OBSTETRICS

Fetal heart rate tracings associated with eclamptic seizures

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BACKGROUND: Although there is a well-known association between fetal bradycardia and maternal eclampsia, the characteristics of fetal heart rate tracings after an eclamptic seizure have not previously been thoroughly described. Fetal heart rate changes are thought to be related to maternal lactic acidemia caused by vasospasm and uterine hyperactivity leading to placental hypoperfusion and fetal hypoxia. The decision to intervene in the case of an abnormal fetal heart rate tracing after an eclamptic seizure is often difficult; however, maternal resuscitation should be the primary focus.

OBJECTIVE: This study aimed to quantify and characterize fetal heart rate changes associated with a maternal eclamptic seizure. Moreover, we sought to document subsequent obstetrical management following these seizures complicated by fetal heart rate decelerations.

STUDY DESIGN: This was a retrospective study of fetal heart rate tracings associated with eclampsia during a 13-year period at a single institution. Eclampsia was diagnosed following the 2013 Executive Summary of the American College of Obstetricians and Gynecologists criteria. Tracings were independently reviewed and classified by 3 physicians using the National Institute of Child Health and Human Development Criteria. Hospital records were reviewed to ascertain obstetrical management after the eclamptic seizure.

RESULTS: A total of 107 women were diagnosed with eclampsia from January 2009 to December 2021. Of these women, 31 experienced 34 intrapartum seizures during which time electronic fetal heart rate monitoring was ongoing. During the 34 seizures, fetal heart rate decelerations were documented in 79% of cases. The mean duration of bradycardia was 5.80 ± 2.98 minutes with a range of 2 to 15 minutes. Fetal heart decelerations occurred, on average, 2.7 ± 1.6 minutes after the onset of the eclamptic seizure. In half of the fetuses with fetal heart rate changes, fetal tachycardia followed, and in 48% of cases, there was minimal variability noted. As a result of the fetal heart rate tracings and clinical findings, 4 women underwent an emergent cesarean delivery, including 2 that were diagnosed with placental abruption. In this cohort, there were 4 cases of abruption. The mean duration from the seizure to delivery was 299 ± 353 minutes. The mean neonatal cord pH was 7.20 ± 0.11 with a mean base excess of -8.6 ± 4.4 mmol/L. There was no perinatal death.

CONCLUSION: After an eclamptic seizure, 79% of fetuses demonstrated prolonged decelerations, and half of the fetuses developed fetal tachycardia after recovery from the episode of bradycardia. Despite these periods of fetal heart rate decelerations associated with eclampsia, prioritization of maternal support and stabilization resulted in a favorable perinatal outcome without immediate operative intervention in more than two-thirds of cases.

Key words: eclampsia, fetal bradycardia, fetal heart rate tracing, fetal tachycardia, placental abruption, seizure

Introduction

The earliest description with quantification of fetal heart rate decelerations with eclampsia was published by Boehm and Growdon in 1974.[1] These investigators described 2 fetuses who were being electronically monitored at the time of an eclamptic seizure, both of whom were born healthy. The authors hypothesized that maternal hypoxia caused transient fetal heart abnormalities. In 1978, Paul et al[2] described 10 fetuses who were being monitored during 14 eclamptic episodes. Although not universal, some of these women had uterine hyperactivity lasting from 2.5 to 14 minutes, and 6 fetuses had bradycardia that lasted as long as 9 minutes. They postulated that "transient fetal distress" was because of impaired uteroplacental blood flow aggravated by transient maternal respiratory arrest. Since then, although there have been other reports concerning the expected fetal heart rate changes with eclampsia, these, however, did not describe the timing, duration, and frequency of these changes.[3–6] The following study was designed to further characterize these abnormalities and to determine how often fetal heart rate abnormalities prompted immediate changes in obstetrical management with maternal eclamptic seizure.

Materials and Methods

This retrospective study was conducted after approval from the institutional review boards of the University of Texas Southwestern Medical Center and Parkland Memorial Hospital (STU 062016-034). Data encounter forms are created for all women delivering and experiencing eclampsia. These are recorded in an obstetrical quality database, an ongoing quality assurance database that tracks maternal and neonatal outcomes. Quality checks are carefully maintained by a team of trained research nurses operating with a standard manual of definitions for all deliveries at >20 weeks of gestation. In addition, we queried discharge diagnoses encoded for eclampsia using the International Classification of Disease, Ninth and Tenth Revisions, to ensure the accuracy of our dataset. Our review included all women delivered at Parkland Memorial Health from January 2009 to December 2021. The records of those whose pregnancy was complicated by eclampsia were studied to ascertain

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Why was this study conducted?
Although maternal eclamptic seizures have been associated with changes in fetal heart rate tracings, a detailed characterization of these findings and subsequent alteration in obstetrical management have not been reported.

