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The association between time of birth and fetal injury resulting in death

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KEY WORDS
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Objective: In obstetrics, the care of patients in labor or with emergencies takes place day and night. Birth-related injury is among the worst of obstetric outcomes. This study sought to examine the relationship between time of birth and fetal injury resulting in death.
Study design: The Birth-Related Neurologic Injury Compensation Association (NICA) is a Florida organization that pays for the care of infants >2500 g with birth-related brain or spinal cord injury resulting in permanent impairment. We conducted a case-control study using all deaths from the NICA database from 1989 to 2002. Data were collected on the antepartum, intrapartum, and postpartum care of the mother and fetus/child. Time of birth was identified for all cases and compared with a randomly selected control group of 1000 births in 1996 from Florida.
Results: Eighty deaths were identified in the NICA database of 447 total cases. Of the 80 cases, 36/80 (45%) were born from 11 PM to 8 AM. Of the 999 controls (1 certificate sealed for adoption) 281 (28.1%) were born from 11 PM to 8 AM. This yields an odds ratio of 2.09 (95% CI 1.29-3.40) for the association of nighttime birth with fetal injury resulting in death.
Conclusion: Fetuses sustaining injuries resulting in death were more than twice as likely as controls to have been born from 11 PM to 8 AM. Further studies are needed to determine the factors that affect this association and what changes might need to be made to optimize care regardless of time of day or night.

Nighttime work is essential for the care of patients. This is true throughout the health care system. Perhaps more than any other field of medicine, however, obstetrics is associated with nighttime work. Labor and delivery and emergencies regularly occur throughout the 24 hours of the day, and the image of the obstetrician being awakened in the middle of the night to deliver a baby is ingrained in our collective consciousness.

Physicians, however, are not the only ones working at night in fields that involve public safety. In many other industries, such as transportation, nuclear power, and the military, people have to work at night. Interestingly, all of these industries have guidelines or regulations governing nighttime work.[1] There is evidence from these industries that nighttime work poses risks.[2]

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Table I Comparison of demographic and delivery data

	NICA (n = 80)	Controls (n = 999)	*P* value
Maternal age	28.9	27.3	.095
Parity (median)	1	1	.928
Gestational age	38.8	38.6	.458
Race			
White	46.9%	58.9%	.0076
Black	21.0%	18.9%	
Hispanic	22.2%	19.0%	
Other	9.9%	3.2%	
Mode of delivery			
NSVD	12.3%	70.7%	< .0001
Cesarean	71.7%	21.4%	
Vacuum	12.3%	6.4%	
Forceps	3.7%	1.5%	

In medicine, however, the topic of time of day and poor outcomes has not received as much attention as other areas relating to patient safety. For example, the 2000 Institute of Medicine report *To Err is Human* concluded that the health care system fails to ensure that patients are safe or that the quality of care they receive is high.[3] But there was little focus on time of day and poor outcomes. This is especially remarkable for a field like obstetrics when one considers how absolutely central nighttime work is to the duties of obstetric providers and the safety of their patients.

We sought to address the issue of the relationship between time of day and obstetric outcomes by examining the association between nighttime birth and fetal injury during labor and delivery, which resulted in the death of the child.

Material and methods

We performed a case-control study using as cases births from 1989 to 2002 that had been submitted to Florida's Birth-Related Neurologic Injury Compensation Association (NICA). NICA was established in 1988 by the Florida legislature. It provides compensation without litigation to children and families who suffer a birth-related neurologic injury while being cared for by a NICA-participating physician. For the purposes of NICA, a birth-related neurologic injury is a brain or spinal cord injury occurring to a live-born infant with a birth weight of at least 2500 g. The injury must be caused by oxygen deprivation or mechanical injury, and occur during the course of labor, delivery, or resuscitation in the immediate postdelivery period in a hospital. The injury must have rendered the infant permanently and substantially mentally and physically impaired. The legislation does not apply to genetic or congenital abnormalities.[4]

The research protocol was approved by the Institutional Review Boards of the University of South Florida and Tampa General Hospital. For the purposes of this study, all cases in the NICA database (80) in which there was death of the child were assessed. All 80 of the children had evidence of severe injury at the time of birth. Data were collected on the antepartum, intrapartum, and postpartum care of the mother and fetus/child. Time of birth was identified for all cases. Two reviewers (ACU, WFO) reviewed all cases and assigned a cause of injury for each case.

