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ORIGINAL ARTICLE

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The impact of gestational age and fetal weight on the risk of failure of spinal anesthesia for cesarean delivery

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ABSTRACT

Background: There are limited data about spinal dosing for cesarean delivery in preterm parturients. We investigated the hypothesis that preterm gestation is associated with an increased incidence of inadequate spinal anesthesia for cesarean delivery compared with term gestation.

Methods: We searched our perioperative database for women who underwent cesarean delivery under spinal or combined spinal-epidural anesthesia with hyperbaric bupivacaine $\geqslant$10.5 mg. The primary outcome was the incidence of inadequate surgical anesthesia needing conversion to general anesthesia or repetition or supplementation of the block. We divided patients into four categories: <28, 28 to <32, 32 to <37 and $\geqslant$37 weeks of gestation. The chi-square test was used to compare failure rates and a multivariable regression analysis was performed to investigate potential confounders of the relationship between gestational age and failure.

Results: A total of 5015 patients (3387 term and 1628 preterm) were included. There were 278 failures (5.5%). The incidence of failure was higher in preterm versus term patients (6.4% vs. 5.1%, P=0.02). Failure rates were 10.8%, 7.7%, 5.3% and 5% for <28, 28 to <32, 32 to <37 and $\geqslant$37 weeks of gestation, respectively. In the multivariable model, low birth weight (P<0.0001), gestational age (P=0.03), ethnicity (P=0.02) and use of combined spinal-epidural anesthesia (P<0.0001) were significantly associated with failure.

Conclusions: At standard spinal doses of hyperbaric bupivacaine used in our practice ($\geqslant$10.5 mg), there were higher odds of inadequate surgical anesthesia in preterm parturients. When adjusting for potential confounders, low birth weight was the main factor associated with failure.

Keywords: Anesthesia; Spinal; Combined spinal-epidural; Cesarean delivery; Gestation age; Failed anesthesia

Introduction

Pregnancy is associated with increased spread of spinal anesthesia.[1] Pregnant women at term require a smaller dose of intrathecal local anesthetic than non-pregnant women to produce the same level of spinal block.[2–4] The physiologic changes of pregnancy such as changes in spinal curvature,[5] decreased cerebrospinal fluid (CSF) volume caused by the distention of epidural veins as a result of inferior vena cava obstruction by the gravid uterus,[6] and enhanced sensitivity of neural tissue to local anesthetics may play a role in these observations.[7,8] While many studies have examined the difference between pregnant and non-pregnant women in the relative spread of spinal block for surgical anesthesia,[2–4] there are limited data reviewing adequate spinal dosing for preterm (<37 weeks of gestation) versus term ($\geqslant$37 weeks of gestation) patients. A previous study[9] demonstrated that hyperbaric bupivacaine 11.25 mg provided adequate spinal block to T4 for women at term but failed to provide the same level in 84% of preterm women undergoing cesarean delivery. Our clinical observation also suggests that our standard doses of intrathecal bupivacaine might fail to achieve adequate sensory block for surgery in some preterm patients. However, altering the dose of intrathecal bupivacaine in preterm parturients is not common practice. Therefore, we performed this retrospective database analysis to investigate the hypothesis that preterm gestation is associated with an increased risk of failed spinal anesthetic for cesarean delivery compared with term gestation.

Methods

After Institutional Review Board approval, we retrospectively retrieved data from the Duke Perioperative

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Anesthesia Database for women who underwent cesarean delivery under spinal or combined spinal-epidural (CSE) anesthesia from 2003 to 2012. Duke University Medical Center is a university teaching hospital with approximately 3500 deliveries/year. A dedicated group of nine obstetric anesthesiologists provides round-the-clock coverage for the labor and delivery ward. First and second year anesthesia residents an obstetric anesthesia fellow and a daytime certified registered nurse anesthetist (CRNA) staff the labor and delivery ward. Third-year residents also have an elective obstetric anesthesia rotation and when present provide daytime coverage.