Key findings
Fetal heart rate abnormalities were associated with nearly 80% of seizures. The findings included bradycardia, which lasted, on average, 5.80±2.98 minutes. Fetal heart decelerations occurred, on average, 2.7±1.6 minutes after the onset of the eclamptic seizure. In those fetuses with abnormal tracings associated with the seizure, 48% were associated with minimal variability with subsequent fetal tachycardia. Despite these fetal heart rate abnormalities, vaginal delivery occurred in more than two-thirds of fetuses with generally favorable infant outcomes.

What does this add to what is known?
There is a paucity of current literature detailing fetal heart rate abnormalities after an eclamptic seizure, although it is well known that these changes occur. We have presented this case series as a reference for providers to understand the extent of fetal heart rate abnormalities, their associated outcomes and discussion of subsequent management recommending maternal stabilization, and the need to avoid immediate cesarean delivery unless obstetrical findings indicate otherwise.

multiple seizures, the initial seizure was used to calculate time-to-delivery intervals. Finally, their subsequent obstetrical management was ascertained to evaluate changes in obstetrical management after the eclamptic seizure.

Results

During the 13-year study, a total of 154,036 women were delivered at Parkland Memorial Hospital. Of these women, 107 had at least 1 eclamptic seizure for a frequency of 6.95 per 10,000 births. As shown in Figure 1, there were 78 women whose seizures occurred in the hospital, and 29 women had out-of-hospital seizures. There were 31 women with antepartum eclampsia during which 34 seizures occurred while undergoing electronic fetal monitoring. The demographics of these women are described in Table 1. Women were, on average, 24±6.7 years old, predominantly

whether seizures occurred before delivery or after delivery and, if the former, whether electronic monitoring was being employed. All women with eclampsia were managed following the guidelines of the Task Force of the American College of Obstetricians and Gynecologists, which reaffirmed the definitions of previous college publications contemporaneous to these cases (2013).[7] In all cases, eclampsia prompted maternal stabilization, magnesium sulfate infusion, control of maternal hypertension, maintenance of airway with supplemental oxygen, and facilitating delivery. The mode of delivery was determined by usual obstetrical indications, and cesarean delivery was not immediately performed for the indication of eclampsia alone.

Records were extracted for variables to include demographic data, clinical course, and obstetrical outcomes. For those women who were undergoing electronic fetal monitoring at the time of an eclamptic episode, the tracings were reviewed independently by 3 of the authors using the National Institute of Child Health and Human Development (NICHD) fetal monitoring terminology.[8] For women who experienced

FIGURE 1
Flow diagram showing location of eclamptic seizure at Parkland Health
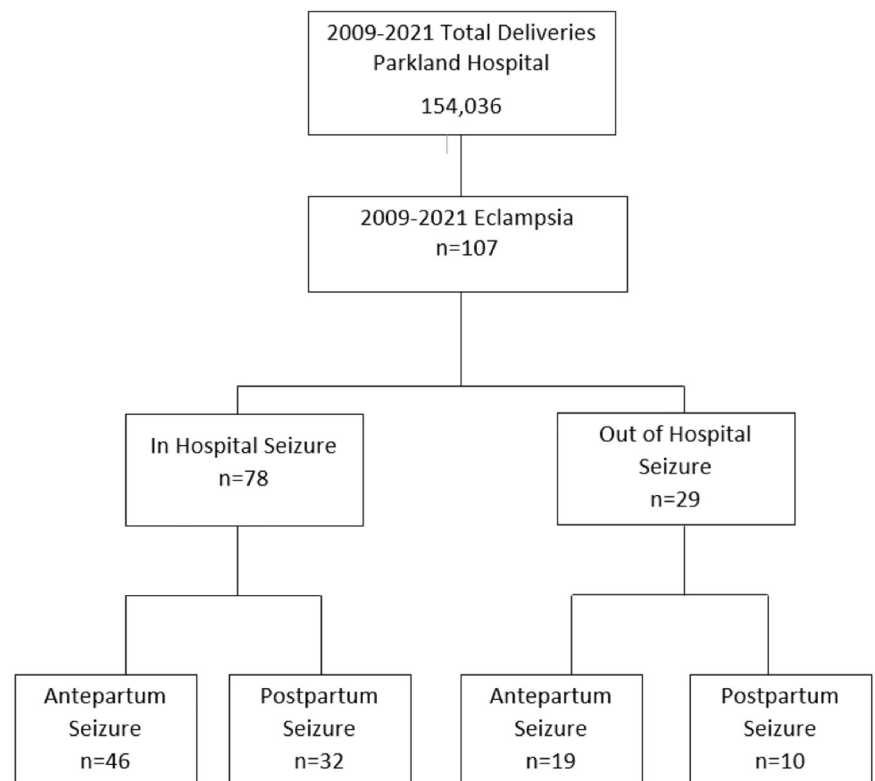
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TABLE 1
Maternal and neonatal characteristics

