDs performed by the four Helicopter Emergency Medical Services in the Netherlands; to describe the procedures, outcomes, complications, and compliance with the recommended guidelines; and to formulate recommendations.

Methods: We performed a population-based retrospective cohort study of all consecutive maternal out-of-hospital cardiac arrests that underwent PCD in the prehospital setting between May 1995 and December 2019. Registered data included patient demographics, operator background, advanced life support interventions, and timelines. Resuscitation performance was evaluated according to the 2015 European Resuscitation Guidelines.

Results: Seven patients underwent a prehospital PCD. Three mothers died on the scene, while four were transported to a hospital but died in the hospital. Seven neonates were born by PCD. One neonate died on the scene and six were transported to a hospital. Three neonates were eventually discharged from the hospital. Among the three surviving neonates, the periods from dispatch to start of PCD were 13, 14, and 21 min.

Conclusions: There was a low incidence of maternal perimortem caesarean deliveries in The Netherlands. Only some neonates survived after PCD. It is recommended that PCD be performed as quickly as possible. Due to the delay, the mother has a far lower chance of survival than the neonate. In fatal cases, autopsy is strongly recommended.

Keywords: Helicopter emergency medical service, Perimortem caesarean delivery, Maternal arrest, Resuscitative hysterotomy, Prehospital

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Introduction

Little is known about the success rates and complications of prehospital perimortem caesarean deliveries (PCDs) performed by physician-led Helicopter Emergency Medical Services (HEMS). Only two studies have examined the incidence of maternal cardiac arrest in the out-of-hospital setting.[1,2] Few obstetrical providers encounter in-hospital acute maternal cardiopulmonary arrest (MCPA), and even fewer prehospital providers. However, the incidence of PCDs is increasing in the Netherlands.[3] There is currently no specific term for caesarean delivery during MCPA. The term PCD was introduced in 1986,[6] and was adopted by both the Society for Obstetric Anesthesiology[7] and the American Heart Association.

In the event of cardiac arrest during pregnancy, PCD is considered essential for resuscitation of both the mother and fetus. PCD should only be performed from 20 weeks of pregnancy but preferably from 24/26 weeks when the pregnant uterus compresses the inferior caval vein. It is recommended that PCD be started after four minutes and performed within the next minute, to maximize the chances of return of spontaneous circulation (ROSC) through caval relief and uterine autotransfusion. Although PCD is not a complex procedure, the cognitive, operational, and emotional circumstances make it difficult, especially in the prehospital setting. Knowledge and performance of resuscitation techniques that account for a pregnant woman's unique physiology are crucial to maximize the chances of survival for both the mother and fetus.[4] The AHA issued a scientific statement on maternal cardiopulmonary arrest, stating that there is insufficient evidence to support prehospital PCD, and that prehospital providers should not be expected to perform PCD due to the limited resources available to perform advanced life support and lack of adequately trained personnel.[5] However, in 2019, the Paris Brigade Cardiac Arrest Group reported that prehospital PCD could improve the probability of the mother's survival,[2] highlighting the controversy amongst specialists.

In 1995, HEMS was introduced in the Netherlands, enabling the rapid delivery of a medical team to the scene, in addition to the regular ambulance crew. A HEMS team comprises a physician (board-certified anesthesiologist or trauma surgeon), specialized nurse (paramedic or registered nurse from the emergency department), and helicopter pilot. HEMS personnel receive additional training, such as managing obstetric emergencies and trauma (MOET), and annually practice surgical skills in a cadaver lab. On average, HEMS is airborne within two minutes after dispatch in daylight, and within five minutes at nighttime. The average flying times range from 8 to 13 minutes, depending on which HEMS is activated.

In this retrospective study, we aimed to describe the experience of HEMS with PCD; to report PCD outcomes, complications, and compliance with recommended guidelines; and to make recommendations for the future.

Methods

Ethics approval

This retrospective study was approved by the Medical Ethical Committee of the Erasmus University Medical Center (MEC-2019−0277).

Study design

We performed a retrospective analysis of all four HEMS databases from May 1, 1995 (the start of HEMS in The Netherlands) until December 2019. We identified all cases involving PCD, and collected information about these cases from the database. We further asked each individual doctor who performed a PCD to complete a questionnaire regarding personal skills and experience, and data missing from the database.

Study setting

The Netherlands has a population of over 17 million people, covering an area of 42 508 km^2. There are four HEMS teams in the Netherlands—each covering one of four areas of the country. HEMS acts in close collaboration with emergency medical services (EMS), and follows the same medical protocols. Pregnant patients constitute $<$1% of all calls, such that expertise and experience are limited. Since June 2013, a nationwide protocol dictates that HEMS is always dispatched together with EMS in cases of cardiac arrest in a pregnant woman.