To establish a control group, 1000 births from 1996 (the midpoint year of the study) were chosen. To select these 1000 births, 1000 random numbers were generated from 1 to 189,678 (the number of birth certificates registered in the state of Florida in 1996.) One of the birth certificates was sealed for adoption, yielding 999 available birth certificates to review. All birth certificate data were collected, with emphasis on time of birth for each delivery. No NICA cases from 1996 were included in the set from which controls were selected, thus ensuring that no cases were included as controls.

Normally distributed continuous variables were compared with a Student *t* test and frequency data with chi-square analysis. Parity was compared with a Mann-Whitney *U*-test. Odds ratios and 95% confidence intervals were calculated to assess the association between time of birth and fetal injury resulting in death. Multivariate analysis was performed using logistic regression. In general, multivariate models were tested that included all variables with trends towards significance on univariate analyses ($P < .10$) as well as any variable suspected of being a confounder clinically. Analysis was performed with SPSS 11.5 (SPSS, Inc, Chicago, IL).

Results

From 1989 to 2002, 447 total cases were registered with NICA. Of these 447 cases, 80 cases resulted in the death of the child. In all 80 cases, there was evidence of significant neurologic injury at the time of birth. Deaths occurred most often during the immediate neonatal period, but ranged up to 7 years. Characteristics of the 80 cases are presented in Table I. In 1996 in the state of Florida, there were 189,678 births. From this group, 999 births were randomly selected through random number generation. Characteristics of these 999 controls are presented in Table I. On average, the mothers of the case children were slightly older than the mothers of the controls, but this difference was not statistically significant. Parity and gestational age did not differ between cases and controls. Significantly more of the NICA cases were black or Hispanic compared with controls. In our 1996 control group, 21.4% of births were via cesarean and the rate of operative vaginal delivery was 7.9%.

Table II Time of birth comparison

	Night (11 PM-8 AM)	Day (8 AM-11 PM)	OR (95% CI)
NICA (n = 80)	36 (45%)	44 (55%)	2.09 (1.29-3.40)
Controls (n = 999)	281 (28%)	718 (72%)	

This differed markedly from the mode of delivery of the NICA cases, in which 71.7% were delivered via cesarean and 16.0% had an operative vaginal delivery.

Table II is the time of birth comparison between the cases and controls demonstrating that of the 80 cases, 36/80 (45%) had a birth time from 11 PM to 8 AM. Of the 999 controls 281 (28.1%) had a birth time from 11 PM to 8 AM. This yields an odds ratio of 2.09 (95% CI 1.29-3.40) for the association of nighttime birth with fetal injury resulting in death. Logistic regression was performed to test for possible confounding from maternal age, birth weight, estimated gestational age at the time of birth, delivery by midwife, and race. Several of the variables including birth weight, gestational age, and race were independent predictors of fetal injury resulting in death, but they were not confounders. Including them in the model did not change the odds ratio for nighttime delivery (adjusted odds ratio for nighttime delivery in the model including all potential confounders noted above: 2.12 with 95% CI 1.3-3.4). Table III demonstrates the odds ratio by 3-hour interval with daytime deliveries (8 AM to 11 PM) as the comparison group. The 11 PM to 2 AM interval had the highest odds ratio of 2.43 (1.22-4.78). The 2 AM to 5 AM interval and 5 AM to 8 AM intervals had odds ratios of 1.79 (0.82-3.85) and 2.04 (0.98-4.16), respectively.

To assess the effect of scheduled repeat cesarean delivery on the odds ratio we repeated the analysis removing from the controls any repeat cesarean deliveries that occurred from 8 AM to 5 PM. There were 50 repeat cesarean deliveries during this time interval. Removing these 50 deliveries from the control group resulted in an odds ratio of 1.95 (95% CI 1.19-3.16).