Characteristics	n=31
Age (y)	24.0±6.7
Race and ethnicity	
Black	2 (6)
White	0 (0)
Hispanic	29 (94)
Body mass index (kg/m^2)	30.9±6.2
Gestational age at delivery (wk)	39±2
Mode of delivery	
Vaginal	14 (45)
Forceps-assisted vaginal delivery	7 (23)
Cesarean delivery	10 (32)
Infant weight (g)	3091±582
Neonatal intensive care unit	7 (23)
Apgar score (1 min)	6.5±2.6
Apgar score (5 min)	8.4±1.2
Umbilical artery pH	7.2±0.11
Base excess	−8.6±4.4

Data are presented as mean±standard deviation or number (percentage).

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Hispanic (94%), and delivered a term gestation (39±2 weeks). Most women underwent spontaneous vaginal delivery (45%) or forceps-assisted vaginal delivery (23%) (Table 1). Of note, 7 women had eclamptic seizures while on magnesium sulfate infusion. Moreover, 6 of these women had serum levels of magnesium sulfate considered to be therapeutic near the time of seizure.

Fetal heart rate decelerations were observed during the seizure in 79% of those women while undergoing simultaneous fetal heart rate monitoring. The mean duration of decelerations was 5.8±3.0 minutes with a range of 2 to 15 minutes. The decelerations began, on average, 2.7±1.6 minutes after the onset of the eclamptic seizure. Of these women with fetal heart rate monitoring

TABLE 2
Characteristics of fetal heart rate decelerations at the time of eclamptic seizure

Characteristics	n=27
Decelerations at time of eclampsia	27 (79)
Duration of decelerations (min)	5.8±3.0
Onset of decelerations after seizure (min)	2.7±1.6
Fetal tachycardia after recovery	14 (52)
Minimal variability	13 (48)

Data are presented as mean±standard deviation or number (percentage).

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during the eclamptic seizure, fetal heart decelerations were reflected in 79%, fetal tachycardia subsequently developed in 52%, and there was minimal variability in 48% (Table 2). Overall, 21% of these women had a category I tracing by NICHD definitions. There was no category III tracing with absent variability.

In 4 of 31 women (13%) in whom fetal heart rate monitoring was in progress, an emergency cesarean delivery was performed (Table 3). In 2 of these 4 women, placental abruption was diagnosed. In the cohort of 31 women experiencing an eclamptic seizure while undergoing fetal heart rate monitoring, the mean time from seizure to delivery was 299±353 minutes.

The mean Apgar scores of the 31 infants were 6.5±2.6 at 1 minute and 8.3±1.2 at 5 minutes. Their mean umbilical artery pH was 7.20±0.11, and the mean base excess was −8.6±4.4 mmol/L. There were 3 neonates with a base excess of −16 mmol/L or greater. Of note, 2 neonates were born after a placental abruption, and the third neonate was delivered after an episode of hypotension associated with anesthesia administration. There were 7 of 31 infants admitted to the neonatal intensive care unit: 4 for placental abruption, 2 for depression at birth, and 1 for glucose monitoring because of having a mother with diabetes mellitus.