Selection of participants

We identified all patients who were pregnant and in cardiac arrest between May 1995 and December 2019, and analyzed the available data, including patient demographics, complications, and operator background. We also evaluated compliance with the guidelines for managing obstetric emergencies and trauma (MOET), which are now part of the European Resuscitation Guidelines issued in 2015.[8] Available maternal-specific resuscitation benchmarks based on the maternal algorithm included intravenous placement above the diaphragm, advanced airway insertion, timely perimortem caesarean delivery (started within four minutes of witnessed arrest, and achieved within one minute), type of incision (midline or lower transverse), and initial cardiac rhythm for pregnancies of $>$20 gestational weeks. Missing data are reported as unknown in the results. Pregnant patients with a gestational age of less than 20 weeks or who were quickly transferred to a hospital to undergo PCD in the emergency department were excluded.

The study is registered under number MEC-2019−0277, and approved by the Institutional Review Board of the Erasmus MC.

Results

Prehospital population and clinical characteristics of pregnant women

Since the start of HEMS in 1995, all four HEMS stations have received over 80 000 calls, of which around 35 000 were canceled by EMS prior to arriving. Thus, HEMS has treated approximately 45 000 patients. These cases included seven pregnant women with prehospital cardiac arrest, in three of the four HEMS areas.

Timelines

For all pregnant women who were in cardiac arrest, HEMS was called together with EMS to ensure rapid assistance. Table 2 shows the period from dispatch to start of PCD, which includes starting time,

flying time, time to arrive at the scene from the landing location, and initiating the actual PCD. In all seven cases, CPR was initially performed by bystanders, policemen, or EMS. When HEMS arrived at the scene, they immediately started the PCD because basic life support and advanced life support had already been provided by EMS. None of the women was transported to perform PCD in hospital.

Maternal characteristics and outcome

The seven pregnant women had a median age of 29.6 years (range, 18–38 years) and were all in the last trimester of pregnancy (range, 31 weeks and 4 days to nearly 42 weeks). All had singleton pregnancies. Only one mother was obese (estimated weight of 140 kg). None of the mothers had comorbidities documented in the HEMS database (Tables 1 and 2).

Of the seven women who underwent a PCD, three were pronounced dead on the scene. The remaining four women were transported to a hospital, two of whom exhibited ROSC at the scene. None of the four women who were admitted to a hospital survived. One woman died in the emergency department, one in the operating room, and two in the intensive care unit (both after five days and due to severe asphyxia).

Fetal outcome and neonatal survival

Seven neonates were born by PCD. One neonate died on the scene, and the other six were transported to the hospital. Of the six neonates admitted to a hospital, three died in the pediatric intensive care unit as a consequence of severe asphyxia. The remaining three babies were discharged from the hospital: two (cases five and seven) in good neurological condition, and the other (case two) in fair neurological condition (at 22 months of age, the patient can crawl and stand up, but doesn't talk). The three surviving neonates were born after the performance of PCD at 13, 14, and 21 min after dispatch (Table 3).

Cardiac arrest characteristics

One woman went into cardiac arrest after a car accident. All seven women had a non-shockable rhythm upon initial rhythm check by EMS or HEMS: five in asystole, and two with pulseless electrical activity

Table 1 – Description of cases **OHCA: out-of-hospital cardiac arrest; PCD: perimortem caesarean delivery; ROSC: return of spontaneous circulation; ED: emergency department; PICU: pediatric intensive care unit; ICU: intensive care unit; CPR: cardio-pulmonary resuscitation.**

