OBSTETRICS

Nighttime delivery and risk of neonatal encephalopathy

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OBJECTIVE: The objective of the study was to determine the relationship between nighttime delivery and neonatal encephalopathy (NE).

STUDY DESIGN: The design of the study was a retrospective population-based cohort of 1,864,766 newborns at a gestation of 36 weeks or longer in California, 1999-2002. We determined the risk of NE associated with nighttime delivery (7:00 PM to 6:59 AM).

RESULTS: Two thousand one hundred thirty-one patients had NE (incidence 1.1 per 1000 births). Nighttime delivery was associated with increased NE (odds ratio [OR], 1.13; 95% confidence interval [CI], 1.03–1.20), birth asphyxia (OR, 1.18; 95% CI, 1.08–1.29), and neonatal seizures (OR, 1.17; 95% CI, 1.07–1.28). In adjusted analyses, nighttime delivery was an independent risk factor for NE (OR, 1.10; 95% CI, 1.01–1.21), as were severe intrauterine growth retardation (OR, 3.8; 95% CI, 3.1–4.8); no prenatal care (OR, 2.0; 95% CI, 1.4–2.9); primiparity (OR, 1.5; 95% CI, 1.4–1.7); advanced maternal age (OR, 1.3; 95% CI, 1.16–1.45); and infant male sex (OR, 1.3; 95% CI, 1.2–1.4).

CONCLUSION: Future studies of time of delivery may generate new strategies to reduce the burden of NE.

Key words: birth asphyxia, epidemiology, neonatal encephalopathy, time of birth

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Neonatal encephalopathy (NE) is an important contributor to long-term motor and cognitive disability in children and occurs in 2-4 per 1000 term births.[1,2] Infants with moderate to severe NE have a 50-60% chance of either dying or developing long-term disabilities from cerebral palsy, mental retardation, or epilepsy.[3,4] Neonatal encephalopathy is often attributed to birth asphyxia, even though the underlying pathogenesis of NE is heterogeneous and poorly understood.

★ EDITORS' CHOICE ★

Perinatal deaths caused by asphyxia have been considered a sensitive indicator of quality of care during labor and delivery.[5-7] It is thus assumed that some cases of NE could be prevented with improved quality of care. However, the strength of the relationship between quality of care and NE is unknown, especially given that intrapartum complications are absent in the vast majority of infants with NE.[8]

Nighttime deliveries occur in the setting of decreased staffing and increased physician fatigue, both of which may have an impact on quality of care.[9] Previous studies have suggested that nighttime delivery may be associated with an increased risk of neonatal mortality.[10-13] Nighttime delivery has also been linked to increased neonatal deaths attributed to intrapartum asphyxia.[12] However, in the largest study that distinguished infants by gestational age, only preterm infants born at night experienced increased neonatal mortality.[14]

During the months of July and August, teaching hospitals frequently employ house officers who have just recently completed their medical education and are thus less experienced. Two studies in England have reported higher intrapartum death rates in the summer.[11,15] This finding has been attributed to an "annual leave effect,"[11] having a potential impact on staffing levels and resulting in decreased supervision of junior medical staff. Weekend births may also result in a relatively higher rate of neonatal deaths.[16] However, population studies in Europe and Sweden have not confirmed the presence of a weekend birth disadvantage.[11,13,17]

There are no recent studies of the relationship between weekend delivery and neonatal outcome in the United States. Whether neonatal outcomes differ in teaching and nonteaching hospitals during the summer months has also not been evaluated to our knowledge. The relationship between the time of delivery and the incidence of NE in term infants has not been studied previously. In a recent California population, we examined the association between NE and factors that have potential implications for quality of care, including hour, day, and month of delivery.

Materials and Methods

We examined a population-based retrospective cohort using the California-linked birth infant death file created spe-

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cifically to study perinatal outcomes.[18] The data set contains information from birth and death certificates linked to state-wide hospital discharge data for mother and infant. We included all infants born in California at a gestation of 36 weeks or longer (term gestation), from Jan. 1, 1999, to Dec. 31, 2002. In this population, we identified infants with NE by searching hospital discharge diagnoses. Infants with extreme birth weights (<1500 g or >5500 g) or maternal ages (<12 or >55 years) were excluded from the study, as were infants with missing data regarding hour of birth.

Neonatal encephalopathy was our primary outcome of interest. Because NE represents a broadly characterized and nonspecific disorder, we attempted to limit heterogeneity by focusing on more severe cases. To be categorized as having NE, a newborn infant had to meet at least 1 of the following birth hospitalization discharge diagnostic criteria:

1. Severe birth asphyxia (*International Classification of Diseases, Ninth Revision* [ICD-9-CM] code 768.5).
2. Neonatal seizure (codes 779.0, 345-345.9, and 780.3).
3. Mechanical ventilation (code 96.70, 96.71 or 96.72) associated with any of the following diagnoses suggestive of NE:[19] birth asphyxia (codes 768.5, 768.6, and 768.9); neonatal seizures (codes 779.0, 345-345.9, and 780.3); cerebral irritability or central nervous system depression (codes 779.1 and 779.2); hypotonia or other perinatal conditions (codes 779.8 and 779.9); fetal distress associated with infant morbidity (codes 768.2-768.4); birth trauma or encephalopathy resulting from birth injury (codes 767.8 and 767.9); intrapartum anoxia or brain hemorrhage resulting from birth trauma (code 767.0); congenital encephalopathy or unspecified anomaly of nervous system (code 742.9); or anoxia or encephalopathy (code 348.1 and 348.3).
4. Neonatal death (within 28 days of delivery) associated with any of the diagnoses listed in the previous text.

Given the heterogeneity of the term NE, we also studied the relationship between time of delivery and birth asphyxia (codes 768.5, 768.6, or 768.9), as well as the relationship between time of birth and neonatal seizures (codes 779.0, 345-345.9, or 780.3).

PREDICTORS

The hour of delivery, our primary predictor of interest, was obtained from birth certificate data. Based on previous literature,[10] we defined a priori the daytime as spanning from 7:00 AM to 6:59 PM and nighttime as the period from 7:00 PM to 6:59 AM. Weekend (Saturday or Sunday) and summer (July and August) deliveries were determined from hospital discharge abstracts. Hospitals were designated into 1 of the following 3 categories according to the California Office of Statewide Health Planning and Development Hospital Annual Financial Data: teaching hospitals; rural hospitals (designated by the state as being either rural or small); or nonteaching, nonrural hospitals.

We examined the following covariates obtained from birth certificates: maternal age, ethnicity, and education; lack of prenatal care; parity; infant sex; gestational age; and multiple gestation. The source of payment for the birth admission was used as an indicator of socioeconomic status (SES). High SES consisted of patients with private insurance or health maintenance organization coverage, and low SES included those who were indigent, self-pay, or who had Medicaid or Medicare. Intrauterine growth restriction (IUGR) was defined as mild (birthweight <10% for gestational age), moderate (<5%), or severe (<1%),[19] based on ethnicity and sex-specific normative data compiled from the entire study population.

The association between hour of birth and NE was determined by calculating univariate and multivariable odds ratios (ORs) and 95% confidence intervals (CIs) using logistic regression. To control for case mix, we included in our multivariable model all factors that had a significance level of $P < .10$ in the univariate analysis: mother's race and age; infant sex; lack of prenatal care; primiparity; gestational age (36 weeks, 37-41 weeks, ≥42 weeks); intrauterine growth retardation (birthweight <1% for gestational age), and type of hospital.

All statistical analyses were performed with SAS (version 9.1; SAS Institute, Cary, NC). No personal identifiers were available in the datasets examined. This study received approval from the institutional review boards at the University of California, San Francisco, the Office of Statewide Health Planning and Development, and the California State Department of Health.

RESULTS

Of 1,864,766 term infants in the study population, 2131 had NE, providing a population incidence of 1.1 per 1000 term live births. The incidence of NE remained unchanged during the study years. Sixteen percent of NE cases resulted in neonatal death prior to 1 month of age. The rate of neonatal mortality associated with NE (0.18 per 1000 term births) remained unchanged during the study period. Of all neonatal deaths that occurred in the birth cohort, 20.8% met inclusion criteria for NE.

Approximately one-third of all infants (32.8%) were delivered at night, and 22.8% were delivered during the weekend. Nighttime delivery was associated with an increase in risk of NE (OR, 1.13; 95% CI, 1.03–1.2). Risk of NE did not vary significantly for weekend or summer deliveries (Table 1). However, being delivered either at a teaching (OR, 1.9; 95% CI, 1.7–2.1) or rural (OR, 1.4; 95% CI, 1.2–1.7) hospital was associated with increased risk of NE when compared with nonteaching, nonrural hospitals.

The risk of NE during the night was highest during the period between 10:00 PM and 4:00 AM (Figure). During these hours, the incidence of NE was 1.33 per 1000 term births, which was significantly higher than the rate of NE among daytime deliveries (OR, 1.22; 95% CI, 1.10–1.36). In contrast, births occurring in the early evening (7:00-10:00 PM) and during the early morning (4:00-7:00 AM) were no different from daytime deliveries with respect to risk of NE ($P > .05$).

After adjusting for potential confounders (Table 2), nighttime delivery