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Perimortem cesarean delivery: Were our assumptions correct?

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KEY WORDS

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Objective: The recommendation to perform a perimortem cesarean delivery within 4 minutes of maternal cardiac arrest was introduced in 1986. This recommendation was based on the assumptions that cardiopulmonary resuscitation is ineffective in the third trimester because of aortocaval compression, and that fetal and perhaps maternal outcomes would be optimized by timely delivery. Our objective was to review the outcomes of perimortem cesarean deliveries to attempt to validate those assumptions.

Study design: Ovid MEDLINE searches using maternal mortality, cardiopulmonary resuscitation, perimortem cesarean delivery, heart attack, and cardiac arrest from 1985 until 2004. Citations from bibliographies of identified publications were perused and cross-referenced for other potential articles. Case reports were included for analysis when mothers had complete cardiopulmonary arrest, and cardiopulmonary resuscitation had been initiated before cesarean delivery.

Results: There were 38 cases of perimortem cesarean delivery identified; 34 infants survived (3 sets of twins, 1 set of triplets); 4 other infants survived initially, but died several days after the deliveries from complications of prematurity and anoxia. Of the 34 infants (25–42 weeks' gestation), time of delivery after maternal cardiac arrest was available for 25. Eleven infants were delivered within 5 minutes, 4 were delivered from 6 to 10 minutes, 2 were delivered from 11 to 15 minutes, and 7 were delivered more than 15 minutes. Of 20 perimortem cesarean deliveries with potentially resuscitatable causes, 13 mothers were resuscitated and discharged from the hospital in good condition. One other mother was successfully resuscitated after the delivery, but died within 24 hours from complications related to her amniotic fluid embolism. In 12 of 18 reports that documented hemodynamic status, cesarean delivery preceded return of maternal pulse and blood pressure, often in a dramatic fashion. Eight other cases noted improvement in maternal status. Importantly, in no case was there deterioration of the maternal condition with the cesarean delivery. We wish to emphasize the large selection bias in this data.

Conclusion: Published reports from 20 years support, but fall far from proving, that perimortem cesarean delivery within 4 minutes of maternal cardiac arrest improves maternal and neonatal outcomes.

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The term perimortem cesarean delivery was introduced in 1986 to describe the procedure of cesarean delivery concurrent with maternal cardiopulmonary resuscitation.¹ The procedure was recommended to be initiated within 4 minutes of maternal cardiopulmonary arrest if resuscitative efforts were unsuccessful. The 4-minute rule was recommended after a review of experimental data and 1 case report, which suggested that maternal chest compressions for cardiac arrest were ineffective in the third trimester.¹⁻⁵ The aortocaval compression from the third-trimester uterus significantly reduces cardiac output.¹⁻⁵ Relieving the compression would allow for venous return and potentially more effective chest compressions. Thus, emptying the uterus, by delivering the infant, would not only ensure better survival of the infant, but also allow for more successful cardiac resuscitation. If the reason for the maternal cardiac arrest was reversible, establishing sufficient cardiac output by 4 to 5 minutes would potentially allow for cerebral oxygenation to prevent maternal neurologic damage.¹

For obvious reasons, the theory on which the 4-minute recommendation for perimortem delivery is based cannot be tested in clinical trials. Also, for obvious reasons, the sooner an infant is delivered after a mother arrests, the greater the likelihood of intact survival. This study was undertaken to review the literature from 1986 through 2004 to add evidence to support or refute the underlying hypothesis regarding timely perimortem cesarean delivery.

Methods

Medical literature was reviewed from 1985 through 2004 using an Ovid Medline search for {perimortem OR postmortem OR cardiac arrest OR heart arrest OR cardiopulmonary arrest OR cardiopulmonary resuscitation} AND cesarean section. The search was initiated in the English language and cross-referenced in other languages. The results of this search were supplemented with case reports identified from reference lists of articles located in the MEDLINE search. Perimortem cesarean delivery was defined as a procedure initiated after cardiopulmonary resuscitation had begun. Cesarean deliveries performed on mothers who were dying from mortal injuries, but still had vital signs, were excluded.

