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Case Report

Cardiopulmonary arrest in pregnancy: two case reports of successful outcomes in association with perimortem Caesarean delivery

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Cardiac arrest in pregnancy is a rare event in which the speed of the response and attention to a number of pregnancy-specific interventions is crucial to the outcome. The commencement of a perimortem Caesarean delivery within 4 min of the onset of the arrest has been recommended as a technique to potentially improve survival in both the mother and the fetus but presents significant logistical challenges to the health-care facility. In this report, we describe two cases of cardiac arrest in pregnancy in which a perimortem Caesarean was performed as part of the resuscitation process and was associated with excellent maternal and neonatal outcomes. We discuss some of the issues surrounding the performance of a perimortem Caesarean delivery that were relevant to this case, including experience from the training that is provided in our institution.

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Cardiac arrest in pregnancy is a rare event, with an estimated incidence of ~1:30 000 pregnancies.[1 2] The speed of the resuscitation response is critical to the outcome of both the mother and the fetus.[3 4] The management of the collapsed pregnant patient differs in several critical areas compared with traditional adult resuscitation.[2 5] These include the need for measures to prevent aortocaval compression, the early securing of the airway by tracheal intubation, the rapid performance of a perimortem Caesarean delivery, and the likelihood of a non-cardiac (and pregnancy specific) cause for the arrest. Pregnant patients may die, despite otherwise exemplary care unless these differences are appreciated.[6]

Perimortem Caesarean deliveries were recommended by Katz and colleagues in 1986.[7] In their initial paper, they recommended a '4 min rule' from the onset of the maternal arrest to the initiation of the Caesarean delivery, with the fetus being delivered within 5 min. This approach was promoted principally on fetal grounds to allow the potential salvage of a viable fetus. The timing of delivery was based on theoretical considerations such as oxygen consumption, neurological injury, and a single case report.[8] A benefit of the perimortem Caesarean is the relief of the aortocaval compression, with a consequent improvement in venous return and potentially more effective chest compressions and improved respiratory mechanics.[3]

Since the initial description, numerous case reports have described often dramatic reversal of the maternal haemodynamic collapse, even in otherwise refractory situations.[3] Presented here are two case reports of maternal cardiac arrest in which a perimortem Caesarean delivery was performed with favourable maternal and neonatal outcomes.

Case report

Case 1

A 36-yr-old, Gravida 2, Parity 2, woman presented to our institution by ambulance at 31 weeks gestation. Two years previously, she had delivered twins by non-elective Caesarean section because of severe pre-eclampsia and the current pregnancy had occurred despite the presence of an intrauterine contraceptive device. On the evening of her presentation, she felt unwell at home, complained of severe abdominal pain and then collapsed. She was transferred directly to our

labour and birth suite with a fluctuating level of consciousness, oxygen saturation (Sp_{O_2}) of 96%, a heart rate of 150 beats min^{-1}, and an unrecordable arterial pressure.

On arrival, she was conscious but during transfer to the hospital bed, she stopped responding to verbal commands and loss of cardiac output was immediately recognized. An emergency was declared and cardiopulmonary resuscitation (CPR) commenced, with left pelvic tilt applied. The arrest team arrived within 1 min and she was intubated immediately, i.v. access was obtained, i.v. epinephrine 1 mg administered, and i.v. crystalloid commenced. There was no return of cardiac output and 5 min post arrest, the decision was made to perform a perimortem Caesarean delivery. While this was being organized, an ultrasound examination confirmed the presence of a fetal heartbeat.

A Pfannenstiel incision was made to gain access to the abdominal cavity. Surgery was complicated by the presence of a large amount of free blood and placental tissue in the abdomen, obstructing visualization of the uterus. Eight minutes after the onset of the arrest, a live male infant was delivered with Apgar scores of 1 and 6 at 1 and 5 min, respectively. Advanced life support was continued throughout the perimortem Caesarean and included continued i.v. fluid resuscitation and further doses of i.v. epinephrine. Spontaneous return of maternal cardiac output occurred 5 min after delivery of the infant (13 min after the initial arrest).

The woman was immediately transferred to the operating theatre for an exploratory laparotomy. A ruptured uterus and multiple bleeding points within the pelvis, secondary to an undiagnosed placenta percreta, were discovered. She underwent a prolonged laparotomy, including a hysterectomy, for haemostatic control and over the next 10 h in the operating theatre she received 72 units of packed red cells, 35 units of fresh-frozen plasma, 64 units of cryoprecipitate, 5 mega-units of pooled platelets, and three doses of recombinant activated factor VII. There was significant haemodynamic instability requiring i.v. infusions of epinephrine, norepinephrine, and vasopressin.