The cause of injury to the fetus in the 80 cases, as determined by the reviewers, is listed in Table IV. Thirty-seven of 80 (46.2%) of cases were classified under the general heading of nonreassuring fetal heart rate tracing (NRFHT) only as there was no evidence of uterine rupture, abruption, fetal trauma, cord prolapse, or other etiology. Seventeen of 80 (21.3%) of the NICA cases were uterine ruptures and 11/80 (13.8%) were placental abruptions. Eight of 80 (10%) were cases in which fetal injury from vacuum or forceps occurred. In all 8 of these cases a vacuum was used, with 3 of the deliveries taking place via forceps after the vacuum had failed. In 6 of these cases the fetal heart rate tracing was available for review and in 5 of these 6 cases it was nonreassuring before the use of vacuum or forceps. There were cranial injuries in all 5 of these cases, but the exact contribution of intrapartum acidemia versus head trauma to the ultimate death of the child could not be determined with certainty. In 1 of the 6 cases, a vacuum was used at the time of cesarean for arrest of dilation. The fetal heart rate tracing was normal. The infant developed a massive subgaleal hemorrhage and died the next day. There were 4/80 (5%) cases of cord prolapse. The other 3 cases were a shoulder dystocia, an amniotic fluid embolus, and a fetomaternal hemorrhage.

In 16 of the 80 cases (20%), the initial testing performed on the fetus on arrival to the hospital was not described as reassuring. In 64 of the 80 cases (80%) initial fetal testing was described as reassuring and the development of nonreassuring fetal testing took place during the hospital course.

Table III Odds ratio by 3-hour interval using 8 AM-11 PM as the comparison group

Time interval	Odds Ratio (95% CI)	Cases n (Total = 80)	Controls n (Total = 999)
11 PM-2 AM	2.43 (1.22-4.78)	14	94
2 AM-5 AM	1.79 (0.82-3.85)	10	91
5 AM-8 AM	2.04 (0.98-4.16)	12	96
8 AM-11 PM	1.00	44	718

Table IV Cause of fetal injury

Cause of injury	Number	Percentage
NRFHT only	37	46.2%
Uterine rupture	17	21.2%
Abruption	11	13.8%
Vacuum or forceps injury	8	10.0%
Cord prolapse	4	5.0%
Other	3	3.8%
Total	80	100%

Comment

Fetuses sustaining injuries severe enough to result in death were more than twice as likely as controls to have been born from 11 PM to 8 AM. This increased odds ratio held across the range of nighttime hours, demonstrating a consistent association between nighttime delivery and fetal injury resulting in death.

This finding is consistent with the previous studies on this subject.[5-13] One recent American study[13] and 5 recent European studies[8-12] have examined the relationship between time of birth and perinatal death, and all found increased risk with nighttime delivery, with risks ranging from 1.04 to 2.18. Several earlier studies also demonstrated this association.[5-7] Our findings are also

consistent with research from other fields that show, for example, increased rates of traffic accidents, ship collisions, and worker injury at night, as well as decreased performance.[14]

The question, then, is what is special about time of day that underlies this association between nighttime birth and fetal injury resulting in death? Previous discussions in the literature and our own findings would suggest 5 main categories of potential contributing factors: the protective effect of daytime scheduled cesarean, day/night differences in staffing, prolonged labor, possible differences in case mix between day and night deliveries, and provider fatigue.