There were 2 cases in which the duration of fetal heart decelerations exceeded 10 minutes. These 2 had decelerations of 12 and 15 minutes with a nadir of 70 to 80 bpm. Shown in Figure 2 is a tracing of a woman at 35 weeks of gestation with a prolonged fetal heart rate deceleration. After recovery to baseline, labor continued, and she underwent cesarean delivery 264 minutes later for a nonreassuring fetal heart rate pattern. The newborn had an Apgar score of 8 and 9 and a cord arterial pH of 7.2. Shown in Figure 3 is a tracing of a 39-week pregnant woman who continued to labor after recovery from prolonged fetal bradycardia. She was delivered vaginally 255 minutes later with a newborn having an Apgar score of

TABLE 3
Selected data from 4 fetuses undergoing emergent cesarean delivery after an eclamptic seizure

Gestational age (wk)	Duration of deceleration (min)	Seizure to delivery (min)	Indication for delivery	Apgar score (1 and 5 min)	Cord gases (BE mmol/L)
41	7	19	Abruptio placenta: abdominal pain and bloody amniotic fluid	6 and 8	pH=6.98/−19
39	7	21	Prolonged deceleration: 40—50 s without recovery	7 and 8	pH=6.99/−16.7
33	8	16	Abruptio placenta: vaginal bleeding	3 and 7	pH=7.15/−11
40	2	12	Second stage of labor seizure on magnesium sulfate requiring intubation	2 and 5	No cord gas

BE, base excess.

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7 and 7. Both of these infants had an uneventful hospital course.

Discussion
Principal findings
From observations now described, the frequency of fetal heart rate decelerations occurring after the eclamptic seizure was 79%. These decelerations occurred shortly after the onset of the maternal seizure and were prolonged at an average of nearly 6 minutes in duration with minimal variability and fetal tachycardia noted at recovery. In most cases, fetal heart rate abnormalities were accompanied by uterine irritability with frequent contractions or frank uterine tetany. This characterization of fetal heart rate abnormalities contemporaneous to maternal seizure is similar to findings from Paul et al[2] among 10 patients with eclampsia in 1978 but further defines characteristics, timing, and

subsequent obstetrical management with neonatal outcomes. In this cohort, most infants were delivered well after the eclamptic seizure with favorable outcomes. Of note, 13% of women underwent an emergency cesarean delivery not because of the seizure itself but because of concerns for fetal compromise after the eclamptic seizure.

Results in the context of what is known
Complications of eclamptic seizures have been documented for centuries. Maternal deaths have been reported from a myriad of complications that included puerperal hemorrhage, placental abruption, strokes, and pulmonary edema from heart failure and aspiration pneumonia.[9—11] Perinatal morbidity and mortality were inordinately high with preterm delivery, stillbirth, and neonatal deaths. During the

first half of the 20th century, 2 management schemes included immediate delivery after seizures and maternal stabilization followed by orderly planning for labor and vaginal delivery. With either method, the primary concern was for maternal well-being, and there was little consideration for fetal salvage; moreover, there was no description of fetal heart rate changes.[12—15] By the midcentury, standard textbooks began to describe fetal reactions to maternal seizures. Because eclamptic convulsions were frequently followed by uterine irritability or tetaniclike contractions, it was concluded that fetal heart rate changes were because of uteroplacental insufficiency caused by excessive uterine activity. It further followed that fetal heart rate decelerations and bradycardia were a symptom of maternal status and would dissipate when the convulsion abated, and if this did not occur,
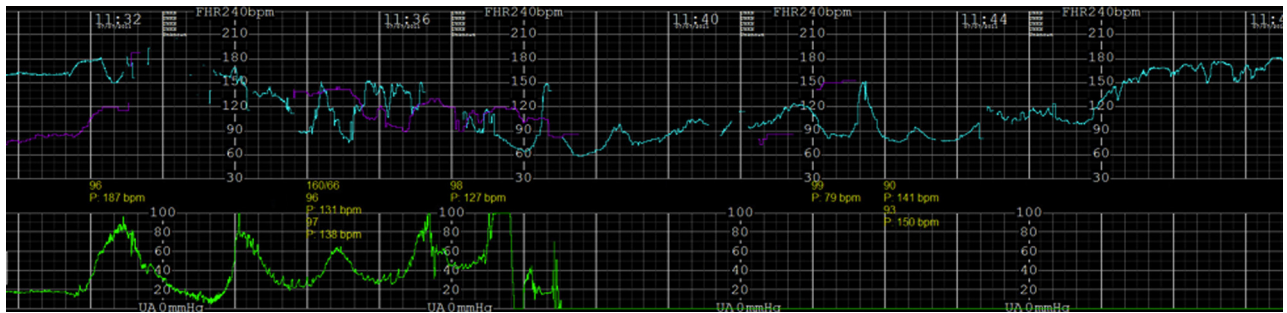
FIGURE 2
Prolonged fetal heart rate deceleration in a 39-week fetus
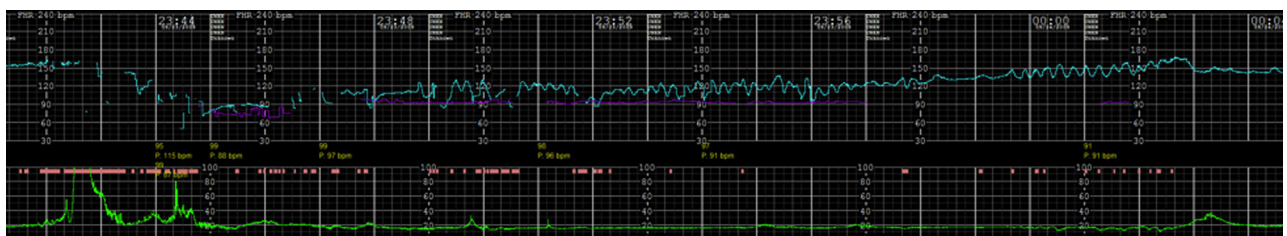
The figure shows a prolonged fetal heart rate deceleration of a 35-week fetus. A primary cesarean delivery was performed 264 minutes later with an Apgar score of 8 and 9. The infant was admitted to the newborn nursery and discharged on day of life 3.