Results

Thirty-eight case reports of perimortem cesarean delivery were identified in the literature since 1986.⁶⁻³⁵ All the case reports identified the cause of maternal cardiac arrest as well as maternal and infant outcomes, although many pertinent obstetric details were omitted.

Table I Perimortem cesarean deliveries with surviving infants with reports of time from maternal cardiac arrest to delivery of the infant, 1985-2004^{6,7,11,12,14-16,20-23,25-27,29,31,33-35}

Time (min)	Gestational age (wk)	Number of patients
0-5	25-42	8 (normal infant) (retinopathy of prematurity and hearing loss) 3 (condition not reported)
Subtotal		12
6-10	28-37	1 (normal infant) 2 (neurologic sequelae) 1 (condition not reported)
Subtotal		4
11-15	38-39	1 (normal infant) 1 (neurologic sequelae)
Subtotal		2
> 15	30-38	4 (normal infants) 2 (neurologic sequelae) 1 (respiratory sequelae)
Subtotal		7
Total		25

Of the 38 procedures 28 resulted in 34 surviving infants, including 3 sets of twins and 1 set of triplets. Thus, in 30 of 38 perimortem cesarean deliveries, surviving infants were delivered. One of the twins died in the neonatal period from anoxic injury and complications of prematurity. Gestational age of surviving infants ranged from 25 to 42 weeks. The time from maternal cardiac arrest until delivery was specified for 24 surviving infants (Table I). Of these 24 infants, 17 had no sequelae, 5 had neurologic sequelae, 1 had chronic respiratory problems, and 1 had hearing loss and retinopathy of prematurity. Of the 10 surviving infants in which interval from maternal arrest until delivery was not specified, 4 had no sequelae, 1 had neurologic sequelae, and in 5 the condition was not listed.^{8,9,13,17,19,27}

The causes of maternal cardiac arrest are listed in Table II. Trauma, cardiac disease, and embolism were major causes. Of 35 women, 20 had potentially resuscitatable causes, of which 13 women survived.^{7,11,13,15,16,19,22,23,26,27,29-31} There were 14 case reports of mothers who were unlikely to be resuscitated. One mother dying from end-stage AIDS had a myocardial infarction while hospitalized with *Pneumocystis carinii* pneumonia.¹⁴ Another patient died from overwhelming sepsis.³⁵ Three patients had fatal gunshot wounds, one with head and neck wounds and two with wounds to the head and chest.^{20,21} One patient succumbed to a massive intracranial hemorrhage.³⁴ Five others had traumatic cardiac arrest in the field after motor vehicle accidents.^{10,25,33} Several patients had lengthy delays between onset of cardiac arrest and arrival at the hospital.^{9,17,28} The most important

Table II Reported cases of perimortem cesarean deliveries with cause of maternal cardiac arrest, 1985-2004

Cause of maternal cardiac arrest	Cases
Trauma	8
Cardiac	8
Embolism (AFE, air)	7
Magnesium overdose	5
Sepsis	3
Anesthesia	2
Eclampsia	1
Spontaneous uterine rupture	1
Intracranial hemorrhage	3
TOTAL	38

question of this study deals with the effects of cesarean section on cardiopulmonary resuscitation. In 22 case reports, information was provided regarding the effects of the cesarean section on maternal hemodynamic status (Table III). Twelve women had sudden and often profound improvement, including return of pulse and blood pressure at the time the uterus was emptied. In some cases it was notably dramatic.^{6-8,11-13,15,16,22,23,26-29}