Nr	Year, age, obstetric history, and weeks pregnant	Course of events	Discharge from hospital mother/child
1	2003, 31 years, G1P0, 39 0/7	Road traffic accident while unrestrained in the front passenger seat. At 11 min after OHCA, PCD was performed via Pfannenstiel incision, which took ~2 min. Both mother and child gained ROSC, and were then transported to a hospital. The mother died the same day in the operating room following massive transfusion. The baby died 3 days later in the PICU due to severe neurological problems.	–/–
2	2014, 30 years, G4P3, 38 4/7	OHCA due to amniotic fluid embolism. At 21 min after starting CPR, PCD was performed via Pfannensthiel incision, which took 4–5 min. The mother did not regain a pulse but was transported to the ED and declared dead soon after arrival. The baby gained ROSC at 2 min after birth, stayed 11 days in the PICU, and was eventually discharged from the hospital. At 2 years of age, the patient is in fair neurological condition, can crawl and stand with no help, but is not talking yet.	–/+
3	2015, 18 years, G1P0, ±32	Unknown OHCA origin. At 18 min after starting CPR, PCD was performed via median incision, which took 1 min. Both mother and baby did not gain ROSC, died in the prehospital setting, and were not transported to the hospital.	–/–
4	2015, 32 years, G3P2, 41 6/7	OHCA due to amniotic fluid embolism. At 27 min after starting CPR, PCD was performed via median incision, which took 1 min. The mother had ROSC 30 min after starting CPR, and was transported to a hospital. After 5 days in the ICU, the mother died due to neurological problems. The baby had ROSC 20 min after PCD was performed, and was transported to a hospital. After 2 days in the PICU, the baby died due to neurological problems.	–/–
5	2015, 38 years, G2P1, 37	Uncertain cause of OHCA. Massive vaginal bleeding occurred, likely due to placenta previa. At 14 min after starting CPR, PCD was performed via median incision, which took 1 min. The mother died at the scene due to blood loss. The baby had ROSC at 9 min after starting PCD. After 6 days in the PICU, the baby was discharged from the hospital in good neurological condition.	–/+
6	2018, 28 years, G3P2, 35 5/7	OHCA due to lung embolism (confirmed by CT). At 32 min after OHCA, PCD was performed via median incision, which took 1 min. The mother was transported to a hospital while receiving CPR and with VF, and gained ROSC in the hospital >1 h after CPR initiation. She was admitted, and died after 5 days in the ICU. The baby gained ROSC 1 min after PCD, and was transported to the hospital. After 5 days in the PICU, the baby died due to neurological problems.	–/–
7	2019, 30 years, G3P1, 31 4/7	OHCA due to lung embolism (confirmed by autopsy). At 18 min after OHCA, PCD was performed via median incision, which took 1 min. The mother never gained ROSC and died on the scene. The baby gained ROSC 12 min after PCD and was transported to the hospital. After 3 days in the PICU, MRI showed no hypoxic lesions. After 8 days in the PICU, the baby was discharged from the hospital in good neurological condition.	–/+

Table 2 – Maternal characteristics **ROSC: return of spontaneous circulation; EMS: emergency medical service; HEMS: Helicopter Emergency Medical Service; RTA: road traffic accident; N.A.: not applicable.**

Case	1	2	3	4	5	6	7
Year	2003	2014	2015	2015	2015	2018	2019
Parity	G1P0	G4P3	G1P0	G3P2	G2P1	G3P2	G3P1
Mother's age, years	31	30	18	32	38	28	30
Incision	Lower transverse abdominal	Lower transverse abdominal	Midline	Midline	Midline	Midline	Midline
Surgeon	Anesthesiologist	Trauma Surgeon	Anesthesiologist	Anesthesiologist	Anesthesiologist	Anesthesiologist	Trauma Surgeon
Procedure duration, minutes	2	4–5	1	1	1	1	1
Gestational age, weeks	39 0/7	38 4/7	+/-32	41 6/7	37? /7	35 5/7	31 4/7
CPR	+	+	+	+	+	+	+
1st Rhythm	asystole	asystole	asystole	PEA	asystole	PEA	Asystole
Diagnoses	Trauma RTA	Amniotic fluid embolism	Unknown	Amniotic fluid embolism	Uncertain, but vaginal bleeding	Pulmonary embolism	Pulmonary embolism
Obduction/CT performed	–/+	–/–	–/–	–/+	+/–	–/+	+/–
Time to ROSC (minutes)	28	–	–	30	–	>45	–
Survival	–	–	–	–	–	–	–
Time from dispatch to start of procedure	11	21	18	27	14	32	13
Transport to hospital	Y	Y	N	Y	N	Y	N
Left lateral tilt (upon HEMS arrival)	Y	N	Y	N	N	Y	N
Intubation	HEMS	EMS	EMS	First i-Gel by EMS, intubated by HEMS	No	EMS	HEMS
Comorbidity	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Weight, kg	75	Normal posture	70	Normal posture	140	72	Normal posture

Table 3 – Neonatal characteristics **CPR: cardiopulmonary resuscitation; ROSC: return of spontaneous circulation; HEMS: Helicopter Emergency Medical Service.**

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Baby's weight, grams	3500	4000	1500–2000	4300	+/– 3000	2620	1900
CPR at birth	+	+	+	+	+	+	+
ROSC/Time to ROSC	+/5	+/2	–/–	+/20	+/4	+/1	+/12
Discharge from hospital	–	+	–	–	+	–	+
Intubation	HEMS	HEMS	HEMS	HEMS	HEMS	HEMS	None

(PEA). Four women never gained ROSC, two women exhibited ROSC at the scene, and one showed ROSC at the emergency room after over one hour of CPR. None of the women were discharged from the hospital. Postmortem CT scanning was performed in only three cases. Among the three women who were not transported to a hospital, only one received an autopsy and a diagnosis (case seven). In one case, no autopsy was performed. In the other case, an autopsy was performed five days after death, and no distinct diagnosis was made that could explain the cardiac arrest.

