



## The MFMU Cesarean Registry: Impact of time of day on cesarean complications

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Received for publication March 10, 2006; revised May 16, 2006; accepted June 1, 2006

### KEY WORDS

Cesarean delivery  
Work shift  
Maternal morbidity  
Neonatal morbidity

**Objective:** Studies suggest that sleep deprivation adversely affects performance. We hypothesized that cesarean delivery complications would be more frequent during the night shift (11 PM–7 AM), and evaluated morbidities by delivery shift.

**Study design:** Eighteen thousand nine hundred and thirty-nine term women undergoing an unscheduled cesarean delivery in 13 centers from 1999 to 2000 within a prospective observational study were included. Maternal/neonatal morbidities and time from decision to cesarean delivery

Dr Bailit is supported by the Women's Reproductive Health Research (WRHR) Career Development Program; K12: HD98004.

Supported by grants from the National Institute of Child Health and Human Development (HD21410, HD21414, HD27860, HD27861, HD27869, HD27905, HD27915, HD27917, HD34116, HD34122, HD34136, HD34208, HD34210, and HD36801).

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Presented at the Twenty-Sixth Annual Meeting of the Society for Maternal Fetal Medicine, Miami, FL, January 30–February 4, 2006.

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Reprints not available from the authors.

were evaluated by time of delivery (7 AM-3 PM, 3 PM-11 PM, 11 PM-7 AM). A composite of maternal morbidities was evaluated by logistic regression controlling for potentially confounding factors. **Results:** Controlling for age, race, insurance, cardiac disease, preeclampsia, diabetes, previous incision type, and prenatal care, shift of delivery had no impact on maternal morbidity (11 PM-7 AM OR 0.9 [95% CI 0.81-1.0]). NICU admissions were slightly increased at night but neonatal complications were not.

**Conclusion:** Maternal and neonatal complications of cesarean delivery do not increase with delivery during the night shift.

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The belief that physicians are affected by sleep deprivation is increasingly moving from anecdotal opinion to evidence based knowledge. Multiple studies have shown that judgment suffers and errors increase when physicians lack sleep.<sup>1-3</sup> There are fewer data regarding surgical performance and sleep deprivation. Much of the available data on surgical performance and sleep deprivation are based on simulated surgical situations.<sup>4,5</sup> Studies of actual surgical performance and sleep deprivation have been small and from single centers. Haynes et al reviewed 1847 emergency procedures and evaluated complication rates by whether the resident had been on call for 24 hours the day before the case and found no difference in complications.<sup>6</sup> Lee looked at errors made with and without a surgical night float system and again found no differences in errors made.<sup>7</sup>

While a firm link between surgical performance and sleep deprivation has not been established, other areas of medicine have shown worse outcomes at night. A population based study of the State of California showed that neonatal outcomes at night were worse than in the day. For live births with no lethal anomalies, they demonstrated a 12% increase in neonatal death for infants born in the early night and a 16% increase in death for those born in the late night.<sup>8</sup>

The objective of our study was to determine whether unscheduled cesarean deliveries had complication rates that varied by shift of occurrence. We hypothesized that complications would be increased on the night shift.

## Material and methods

Women undergoing an unscheduled cesarean delivery (CD) in 13 tertiary care teaching hospitals from 1999 to 2000 within a prospective observational study were included in this secondary analysis. The details of the original study from which the data were derived have been previously published.<sup>9</sup> We included only term unscheduled cesareans because the day shift is more likely to have elective CDs, which are less likely to have complications and might skew the results. Term pregnancies were chosen as prematurity and causes of prematurity such as infection were more likely to affect maternal and neonatal morbidities. Institutional review board (IRB) approval was obtained from each of the participating

centers for the primary study. IRB exemption was obtained from MetroHealth Medical Center for the secondary analysis.

Demographic characteristics and medical history of the patients were collected and analyzed according to work shift defined as day shift (7 AM-3 PM), evening shift (3 PM-11 PM), and night shift (11 PM-7 AM). Maternal and infant complications of cesarean delivery were considered individually and as a composite morbidity. Maternal composite morbidity included any of the following: blood transfusion, cystotomy, bowel injury, ureteral injury, postpartum endometritis, wound infection, wound hematoma, ileus, cesarean hysterectomy, maternal readmission, anesthesia complications, deep vein thrombosis, pelvic/abdominal abscess, septic pelvic thrombosis, pneumonia, pulmonary embolus, uterine rupture, uterine dehiscence, postoperative need for ventilation, postoperative seizure, central line, necrotizing fasciitis, sepsis, wound evisceration, wound dehiscence, coagulopathy, pulmonary edema, ICU admission, and maternal death. Neonatal morbidities included any of the following: cord pH < 7.00, base excess < -12, brachial plexus injury, skull fracture, facial nerve palsy, clavicular fracture, other fractures, fetal lacerations, NICU admission, neonatal seizure, and infant death.

Maternal and neonatal morbidities were analyzed by work shift using the Wilcoxon rank sum, Fisher exact, and chi-square tests as appropriate.

Multivariable analysis was performed for maternal composite morbidity accounting for work shift (day as baseline), weekday or weekend, maternal age, race, decision to delivery time, insurance, prenatal care, preeclampsia, type of cesarean (low transverse vs classic), diabetes, asthma, hypertension, and renal disease. Multivariable analysis was also performed for maternal composite morbidity in urgent cesarean deliveries accounting for the same variables.

Nominal 2-sided *P* values are reported, with *P* < .05 being considered significant. No adjustments were made for multiple comparisons.

## Results

There were 18,939 term patients delivered by unscheduled cesarean delivery during the study time period.

**Table I** Characteristics of women undergoing unscheduled cesarean delivery at 13 centers (1999-2000)

Characteristic	Shift of cesarean delivery			P value
	7 AM-3 PM 6256	3 PM-11 PM 7375	11 PM-7 AM 5308	
Age (y) (SD)	27.1 (6.5)	27.1 (6.4)	26.7 (6.3)	.001
Race/ethnicity n (%)				
Black	2134 (34.1)	2417 (32.8)	1771 (33.4)	.0013
White	2103 (33.6)	2713 (36.8)	1762 (33.2)	
Hispanic	1673 (26.7)	1832 (24.8)	1482 (27.9)	
Asian	109 (1.7)	138 (1.9)	99 (1.9)	
Native American	8 (0.1)	10 (0.1)	6 (0.1)	
Other	229 (3.7)	265 (3.6)	188 (3.5)	
Urgent CS*†	320 (5.1)	353 (4.8)	198 (3.8)	.001
Hrs from decision to delivery time Mean (sd)	1.6 (2.3)	1.4 (1.9)	1.3 (1.9)	<.0001
Private insurance n (%)	2367 (37.8)	3197 (43.4)	1984 (37.4)	<.0001
Prenatal care n (%)	6119 (97.8)	7241 (98.2)	5187 (97.7)	.14
Preeclampsia n (%)	765 (12.2)	1015 (13.8)	766 (14.4)	.0015
Previous low transverse CS n (%)	1940 (31.0)	1798 (24.4)	1159 (21.8)	<.0001
Previous classic CS n (%)	120 (1.9)	80 (1.1)	36 (0.7)	<.0001
Primary CS in current pregnancy n (%)	4192 (67.0)	5491 (74.5)	4111 (77.5)	<.0001
Repeat CS in current pregnancy n (%)	1335 (21.3)	896 (12.1)	632 (11.9)	<.0001
Failed VBAC in current pregnancy n (%)	729 (11.7)	988 (13.4)	565 (10.6)	<.0001
Diabetes n (%)	533 (8.5)	570 (7.7)	434 (8.2)	.24
Asthma n (%)	439 (7.0)	532 (7.2)	389 (7.3)	.80
Chronic hypertension n (%)	108 (1.7)	125 (1.7)	77 (1.5)	.45
Renal disease n (%)	51 (0.8)	42 (0.6)	29 (0.5)	.12
Heart disease n (%)	50 (0.8)	77 (1.0)	58 (1.1)	.21

\* Decision to delivery <15 minutes.

† Ninety-two cases are missing decision to delivery time.

Demographic and medical characteristics are seen in [Table I](#). Characteristics do vary by shift of delivery. Though statistically significant, the differences seen appear to be of marginal clinical importance.

Even with a large sample size, there were no differences in maternal morbidity by shift ([Table II](#)). Multivariate analysis controlling for potential confounders found a slight reduction in composite maternal morbidity for the night shift. The adjusted odds ratio for cesarean morbidity during the evening shift was 0.929 (95% confidence interval .844-1.022) and for night shift was 0.898 (0.809-0.997). The odds ratio for weekend cesarean morbidity was 1.040 (0.957-1.130). For urgent cesareans (<15 minutes from decision to delivery) there was no significant difference in morbidity on the night shift (adjusted odds ratio .95, 95% confidence interval .596-1.521). The power of this dataset to identify a 16.7% (1/6) increase in maternal morbidity from 15% in the day and evening shift to 17.5% in the night shift was 97% with type I error of 5%. The power of this data set to detect a difference in strictly surgical

complications (cystotomy, bowel injury, ureteral injury, and fetal laceration) from 1% on the day shift to 1.5% on the nights shift was 74%.

Although there were more NICU admissions, neonatal morbidity was not substantially increased on the night shift ([Table III](#)).

## Comment

In this large multicenter observational study, we found no important differences in maternal or neonatal morbidity after unscheduled cesarean delivery according to work shift. This is in sharp contrast to the Gould study, which showed that neonatal outcomes were worse at night in the State of California.<sup>8</sup> There are several possible explanations for our findings. (1) All obstetric teaching departments are required to have an attending physician on 24 hours a day. Many studies showing that errors increase at night evaluated residents.<sup>1,4,5</sup> It is possible that the presence of a fully trained physician

**Table II** Maternal complications after unscheduled cesarean deliveries according to shift of delivery

Complications	Shift of cesarean delivery			P value
	7 AM-3 PM 6256	3 PM-11 PM 7375	11 PM-7 AM 5308	
Transfusion n (%)	164 (2.6)	163 (2.2)	137 (2.6)	.23
Cystotomy n (%)	18 (0.3)	19 (0.3)	14 (0.3)	.94
Bowel injury n (%)	4 (0.1)	4 (0.1)	0 (0.0)	.19
Ureteral injury n (%)	5 (0.1)	5 (0.1)	0 (0.0)	.10
Postpartum endometritis n (%)	622 (9.9)	677 (9.2)	512 (9.6)	.31
Wound infection n (%)	40 (0.6)	52 (0.7)	30 (0.6)	.62
Wound hematoma n (%)	19 (0.3)	17 (0.2)	9 (0.2)	.33
Ileus n (%)	54 (0.9)	60 (0.8)	43 (0.8)	.94
Cesarean hysterectomy n (%)	24 (0.4)	20 (0.3)	14 (0.3)	.40
Maternal readmission n (%)	101 (1.6)	109 (1.5)	83 (1.6)	.81
Combined morbidity n (%)	996 (15.9)	1078 (14.6)	799 (15.1)	.10
Selected rare morbidities n (%)				
Maternal death	2 (0.03)	1 (0.01)	3 (0.06)	.39
Maternal ICU admission	34 (0.54)	35 (0.47)	32 (0.60)	.60
Postoperative ventilation	13 (0.21)	17 (0.23)	10 (0.19)	.88

**Table III** Neonatal complications after unscheduled cesarean deliveries according to shift of delivery

Complications	Shift of cesarean delivery			P value
	7 AM-3 PM 6256	3 PM-11 PM 7375	11 PM-7 AM 5308	
Cord pH <7.00*	82/3287 (2.5)	71/3745 (1.9)	71/2916 (2.4)	.18
Base excess <-12*	17/3063 (0.6)	12/3482 (0.3)	3/2736 (0.1)	.02
Brachial plexus injury	3 (0.05)	2 (0.03)	2 (0.04)	.89
Skull fracture	1 (0.02)	2 (0.03)	1 (0.02)	1.00
Facial nerve palsy	1 (0.02)	2 (0.03)	2 (0.04)	.86
Clavicular fracture	1 (0.02)	3 (0.04)	2 (0.04)	.77
Other fractures	0 (0.00)	1 (0.01)	1 (0.01)	.74
Fetal laceration	45 (0.7)	60 (0.8)	43 (0.8)	.79
NICU admission	1205 (19.3)	1405 (19.1)	1110 (20.9)	.02
Neonatal seizures	18 (0.3)	20 (0.3)	24 (0.5)	.17
Infant death	17 (0.3)	12 (0.2)	10 (0.2)	.36

\* Cord pH was not performed in all deliveries.

mitigate the potential effects of sleep deprivation. (2) Many of the studies of surgical performance and sleep deprivation have been done on surgical simulators.<sup>4,5</sup> It is possible that the adrenaline response associated with performing real surgery overcomes the sleep deprivation effect seen with surgical simulators. (3) In 9 of the 12 hospitals for which we had information, there was some variation of a night float systems in place. A night float is when residents sleep during the day and work a shift that starts in the evening and ends in the morning. It is possible that having a night float system alleviates the errors that may be seen when shifts are longer than half a day. Despite night float system, attending fatigue and nurse staffing patterns may still be different on the night shift. To try and account for any night float effect, we also examined the data by weekday versus

weekend. At all of the hospitals with a night shift, the night shift ran Sunday night through Thursday night. Friday and Saturday night were not covered by a night float system. When we examined our sample by weekend or weeknight, morbidities on the night shift showed the same patterns (data not shown). Additionally, we included weekend in our multivariate model and the odds ratio remained nonsignificant.

While there was an increase in NICU admissions at night, the need for NICU admission as a morbidity may be more subjective than many of the other neonatal morbidities. For example, cord blood pH and base excess results were not significantly worse on the night shift, suggesting that it might be a neonatal assessment and not obstetric treatment that differs at night. It is also possible that the regular nursery staff at night may be

less experienced, or the nursery not as adequately staffed compared to the daytime, which contributes to the differences seen in NICU admissions.

The rate of wound infection in our sample is lower than would be expected. Our data are of initial hospitalization only and it is possible that wound infections were treated as outpatients or as readmission and thus not picked up in our data. Data definitions of complications were well delineated and previously published papers have described the efforts made to insure complete detection and collection of complications.<sup>9</sup>

The finding in this study that cesarean morbidities are not increased at night does not necessarily mean that errors are equally distributed across shifts. Not all medical errors lead to complications and, therefore, patient morbidity is an insensitive indicator of errors. Prospective studies are needed to adequately determine if errors vary by shift and at least 1 large prospective study has shown that errors do increase with sleep deprivation.<sup>1</sup> Despite the published evidence that errors are more likely at night, our findings that morbidity after unscheduled cesarean delivery is not worse at night is reassuring. While errors are an important concern in and of themselves and every effort should be made to reduce them, patient morbidity is ultimately the greatest concern.

All of the hospitals in our study are large tertiary care teaching hospitals and the results cannot be generalized to nonteaching community hospitals. There are several qualities of teaching hospitals that may not be present in community hospitals: more than 1 physician per patient, multiple physicians checking each other's work and operating together, and the availability of in hospital anesthesia and pediatrics services 24 hours a day. Most deliveries occur in community hospitals.<sup>10</sup> Future studies of perioperative morbidity in community hospitals by shift are needed before these findings could be generalized. Such a study would require the participation of a large number of community hospitals to have an adequate sample size.

Our study is limited by not having prospective data regarding the sleep and work shift patterns of the doctors in each hospital. We have assumed that sleep deprivation occurs more often on the night shift but cannot measure or prove this assumption. However, even with a night float system, 24-hour call is necessary on the weekends and we believe it is safe to assume that some sleep deprivation occurs on a 24-hour shift.

Our study supports the findings of Lee and Haynes that surgical outcomes are not worse at night.<sup>6,7</sup> While previous studies were limited by small sample size and single center experience, our large multicenter cohort with adequate power had the same findings. Despite published evidence that errors are greater with sleep deprivation, we could not find evidence that patient morbidity is affected by the shift during which the cesarean occurred.

Adverse maternal and neonatal outcomes from cesarean birth are not increased at night in our large multicenter study of teaching hospitals. Further studies in nonteaching hospitals staffed by attending physicians are warranted.

## Acknowledgments

The authors would like to thank the following people for their contribution to the manuscript: protocol development and protocol/data management: Sharon Gilbert, MS; protocol development and coordination between clinical research centers: Frances Johnson, RN; and manuscript development: Brian M. Mercer, MD.

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## Appendix

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A. Guzman; Thomas Jefferson University: A. Sciscione, M. DiVito, M. Talucci, M. Pollock; Wayne State University: M. Dombrowski, G. Norman, A. Millinder, C. Sudz, B. Steffy; University of Pittsburgh and Magee Women's Hospital: K. Lain, M. Cotroneo, D. Fischer, M. Luce; Wake Forest University: P. Meis, M. Swain, C. Moorefield, K. Lanier, L. Steele; University of Miami: G. Burkett, J. Gilles, J. Potter, F. Doyle,

S. Chandler; University of Cincinnati: T. Siddiqi, H. How, N. Elder; University of Tennessee: W. Mabie, R. Ramsey; University of Chicago: J. Hibbard, P. Jones, M. Ramos-Brinson, M. Moran, D. Scott; University of Texas Health Science Center at San Antonio: D. Conway, S. Barker, M. Rodriguez; George Washington University Biostatistics Center: S. Gilbert, Y. Lai, H. Juliussen-Stevenson, M. Fischer.