In 2 patients, nonspecific improvement after cesarean section was noted. One patient had an electrocardiogram (EKG) change from asystole to electromechanical disassociation (pulseless electrical activity) after cesarean section, but resuscitation was discontinued because of massive head injury.²¹ The second patient's EKG changed from asystole to ventricular fibrillation after cesarean section and the patient was successfully resuscitated.²⁶ Among 8 patients in whom the effect of cesarean delivery was reported as no change of hemodynamic status, the causes for the arrests were lethal insults.^{6,9,10,14,17,18,33} In 2 other women, cardiopulmonary resuscitation was partially successful in achieving pulses but unstable blood pressure. Both of these women had cesarean deliveries within 5 minutes of arrest. One was a 42-year-old woman with a magnesium overdose. Chest compression, epinephrine, and defibrillation were used and blood pressure of about 70 mm Hg was obtained within 5 minutes.²⁴ With persistent fetal bradycardia, a cesarean section was initiated. After the uterus was emptied, the mother rapidly improved. Infant and mother had no long-term sequelae. The other patient was a 36-year-old woman at 32 weeks' gestation with severe preeclampsia, aortic insufficiency, and myocardial disease who arrested while being prepared for a cesarean delivery.⁸ After defibrillation, a weak pulse was obtained with chest compression. A cesarean delivery was performed. The infant did well but spontaneous cardiac activity in the mother could never be obtained and the maternal resuscitation was stopped after 70 minutes.

There were no reports of worsened maternal hemodynamic status after perimortem cesarean delivery. The

Table III Effect of perimortem cesarean section on maternal circulation, reported cases 1985-2004^{7,9-18,22,23,27-29,33,35}

Time from maternal cardiac arrest until delivery (min)	Return of spontaneous circulation and or improvement in hemodynamic status	
		No change
0-5	5	2
6-10	3	—
11-15	1	—
> 15	4	5
Not reported	1	1
Total	12	8

remaining 14 case reports contained no descriptions regarding maternal status after cesarean delivery, and were performed for mothers thought to be unresuscitatable. The procedures were performed in attempts to save the fetus. One of these women recovered after cesarean delivery, but succumbed within 24 hours from complications from an amniotic fluid embolism.

The amount of time which elapsed from onset of maternal cardiac arrest until cesarean delivery varied widely in this case series, ranging from 2 minutes to greater than 60 minutes. Only 8 of the 38 reported cases met the recommendation for perimortem cesarean delivery within 4 to 5 minutes of maternal cardiac arrest, if basic life support (BLS) and advanced cardiac life support (ACLS) were unsuccessful at resuscitation. The time delay in 4 of the cesarean deliveries performed more than 15 minutes after cardiac arrest can be attributed to out of hospital cardiac arrest.^{6,10,18,28,33} Reason for delay was not identified in the remainder of the case reports.

Comment

This review, of cases from 1986 through 2004, strongly supports performing a perimortem section within 4 minutes of maternal cardiac arrest if resuscitation is ineffective.

The original report advocating prompt perimortem cesarean delivery as an important tool of maternal resuscitation was based on theory and 1 case report. The theory is that effective cardiopulmonary resuscitation (CPR) is extremely difficult in the pregnant patient at term. Effective chest compressions are dependent on the victim being in the supine position. Under optimal conditions, chest compressions produce a cardiac output less than a third of normal.³⁶⁻³⁸ In a pregnant woman at term, the compression of the great vessels by the uterus reduces cardiac output another two thirds.² Thus, chest compression leads, in the best of circumstances to a cardiac output 10% of normal.^{1,6,37,38} The theory of perimortem cesarean section states that if chest compressions do not produce a pulse, then emptying the

uterus would be the next best step to allow effective CPR. Six minutes is the time for onset of neurologic injury in the mother after cessation of cerebral blood flow.³⁶⁻³⁹ Thus, the rationale for the 4-minute rule: start the procedure at 4 minutes if no pulse to obtain cardiac return by 5 minutes. Since 1986, the principle of the 4-minute rule has been adopted by the American Heart Association as a consideration when maternal CPR efforts are ineffective.³⁷

The current study was initiated to examine the principles of timely perimortem cesarean delivery. Twelve women were unresponsive to appropriate CPR. After perimortem cesarean deliveries, after emptying of the uterus, maternal pulses and blood pressure returned. For 8 other women the cesarean delivery benefited resuscitation.