We searched for patients who received our standard doses of local anesthetic ($\geqslant$10.5 mg of 0.75% wt/vol hyperbaric bupivacaine with fentanyl 15 μg and morphine 0.1–0.2 mg) and were 152–183 cm in height. Inadequate surgical anesthesia after initial spinal dose (failure) was the primary outcome. Failure was defined as the need to repeat the spinal technique to obtain adequate block height (T6–T2), convert to general anesthesia secondary to pain within 60 min of skin incision, augment the initial block with epidural lidocaine before or within 30 min of skin incision (if the CSE technique was used), or supplement by inhalation or intravenously with at least two of the following within 60 min of skin incision: nitrous oxide, fentanyl (>100 μg), ketamine, midazolam or propofol. Patients who received epidural labor analgesia before cesarean delivery were excluded. Anesthetic records were reviewed to confirm reasons for failure and its management. We divided patients into four categories according to gestational age: <28 weeks (extremely preterm), 28 to <32 (very preterm), 32 to <37 weeks (moderate to late preterm), and $\geqslant$37 weeks (term).[10] We also collected information about the highest recorded block level. This is recorded in our electronic medical record as follows: T10–T7, T6–T2 and $\geqslant$T1.

Statistical analysis

The Cochran–Armitage (CA) trend test, chi-square test and Kruskal–Wallis test were used to compare patient characteristics and intraoperative variables between those with failed blocks versus those with successful blocks, and between the different gestational age groups. We performed a multivariable logistic regression analysis to account for potential confounders of the relationship between gestational age and failed blocks. We considered the following potential confounders: age, body mass index (BMI), ethnicity, low birth weight (<2500 g), priority of cesarean delivery (scheduled or non-scheduled), block type (spinal or CSE), provider performing the block (resident, fellow, CRNA or attending) and hyperbaric bupivacaine dose. Before analysis, we evaluated the relationship between the empirical logit of failure on the deciles of the continuous covariates to determine if the relationship was non-linear. We identified a non-linear relationship for gestational age, and we used our defined four-category gestational age variable in the multivariable model. For birth weight, we found evidence of a threshold effect near the standard definition of low birth weight (<2500 g) with those below the threshold having an elevated empirical odds of failure compared with those above the threshold; hence we utilized a binary birth weight covariate in our models. None of the other continuous variables demonstrated departures from linearity and were used as continuous covariates in the multivariable models. Model fit of the multivariable logistic regression model was assessed via the Hosmer–Lemeshow goodness of fit test, and the C-index. We also performed three sensitivity analyses: one excluding cases in which failure was identified by augmentation of the initial block with epidural lidocaine when a CSE technique was used; a second restricting the analysis to cases where the neuraxial block was spinal; and a third including the experience of the provider performing the block as an additional potential confounder. Analysis was performed in SAS version 9.4 (SAS Inc., Cary, NC, USA) and statistical significance was assessed at $P<0.05$.

Results

A total of 5015 patients (3387 term and 1628 preterm) fulfilled the inclusion criteria and were included in the analysis. The most common dose of hyperbaric bupivacaine administered was 12 mg (61.7%), followed by 11.25 mg (23.0%), 10.5 mg (9.1%), 13.5 mg (3.8%), 12.75 mg (1.9%) and 15 mg (0.5%). Overall, there were 278 failed anesthetics (5.5%). Spinal anesthesia was used in 80.7% of cases [238 (87.3%), 320 (88.9%), 799 (82.7%) and 2698 (81.1%) for patients at <28, 28 to <32, 32 to <37 and $\geqslant$37 weeks of gestation, respectively] and CSE was used in 19.3% of cases. There was a trend for greater use of CSE as gestational age increased ($P<0.0001$). Doses of intrathecal bupivacaine were larger in patients who received CSE compared with those who received a single-shot spinal anesthetic ($P<0.0001$). Fifty-four percent of cesarean deliveries were scheduled and 46% unscheduled. There was a decreasing trend in unscheduled cesarean deliveries with increasing gestational age [252 (90.7%), 304 (83.3%), 680 (69.3%) and 1047 (30.9%) for patients <28, 28 to <32, 32 to <37 and $\geqslant$37 weeks of gestation respectively, CA trend $P<0.0001$].

Patient demographics and intraoperative characteristics according to block failure are shown in Table 1. Augmentation of CSE with epidural lidocaine accounted for 130 (46.8%) of failures, followed by supplementation of spinal anesthetic with intravenous adjuvants with or without nitrous oxide (n=50, 18.0%), conversion to general anesthesia (n=41, 14.8%), repetition of spinal anesthesia (n=41, 14.8%),