All seven neonates received CPR at birth. Six neonates gained ROSC, of whom four showed ROSC within five minutes or less (including two neonates who were discharged from the hospital). On the scene, it was difficult to assess whether a pulse was present (for example, due to bad lighting or noise); thus, in some cases, CPR was initiated but stopped after ultrasound confirmation of heart contractions.

Guideline compliance

Paramedics are not allowed to perform PCD; therefore, PCD could not be initiated until HEMS arrived. In all cases, CPR was started by EMS or bystanders. Not all women received endotracheal intubation. Three mothers were intubated by EMS, one by HEMS, one had a laryngeal mask airway (i-Gel©) inserted by EMS and was intubated by the HEMS physician upon arrival, and one was ventilated using bag-valve-mask ventilation. All women had an intravenous access above the diaphragm in one arm. All women received adrenaline according to protocol. Only one woman developed ventricular fibrillation and was shocked four times during CPR (case six). The period from dispatch to PCD initiation was well over ten minutes, with a maximum of 32 min. All median incision procedures took approximately one minute to perform. Incision by lower transverse abdominal incision (Pfannenstiel incision) took longer: two to five minutes. In four women, EMS or bystanders did not apply manual uterus displacement, which was corrected by HEMS upon arrival.

Debriefing

It is routine to have a debriefing after returning to the HEMS station with the team. In all the described cases debriefings and perinatal audits were held for all involved health care providers.

Discussion

According to the nationwide database of the Dutch Heart Association,[9] 8000 out-of-hospital cardiac arrests occur each year, including only a few in pregnant women.[10] In this retrospective study, we describe all seven perimortem caesarean deliveries (PCD) performed by HEMS in The Netherlands between 1995–2019.

We found that the time from dispatch to PCD initiation (Table 2) was well over the recommended 4 – 5 min.[11] It is difficult to perform PCD within five minutes after cardiac arrest, especially in the prehospital setting,[8,12] and this criterion cannot always be met even for in-hospital PCDs.[3,11] In our present study, among the three neonates who survived, the times until PCD initiation were 13, 14, and 21 min—well beyond the recommended 4–5 min. In the prehospital setting, the target of 4–5 min is not feasible since medical emergency units always take more time to arrive, even HEMS. Nevertheless, we recommend that PCD be performed as soon as technically possible. Although maternal survival is rare after >14 min, there is still a chance of neonatal survival, and no danger of further maternal damage. One could argue that maternal survival might be improved if PCD were performed by paramedics who arrive at the scene earlier; however, paramedics have no surgical experience and are not authorized to perform this procedure. In all seven patients, upon HEMS arrival, CPR had been started by EMS or started by bystanders and taken over by EMS. Four women were already intubated, and all women had an intravenous access above diaphragm. All patients initially had a non-shockable rhythm. HEMS was able to immediately start PCD upon arrival in all cases.

In 2015, the American Heart Association[5] released a scientific statement indicating that prehospital PCD should not be performed due to the lack of adequately trained personnel, and that focus should instead be on providing basic and advanced life support, and quick transport to a facility that can perform PCD. In 2019, the Paris Brigade Cardiac Arrest Work Group described 16 pregnant patients in OHCA, and reported that prehospital PCD improved the likelihood of the mother's survival.[2] They also stated that basic and advanced life support are warranted when PCD can be performed by a trained doctor. In our opinion, the EMS teams in the Netherlands can secure the airway, insert an intravenous access cannula, provide medication according to the nationwide advanced life support protocol and, if necessary, defibrillate the patient—while HEMS can quickly perform the PCD.