After operation, she was transferred to the intensive care unit (ICU) where she required further ventilation, inotropic support, and suffered from multi-organ failure. She was discharged from a rehabilitation facility 45 days after the initial event. Six months later, her only issues are a minor impairment of her short-term memory and a neuropathic pain syndrome in her both legs. In the first few hours after birth, the male neonate had a seizure. Ultrasound and MRI examinations showed evidence of low-grade intraventricular haemorrhage and hypoxic ischaemic encephalopathy. He was discharged from hospital 46 days after delivery with no clinical evidence of neurological injury.

Case 2

A 32-yr-old Gravida 3, Parity 0, female was booked for delivery at our on-site, low-risk pregnancy, midwifery-led birthing centre. She presented in early labour at 40 weeks plus 10 days gestation after spontaneous rupture of the membranes. She had been assessed the previous day for elevated arterial pressure (140/80 *vs* 110/60 mm Hg at booking) but had no other clinical or biochemical features to suggest pre-eclampsia.

Her labour progressed satisfactorily and her cervical dilatation was 8 cm 14 h after the rupture of her membranes. Her arterial pressure remained elevated at 140/80 mm Hg. At ~16 h, the woman felt unwell while walking to the toilet. She collapsed but remained conscious and was placed in a left lateral position. This was promptly followed by a seizure lasting 30–60 s, so an emergency was declared.

On arrival of the hospital cardiac arrest team, the seizure had self-terminated, but she remained unresponsive to commands. The patient was maintained in the left lateral position, given supplemental oxygen and i.v. access was established. An i.v. infusion of magnesium sulphate 8% was commenced for a presumed eclamptic seizure.

Approximately 10 min after the seizure, the patient regained consciousness but was combative and difficult to manage. Immediately thereafter, she had a respiratory arrest followed by loss of cardiac output. It was noticed that the magnesium infusion had not been connected to an electronic infusion pump and was flowing freely under gravitational pressure. During this time period, she had received ~200 ml (16 g) of the magnesium solution.

CPR was commenced and the patient was intubated immediately. Four minutes after the cardiac arrest, an electrocardiographic trace had not been obtained and it was unclear whether cardiac output was present. A perimortem Caesarean section was promptly performed through a Pfannenstiel then lower uterine segment incision. The operative field was noted to be bloodless and bleeding did not resume until the return of a palpable pulse 1 min later.

The neonate was born with Apgar scores of 4, 7, and 8 at 1, 5, and 10 min, respectively, and responded to simple resuscitation. The woman was transferred to the operating theatre for wound closure. A serum magnesium concentration measured at the time of loss of cardiac output was 10.1 mmol $litre^{-1}$ (normal range 0.7–1.1 mmol $litre^{-1}$). She was transferred to the ICU after operation where she was extubated the following day and transferred back to a ward environment. After operation, she developed clinical and biochemical evidence of severe pre-eclampsia, but thereafter both the mother and the baby made an uneventful recovery.

Discussion

In this report, two cases of maternal cardiac arrest, in which favourable outcomes were associated with the performance of a perimortem Caesarean delivery, are described. In case 1, the rapid delivery almost certainly improved the fetal

outcome because the intra-abdominal haemorrhage was unlikely to be responsive to non-surgical management. In case 2, it is likely that the iatrogenic administration of excessive magnesium sulphate led to the respiratory and possibly cardiac arrest. In this situation, the relief of the aortocaval compression secondary to the delivery of the fetus may have made resuscitation more effective.

The performance of a perimortem Caesarean delivery is a challenging aspect of maternal resuscitation. Adherence to a '4 min rule' means that the response team must rapidly assess the patient, institute appropriate resuscitation, and also prepare for delivery.[6 9] The timing of restoration of adequate cardiac output is critical for both the mother and the baby, with the mother likely to experience hypoxia earlier in the course of an arrest due to the increased oxygen demands of pregnancy and decreased oxygen storage,[7 10] while the fetus is reliant on the maternal circulation for oxygen supply.

With the change in the obstetric population characteristic to women being older, heavier, and having more complex medical problems during pregnancy,[11] the number of women who become seriously unwell while pregnant is likely to increase. It has been widely recommended that institutions should undertake regular training and practice maternal cardiac arrest drills to ensure that appropriate care is provided in a timely fashion.[11–14] This training should be multidisciplinary and involve all levels of staff.[6 15] Recent research has shown a significant lack of knowledge among obstetric care providers about differences in the resuscitation of the pregnant patient.[15 16] Cohen and colleagues[15] found that 25–40% of respondents were unaware of a number of crucial differences. Recent CEMACH reports have suggested that care was substandard in more than 50% of maternal deaths and that resuscitation skills were 'considered poor in an unacceptably high number of cases'.[11 12] The Royal College of Obstetricians and Gynaecologists have now recommended that knowledge of resuscitation in pregnancy be an auditable standard.