Patients undergoing a scheduled daytime cesarean are still at risk for fetal injury resulting in death, but that risk is considerably smaller than for other patients. Therefore, the fact that the vast majority of scheduled cesareans occur during the day is likely to play a role in our described association. We were unable to determine which of the control deliveries were scheduled cesareans based on the birth certificate data. We were, however, able to determine which were repeat cesareans. Therefore, to determine the effect of scheduled cesarean on our observed association we reanalyzed the data after removing from the control group all 50 repeat cesarean deliveries that took place from 8 AM to 5 PM. We were left with a lower, but still statistically significant odds ratio (1.95 [1.19-3.16]). However, this "correction" may inaccurately lower the odds ratio as an unknown number of the repeat cesarean deliveries during this time interval may not, in fact, have been scheduled repeat cesarean deliveries. For example, a significant percentage of these women may have been attempting a vaginal birth after cesarean (VBAC) and may have been delivered via cesarean for a nonreassuring fetal heart rate tracing. In Florida in 1996, the VBAC rate was 25.7%.[15] Thus, it is likely that a significant percentage of women from the control group who had a repeat cesarean were, in fact, attempting VBAC. Therefore, excluding them from the daytime group may incorrectly lower the odds ratio. Likely offsetting this, however, are the scheduled cesareans from the primary cesarean group. We see, then, that scheduled daytime cesarean does appear to contribute to the observed association, but does not wholly account for it.

Along similar lines, another possible contributing factor is the effect of pregnancy conditions that would lead to normally scheduled deliveries during the day, but could lead to emergencies and poor outcomes. An example of this is placenta previa. Patients with placenta previa who do not have bleeding will, almost always, be delivered by scheduled cesarean during the day. Those patients with previa who hemorrhage will come in randomly over the course of the 24-hour day and these patients are more likely to have fetal injury resulting in death. Therefore, this effect would skew the odds ratio towards showing increased risk at night. However, in our data set of 80 cases of fetal injury resulting in death, only 2 of the 80 cases involved a patient who would have been scheduled for a cesarean: 1 patient in labor with a placenta previa who delivered vaginally and another with a breech fetus who arrived to the hospital in second stage labor. Thus, 78 of the 80 cases did not involve conditions for which cesarean would have been scheduled. In fact, the overwhelming majority of cases (64/80) involved fetuses who had reassuring fetal heart rate testing documented at some point during their hospitalization and went on to develop conditions (eg, uterine rupture, abruption, trauma from instrumental delivery, progressive intrapartum hypoxia) that appear to have led to fetal injury resulting in death.

Day/night staffing differences may also contribute to our observed association. Certainly, staffing patterns in many departments (eg, nursing, anesthesia, pediatrics, and obstetrics) are likely to be different at night than during the day. This is true both for the ratio of providers to patients as well as for the issue of in-house versus at-home availability. Furthermore, in some institutions there may be a difference in experience of the providers during the night shift with more junior, or less-experienced staff on at night compared with the day. However, in our review of the 80 NICA cases there was only 1 overt mention in the chart of a staffing issue: a case in which the obstetrician had to wait for an operating room to become available to perform a cesarean. Routine documentation of staffing in individual patient charts is unlikely; thus, it is possible that staffing issues were involved in ways that were not documented in the charts.

Regarding the progress of labor, most inductions start during the day and studies have shown that patients in spontaneous labor have higher rates of early afternoon delivery.[16-18] Thus, those labors that extend into the hours from 11 PM to 8 AM may be a higher risk group with abnormal progress in labor, and at higher likelihood to have a poor outcome. Lengths of labor and induction data were not available for the 999 controls so a direct comparison cannot be made. Review of the 80 NICA cases, however, showed that most of the nighttime deliveries did not demonstrate protraction or arrest of labor.

It is possible that differences in case mix contribute to our observed association. That is, patients with higher risk pregnancies may be more likely to deliver at night. We did not adjust for case mix because full information on pregnancy complications was not available for all of our cases and birth certificates have not been shown to always provide accurate information concerning complications in the pregnancies they report.[19-21] Gould et al in their study of 3,363,157 infants in California did find that the percentages of black non-Hispanics, teenagers, mothers with only third-trimester or no prenatal care, and those with hypertension were increased in the night delivery group. However, after adjusting for case mix,

they still found a 12% increase for early night births and a 16% increase for late night births in the odds of neonatal death.[13]

Finally, there is the issue of fatigue. What obviously stands out about this time interval (11 PM to 8 AM) is that it is when most human beings sleep. At some point from 11 PM to 8 AM, most humans are at their circadian nadir with an increased sleep propensity. Studies have shown that this time period is associated with decreased human performance.[22-24] Fatigue or sleep deprivation would, then, seem to be an obvious potential cause for the association. In terms of fatigue's impact on physicians, it has been shown to lead to worsened mood,[25,26] increased rates of car accidents,[27] worsened performance on training simulators,[28-30] increased attentional failures,[31] and increased numbers of medical errors.[32] However, as with staffing, fatigue was not specifically mentioned in the charts in these cases.