Brain damage begins after five minutes of anoxia. Under the 4- to 5-minute guideline, PCD is to be initiated at four minutes, and be completed in a timely manner (within one minute) to deliver the fetus prior to the occurrence of brain damage. If a woman has a resuscitable cardiac arrest, her life may also be saved by a prompt and timely PCD during CPR. A neonate can survive and remain in good neurological condition after a longer period of anoxia. A small British study reveals that neonatal damage or death will not occur until after a 20-minute period of anoxia.[13] In the CAPS study,[14] maternal survival rates depended on the time from collapse to the start of in-hospital perimortem caesarean delivery. Pregnant patients receiving CPR who underwent in-hospital perimortem caesarean delivery and survived all had their perimortem caesarean delivery within 12 min. In the Netherlands, Dijkman reported no survival of pregnant patients when it took longer than 14 min to start in-hospital PCD.[3] In the prehospital environment, it is difficult to arrive on time to start PCD within 12–14 min.

The timing of performing a PCD is quite important for the survival of both mother and fetus. A recent British study describes a decrease of maternal survival depending on the interval between cardiac arrest and PCD[14]. In this study the survivors had a PCD between 0 and 39 min after their cardiac arrests. The median interval of the cardiac arrest/PCD period between survivors and those who died was respectively 3 and 12 min. This same article found that maternal survival doubled in women that were not transported to another place to perform the PCD. The neonatal survival decreases after an interval of more than five minutes. In the British study the difference in survival is 96% if delivered within 5 min and 70% if delivered after more than five minutes. An overview of the importance of the interval time is also given in the review article by Zelop et al[15].

The cause of cardiac arrest could be determined in only five cases in our study. We strongly recommend that this diagnosis be obtained through CT or MRI scanning and/or autopsy. Elucidating the cause is important for determining why women die, to potentially adjust training and create awareness amongst doctors and nurses. Furthermore, in individual cases, a diagnosis may reveal why resuscitation was not successful. Rarely, autopsy may lead to the identification of previously unknown inherited diseases. Finally, elucidation of the cause of death may provide some consolation to the relatives. In some countries, autopsy is obligatory for pregnant women; for example, it has been compulsory in Sri Lanka since 2008.

Although obstetricians might be more comfortable with lower transverse abdominal incisions, a midline incision may be recommended in some cases, especially for care providers having less experienced with lower transverse caesarean section. Notably, in our study, even the trauma surgeon took a longer time to perform PCD using a lower transverse abdominal incision. The midline procedure is technically easier because the abdominal wall is thinner, the resistance and structures in the abdominal wall are simpler, and the uterus is always immediately encountered upon cutting through the abdominal wall—thereby protecting other structures, such as the bladder and bowel. In this study, all PCDs performed via median incision took less time than those performed via lower transverse abdominal (Pfannenstiel) incision (Table 2). Using a vertical midline laparotomy incision will maximize exposure and allow the greatest access to facilitate the procedure,[16] and is thus recommended. After delivery of the neonate and cutting the umbilical cord, the placenta may be left in place or manually removed.

In The Netherlands, the Managing Obstetric Emergencies and Trauma (MOET) course started in December 2003. During the early years of HEMS in The Netherlands, obstetric emergencies were not in the dispatch protocols. This changed in June 2013, when the nationwide protocol for HEMS activation was adjusted, with the addition of complications during birth or pregnancy. In these cases, HEMS is primarily activated, together with EMS. This may explain why almost all PCDs in our study were performed during the last five years. The first PCD was after a car accident, which is a primary HEMS deployment criterion.

Conclusions and recommendations

This was the first study to report the outcomes of a cohort of pregnant woman who suffered out-of-hospital cardiac arrest, and received prehospital treatment by physician-led HEMS in The Netherlands. We found a low incidence of PCDs during maternal out-of-hospital cardiac arrests. In the prehospital setting, even with HEMS availability, the 4- to 5-minute guideline was not achieved in any case. While we still recommend that perimortem caesarean delivery be performed as early as possible, one must realize that the delay in the prehospital setting means that the likelihood of saving the mother is far lower than that of saving the neonate. In prehospital resuscitations and PCD, special attention should be paid to performing intubation (with capnography), manual uterine displacement to avoid aortocaval compression, and using a midline rather than a lower transverse (Pfannenstiel) incision.

In cases of maternal death, autopsy is strongly recommended to identify the cause of cardiac arrest and to understand the failure of the procedure. Cardiac arrest is so rare, especially in young women, that it is mandatory to investigate its cause as thoroughly as possible. If autopsy is not allowed or refused, a full-body MRI or CT scan may serve as an alternative.

Credit author

Enclosed, please find our original article: “Analysis of all out-of-hospital perimortem caesarean deliveries performed by Helicopter Emergency Medical Services in The Netherlands and recommendations for the future”, which we would like you to consider for publication in Resuscitation.

All authors have made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

Conflicts of interest

None.

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