Our institution caters for ~6500 deliveries per annum and coordinates a number of staff training programmes on the management of obstetric emergencies. A regular full day multidisciplinary course is based on the format of the PROMPT Course (Practical Obstetric Multiprofessional Training, Bristol, UK, www.prompt-course.org). Midwifery staff are offered a monthly in-service on resuscitation, with attendance compulsory at least once every 2 yr. New anaesthetic staff attend a 1 day simulation session on the anaesthetic management of obstetric emergencies, based on a course developed at the North Shore Hospital Simulation Centre in Sydney, Australia. Mock resuscitation and obstetric emergency drills for the in-house resuscitation team are conducted at various locations throughout the hospital on a monthly basis.

These initiatives, and the experience obtained from mock drills requiring a perimortem Caesarean, led to the creation of dedicated perimortem Caesarean equipment packs which are located in our emergency centre, labour and birth suite, and on an operating theatre resuscitation trolley that is sent to all hospital cardiac arrests. The pack contents are simple and include an antiseptic solution, a disposable pre-loaded scalpel, and packs for the uterus. Both perimortem Caesarean deliveries described in this report were managed by trainee obstetric and anaesthetic staff outside of normal working hours. All had attended at least one of the training courses and reflected on the confidence this gave them to perform the Caesarean delivery when indicated, despite the absence of on-site consultant staff.

In terms of the outcomes from perimortem Caesarean deliveries, Katz and colleagues[3] conducted a review of all published cases from 1985 to 2004. They reported 38 perimortem Caesarean sections from which 34 infants of 28 women (three sets of twins, one set of triplets) survived. Although subject to selection and publication bias, the neurological outcomes appeared better among infants born within 5 min of the cardiac arrest. Twenty women were identified as having had potentially survivable insults and of these, 12 survived to hospital discharge. Only eight of the 38 cases met the recommended '4 min' timeframe for commencement of the Caesarean section. In no patient did the performance of a perimortem Caesarean worsen the maternal haemodynamic state. Recent data from the triennial Confidential Enquiries into Maternal and Child Health (CEMACH) reports suggest that neonatal outcomes are improved when there is advanced gestational age and the arrest occurs in a delivery suite or operating theatre environment.[11]

Some aspects of these two cases deserve further comment. In both cases, the Caesarean was performed via a Pfannenstiel incision. It has been previously recommended that a midline abdominal incision is the preferred technique.[17] Given that there is considerable time pressure in these situations, the surgeon should perform whichever technique they feel most comfortable with so as to not unnecessarily delay delivery of the fetus.

In case 1, a pre-Caesarean ultrasound examination was performed to ascertain whether there was a fetal heartbeat. This should only occur if it does not delay the performance of the Caesarean delivery.[5] If the fetus is thought to be more than 24 weeks gestation, then its delivery, either alive or dead, may assist in restoring maternal venous return and improving the chance of successful maternal resuscitation.

In case 2, the loss of cardiac output may have been due to either iatrogenic magnesium overdose or a hypoxic cardiac arrest. There were a number of potential contributing factors to this situation. At the time of this case, the magnesium sulphate in use in this institution was presented as an 8% solution in a 500 ml bag, with hospital protocol requiring administration through an electronic infusion device. This bag was very similar in appearance

to other commonly used i.v. fluids. The emergency also occurred in an area of the hospital that does not normally have to manage i.v. magnesium infusions. In light of this incident, we have had discussions with the manufacturer to change both the volume and appearance of the magnesium solutions, in the interim we have changed to individual ampoules of magnesium sulphate (2.47 g) on our resuscitation trolleys.

It was also unclear in case 2 whether the cardiac output had returned at the commencement of the Caesarean delivery, although the bloodless surgical field suggest that it was absent. The management of situations in which cardiac output returns at an early stage of resuscitation can be complex.[3] In these situations, the fetus is likely to be compromised and may exhibit fetal bradycardia secondary to the temporary loss of placental perfusion. It would appear reasonable, if the maternal cardiac output is restored, to delay delivery and arrange immediate transfer to either an operating environment for conventional Caesarean section or to a high-dependency area.

In summary, two cases of perimortem Caesarean delivery associated with good maternal and neonatal outcomes are presented. It is likely that the combination of multidisciplinary training and regular practice drills contributed to the positive outcomes. We recommend that all centres that provide care for obstetric patients have perimortem Caesarean packs readily available and that they refine their resuscitation management by means of simulated events. Emergency departments that may be involved in the resuscitation of pregnant patients should also be prepared to perform a perimortem Caesarean delivery. This may require additional training of emergency medicine staff and protocols for the immediate response of an obstetrician to such situations. The neonate is likely to be compromised at birth, so staff trained in the performance of neonatal resuscitation should form part of the response team.

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