Our study has several limitations. In terms of our data, we did not have complete information regarding prenatal care, intrapartum management, or complications for the controls. For the purposes of this study, however, the most important data that we relied upon was the time of birth. Concerning control group selection, ideally we would have been able to match the cases with controls from each respective hospital for each month or year that the case delivery took place. However, this was not technically feasible and we have no reason to assume that the birth times for most babies who did not experience fetal injury resulting in death would differ significantly from our 1996 controls. In fact, time of birth data from the state of Massachusetts for the years 1989 to 1995[17] is consistent with our 1996 data from the state of Florida: namely, that approximately 30% of deliveries take place from 11 PM to 8 AM while approximately 70% take place from 8 AM to 11 PM. A similar distribution was found by Mancuso et al, who showed that in low-risk women with singleton gestations and spontaneous onset of labor at term (ie, not undergoing induction), 37% will deliver between 11 PM to 8 AM and 63% will deliver between 8 AM to 11 PM.[18] Gould et al recently studied births in California and showed that 19.9% occurred from 1 AM to 6 AM and 80.1% occurred during the other hours.[13] If the distribution of birth times in the entire population of possible controls differed from the 70/30 day/night split found in our study, then our odds ratio would be lowered accordingly. However, based upon the abovementioned studies and the concordance of our results with these studies, we have no reason to assume that another control group would be more likely to have a greater proportion of nighttime births.

Another limitation is the completeness of case ascertainment. All hospitals and physicians in the state of Florida are not registered with NICA. Even in those cases in which there was a NICA-eligible fetal injury resulting in death, in rare situations that case may have not been submitted to NICA as a claim. We have no reason to believe, however, that under-ascertainment of cases would be associated with time of birth. That is, there is no apparent reason why cases of fetal injury resulting in death that occurred outside of the NICA system would be less likely to have occurred at night than those that were submitted to NICA. Finally, regarding causation, we do not have complete information on hospital staffing or provider fatigue.

Future study can assess the impact of the demographics of hospitals on the association between time of birth and fetal injury resulting in death. In our study both the cases and controls came from a wide cross-section of hospitals throughout the state of Florida. In the case group, several of the injuries took place in academic teaching hospitals in major Florida cities with 24-hour anesthesia while others took place in smaller rural hospitals. The control group demonstrated similar representation. Given the duration of the time period of study and the limitations in birth certificate data, however, we were unable to fully explore these issues, which will make a fertile topic for future study. We also plan to study the remainder of the NICA cases in which there was fetal neurologic injury but the infant survived.

The implications of our findings are significant. If future research confirms our findings and more fully elucidates the factors underlying the association between nighttime delivery and poor outcome, then changes will have to take place in the areas identified. However, while further research in this area is certainly needed, it is important to note, as other authors have, that other industries have not waited for absolute proof of increased risk at night before initiating changes and establishing regulations.[1] It is also important to note, however, that the 80 cases of fetal injury resulting in death represent only a very minute proportion of the millions of deliveries that took place in Florida during this time period. And, while the relative risk for fetal injury resulting in death appears to be increased at night, the absolute risk is very low. In the vast majority of cases, women in the United States can anticipate the delivery of a healthy newborn regardless of the time of day that the delivery takes place.

In conclusion, this study demonstrates that there is an association between time of birth and poor obstetric outcome. Infants with neurologic injury resulting in death are more than twice as likely to have had a nighttime delivery than healthy infants. Further study is needed as safe nighttime care is essential to the health of our patients and integral to the practice of obstetrics.

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