Most resuscitation will be futile because the causes of maternal cardiac arrest are fatal. For these women there is no reason to delay cesarean delivery. The operation should be performed to save the infant. In these types of cases, we noted several children who survived because of perimortem cesarean section. For women with any question at all of survival, standard and full resuscitative measures are mandatory. However, prolonged resuscitation if no pulse can be obtained, we believe, is inappropriate. If no pulse is obtained despite chest compression, then the uterus should be emptied to allow for more effective CPR. This not only allows for a healthier infant, but also may allow for a successful resuscitation.

There are reports in the literature of pregnant women having successful chest compression and CPR for cardiac arrest. The lateral, head down tilt has been suggested as an effective way to overcome the aortocaval compression of the third-trimester uterus.⁴⁰⁻⁴² Obviously if resuscitation is successful in a short time, cesarean is unnecessary. Intuitively, one would anticipate that perimortem cesarean delivery would most benefit mothers in the late third trimester. Unfortunately, our data were not broad enough to evaluate that assumption. For any indication of maternal cardiac arrest, if pulses cannot be obtained, the cesarean delivery should be performed. There is danger is waiting too long for both mother and infant.

In our review, we excluded numerous reports of postmortem sections performed on trauma victims who were brought to emergency rooms at lengthy periods of time after injury. We also noted 20 of 38 women to have potentially resuscitatable insults. Both of these issues highlight the huge selection bias and publication bias in this report, which is a weakness of this review. For this reason, we can only infer conclusions, and qualify our findings with the emphasis that our recommendations are based on case reports, not Level III evidence. For obvious reasons we will not ever have a randomized trial for this problem, and case reports along with clinical judgment will be our best guide.

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Editor's note: This manuscript was revised after these discussions were presented.

Discussion

DR MICHAEL NAGEOTTE, Long Beach, Calif. In this interesting report, Drs Katz, Balderston, and De Freest expand on an earlier publication from October 1986 in which the concept of "perimortem" cesarean delivery

was first introduced. Not to be confused with post-mortem cesarean delivery, with its entire attendant mythologic, religious, legal, and biologic overtones, perimortem cesarean delivery was defined as the initiation of cesarean delivery within 4 minutes of maternal cardiopulmonary arrest and delivery being effected within 5 minutes of arrest. Reviewing case reports as well as exploring the maternal physiologic response to the clear physical barriers of effective CPR in a gravid patient, Dr Katz and colleagues at the University of North Carolina recommended in their earlier report a "4-minute rule" to optimize saving the lives of both mother and newborn in a setting of cardiac arrest during pregnancy.

What has just been presented is an update and refinement of these earlier recommendations. Using a literature search tool for the years 1985 through 2004, the investigators present 38 cases of perimortem cesarean sections. Of the 38 surgeries 28 resulted in 34 initially surviving infants. Again, there appears to be benefit to both the mother and fetus with earlier cesarean delivery after maternal cardiac arrest and these findings lend further support to the prior recommendations.

This subject is remarkably challenging to study, as it does not readily lend itself to experimental design or control. Further, as pointed out by the authors, the likelihood of reporting bias is overwhelming with poor outcomes very likely to be underreported. Perhaps more importantly, the inability to control for confounding variables such as maternal size, gestational age, cause of acute cardiovascular decompensation, quality of resuscitation, intravenous access, airway management, location of arrest, maternal comorbidities, availability of surgeon and operating options, not to mention patient wishes regarding intervention present unique and profound problems when evaluating such cases. The ability to assess such a complex clinical issue and take it to the level of recommendations for management is at best daunting and potentially dangerous. It is with a full appreciation of these limitations that this study has been presented by its authors.

When faced with such a catastrophic scenario, the obstetrician must rapidly distill multiple issues before initiating a surgical procedure that could improve or potentially worsen an acutely dire clinical condition. Is the cause of arrest reversible? Is the gestational age accurate? Is the timeline of arrest reliable? Could immediate surgical intervention worsen the prognosis in a setting that is likely unsterile and at best remarkably challenging? How long is too long?

Having personally been faced with such a daunting clinical dilemma, I congratulate Dr Katz and his colleagues for this excellent review and discussion of a thankfully rare yet unforgettable event in any obstetrician's career.

My questions for Dr. Katz are as follows: