OBSTETRICS

Time of delivery and neonatal morbidity and mortality

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OBJECTIVE: The objective of the study was to examine the association between time of delivery and neonatal outcomes in term deliveries.

STUDY DESIGN: We conducted a retrospective cohort study of all term pregnancies delivered at an academic institution with 24-hour in-house obstetric and anesthesia coverage. Time of delivery was categorized as day (7 AM to 6 PM), evening (6 PM to 12 midnight), and late night (12 midnight to 7 AM). Outcomes included 5-minute Apgar less than 7, umbilical artery pH less than 7.0, base excess less than −12, admission to the neonatal intensive care unit (NICU), and neonatal death. We excluded patients delivered via cesarean delivery not in labor. We had greater than 80% power to detect a 25% difference in Apgar score, base excess, and admission to the NICU and 80% power to detect a 50% difference in umbilical artery pH less than 7.0.

RESULTS: Among the 34,424 deliveries meeting inclusion criteria, 15,664 were during the day, 8495 were during the evening, and 10,265 were during the night. In univariate comparisons, there were no statistically significant differences in neonatal outcomes. For example, the rate of pH less than 7.0 was 0.7% during the day, 1.0% in the evening, and 0.6% at night ($P = .12$). Admissions to the NICU were 3.6% during the day, 3.7% in the evening, and 3.5% at night ($P = .81$). When we controlled for obstetric history, demographic factors, and labor characteristics, there were still no differences in rates of either neonatal morbidity or mortality by time of delivery.

CONCLUSION: At our institution, we could not demonstrate any significant differences in neonatal morbidity or mortality by time of day among neonates delivered at term. These data can be used to counsel patients and families concerned about differences in time of delivery and potential impact on their infant's health. Future research should include time of delivery in relation to maternal and neonatal outcomes in various types of inpatient settings.

Key words: neonatal mortality, perinatal morbidity, time of delivery

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Perinatal death, in particular intrapartum stillbirth and short-term neonatal death, has been associated with the time of day that the birth occurs.[1,2] Generally, the rates of perinatal death are reportedly higher in the middle of the night, although some studies have demonstrated an increase in the evening hours as well.[3] Whereas these associations have been demonstrated in a wide variety of settings in the United States and Europe, the causal nature of this relationship has been only minimally investigated.

An early study on the topic suggested that it was the relationship between mother's circadian rhythm and infant birth outcomes.[4] It has been demonstrated that oxytocin levels are higher at night.[5] In recent years, when a majority of women are being augmented with oxytocin, the increase in maternal oxytocin secretion during the night may cause uterine hyperstimulation leading to risk of fetal asphyxia. Additionally, there is evidence that spontaneous labor is more likely to start at night with multiparous women more likely to deliver in the late morning and nulliparous women in the early afternoon.[6] Thus, those women with labor extending into the night may represent a higher-risk group. A reason for this could possibly be related to maternal fatigue. For example, poor maternal sleep has been associated with prolonged labor and increased rates of cesarean delivery.[7] Although these biologic etiologies are theoretically possible, organizational and fatigue-related mishaps related to scheduling[8] and availability of clinicians in labor and delivery have also been proposed.[9] For example, 1 study found that there were adverse outcomes related not only to nighttime delivery but also during months when vacations were commonly scheduled, thus resulting in less experienced staff during these times.[10]

There is a broad literature on nursing[11,12] and physician fatigue[13,14] leading to higher rates of adverse and near-miss events. A recent study found that physician fatigue and working 24-hour shifts was associated with a higher rate of motor vehicle accidents.[15] It may be that staff fatigue also contributes to higher perinatal mortality at night in the labor and delivery setting. Another issue is the

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degree of supervision of residents, which is often less available at night than during the day. In 1 study of adverse events, residents themselves identified decreased supervision as a contributing factor.[16]

In addition to these possible issues, another important aspect of the care of laboring women is the presence of in-house obstetricians and anesthesiologists. Without such staffing, the ability of an institution to respond to an emergency such as a cord prolapse, placental abruption, or uterine rupture will be delayed. In 1 study that attempted to control for this possibility by including type of hospital in its multivariate analyses, differences by type of hospital were not addressed.[17] In a recent study that did report differences by type of hospital, institutions were classified by type of neonatal care rather than obstetric care because such information was not available to the researchers.[18]

In addition to the factor of in-house clinician staffing, there are a number of study design and methodologic issues with many of the existing studies. These include lack of exclusion of stillbirths, inadequate power to examine outcomes by subgroups, and, most importantly, the inclusion of women undergoing elective repeat cesarean deliveries. This is particularly important because the number of repeat cesarean deliveries has increased in recent years. Furthermore, it has been specifically demonstrated that infants delivered by elective repeat cesarean have lower neonatal mortality rates,[19] although how much difference exists varies in the literature.[20]

Given this background, we sought to further explore this issue by examining the rate of neonatal death in the specific setting of an academic teaching hospital with in-house obstetricians and anesthesiologists. Furthermore, we sought to explore the effects of time of day on neonatal mortality as well as neonatal morbidity.

MATERIALS AND METHODS

We designed a retrospective cohort study of all singleton, cephalic neonates delivered beyond 37 weeks' gestational age from 1976 to 2001 at the Moffitt-Long Hospital associated with the University of California, San Francisco (UCSF). This study was approved by the Institutional Review Board at UCSF. Exclusion criteria included delivery prior to 37 weeks of gestation and pregnancies complicated by lethal congenital fetal anomalies, noncephalic presentation, placenta previa, and multiple gestations. In addition, for the primary analysis, we excluded all cesarean births performed on women who were not in labor (eg elective repeat cesarean). Time of day was divided into 3 intervals: 7 AM to 6 PM, 6 PM to 12 midnight, and 12 midnight to 7 AM. These stratifications are based on timing of shift changes and rounds in our labor and delivery unit, although the choice of midnight was arbitrary for separating the nighttime periods.

At our institution, umbilical artery and vein blood gases are obtained on every neonate. Data on the following outcomes were also collected from the medical record by trained medical abstractors: umbilical artery pH, umbilical artery base excess, presence of meconium, meconium aspiration syndrome, admission to the neonatal intensive care unit (NICU), 5 minute Apgar scores, birth trauma (including skull fracture, clavicular fracture, facial nerve palsy, and brachial plexus injuries), and intrapartum stillbirth or short-term neonatal death up to either hospital discharge or 28 days of life. Data were prospectively entered into an ongoing database. Numerous obstetric, maternal, and neonatal outcomes are routinely verified on a monthly basis. The following variables were examined as confounders: maternal age, ethnicity, education, length of labor, mode of delivery, year of delivery, parity, type of anesthesia, birthweight, and labor management (induction of labor, augmentation of labor via artificial rupture of membranes, and augmentation of labor via oxytocin).

The data were then compiled and analyzed using STATA version 7 software (StataCorp, College Station, TX). Because the primary predictor of interest was time of delivery, the dependent variables of interest were compared in a univariate fashion with the 3 identified time periods. Because resident coverage differs between weekends and weekdays, we also conducted stratified analyses by day of the week. Comparisons of proportions were made using the χ^2 test, and means were compared using the Student t test.

Assuming a baseline rate of outcomes of 1% and 10,000 women per group, we estimated that we would have 89% power to demonstrate a 50% difference by time period for delivery with a 2-sided alpha of 0.05. For outcomes with a baseline rate of 3%, we had 84% power to identify a 25% difference. To control for potential confounding, variables of interest were examined using multivariate logistic regression. Cross-product terms to examine interaction between predictor variables were created. Their contribution to the model was tested using the maximum likelihood ratio test, and only statistically significant interaction terms were kept in the model. Statistical significance was set at $P < .05$.

RESULTS

During the study period, there were 44,144 deliveries. Of these, 7337 were delivered preterm, 1817 were multiple gestations, and 4013 women had cesarean deliveries for such indications as repeat cesarean, placenta previa, noncephalic presentation, or herpes simplex virus outbreak. Because many of the exclusions met more than 1 criterion, in the end, 10,098 women were excluded, leaving 34,046 women who met study criteria and 16,911 (49.7%) delivered during the day (7 AM to 6 PM), 5620 (16.5%) delivered during the evening (6 PM to 12 midnight), and 11,515 (33.8%) delivered during the night (12 midnight to 7 AM).

These women were ethnically diverse and relatively well educated as indicated by the 51.5% who completed 4 years of college (Table 1). Although there were some statistically significant differences in induction rates, epidural use, and cesarean rates among the 3 time periods, such differences were clinically small. Cross-product terms were not found to be significant in any of the multivariate models and were not used in the final models.