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The figure shows a prolonged fetal heart rate deceleration of a 39-week fetus. Vaginal delivery was performed 255 minutes after an eclamptic seizure delivering a 2880 g female infant with an Apgar score of 7 and 7. The infant was admitted to the newborn nursery and discharged on day 2 of life.

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considerations were given for alternative etiologies, such as placental abruption or cord prolapse.[6,16—18] In our overall cohort, 4 instances of placental abruption were diagnosed at the time of delivery. Of note, 2 of these women underwent emergency cesarean delivery after decelerations lasting 7 and 8 minutes, which are below the 10 minutes otherwise described in the literature for consideration of abruption.[12] The 2 women found to have abruptions at the time of their vaginal delivery had decelerations lasting 5 and 6 minutes.

Fetal bradycardia is not unique to eclamptic convulsions. Similar fetal heart rate abnormalities are described with grand mal and complex partial epileptic seizures, although their pathology is different.[19—22] Similarly, many of these cases with prolonged decelerations are associated with uterine tetanic contractions lending credence to the pathophysiology of eclampsia-induced fetal bradycardia observed by Boehm and Growdon[1] and Paul et al.[2] Moreover, similar to those with eclampsia, fetuses born after maternal epileptic seizures are metabolically recovered when delivered remotely from the seizure.

Clinical and research implications

The complications of maternal eclampsia have been well described, and expert opinion has advocated for active management and resuscitation of the mother rather than emergent delivery.

Our findings supported the concept that fetal heart rate abnormalities as a result of maternal eclampsia are a reflection of maternal status and that supportive care of the mother results in recovery of fetal heart rate abnormalities allowing for proceeding with labor management.

Strengths and limitations

Our study encompassed a contemporary cohort of patients with maternal eclampsia with a detailed description of fetal heart rate abnormalities. Study strengths included the large cohort and the redundancy of review to ensure accurate data collection. Although 65% of antepartum seizures that occurred in the hospital had an associated fetal heart rate tracing, which we have reported, all patients were not being monitored at the time of the eclamptic seizure. In addition, this was a pragmatic study in which physician management of fetal heart rate tracings was not standardized. Therefore, additional research into the improvement in maternal and neonatal outcomes should be continued.

Conclusions

Our findings supported the currently prevailing opinion that postclamptic seizure fetal heart rate decelerations and bradycardia without other findings are not an indication for emergency cesarean delivery.[6,16—18] Eclampsia management includes control of the seizures along with maternal oxygenation to allow resolution of hypoxia and acidosis

rather than inflict a major surgical procedure on the mother with a precarious metabolic state. The priority of eclampsia management is first maternal resuscitation and stabilization with prevention of recurrent seizures, control of maternal blood pressure, prevention of maternal injury, and maintenance of the airway with maternal oxygen administration. In most cases, fetal heart rate abnormalities will resolve. Our findings of subsequent vaginal delivery occurred in more than two-thirds of cases, thus avoiding the need for operative delivery. As a general rule, "what is best for the mother is also best for the fetus."[4] ■

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