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ORIGINAL ARTICLE

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Anesthetic technique for cesarean delivery and neonatal acid–base status: a retrospective database analysis

Z.Y. Strouch, C.G. Dakik, W.D. White, A.S. Habib
Department of Anesthesiology, Duke University Medical Center, Durham, NC, USA

ABSTRACT
Introduction: A previous meta-analysis reported lower umbilical artery pH with spinal anesthesia for cesarean delivery compared to general or epidural anesthesia. Ephedrine was used in the majority of studies. The objective of this study was to evaluate the effect of anesthetic technique on neonatal acid–base status now that phenylephrine has replaced ephedrine in our institution.
Methods: We retrospectively reviewed our database to identify patients who underwent cesarean delivery and had umbilical artery pH available. We decided *a priori* to test separately cases where cesarean delivery was performed emergently (category I and II) or non-emergently (category III and IV). Multivariable models were constructed to detect significant predictors of lower umbilical artery pH.
Results: One thousand sixty-four cases were included (647 emergent, 417 non emergent). In emergent cesarean delivery, anesthesia type was a significant predictor of lower umbilical artery pH (P <0.0001) with the pairwise comparisons showing lower neonatal umbilical artery pH [mean (95% CI)] with general anesthesia [7.16 (7.13, 7.19)] compared with spinal anesthesia [7.24 (7.22, 7.25)] and epidural anesthesia [7.23 (7.21, 7.24)], with no difference between spinal and epidural anesthesia. When excluding cases where general anesthesia was chosen due to insufficient time to place a neuraxial block or dose an existing epidural catheter, anesthesia type was not a predictor of lower umbilical artery pH. Anesthetic technique was not a predictor of lower umbilical artery pH in non-emergent cases.
Conclusions: Spinal anesthesia was not associated with lower umbilical artery pH compared to other types of anesthesia. This might be due to the use of phenylephrine in our practice.

Keywords: Anesthesia; Spinal; Cesarean delivery; Phenylephrine

Introduction

Neuraxial anesthesia for cesarean delivery likely offers a more favorable safety profile for the mother than general anesthesia, which carries the risk of failed airway and aspiration in a high-risk population.[1] However, the impact of neuraxial anesthesia on fetal outcome is less clear. While neuraxial anesthesia avoids the direct depressant effects of general anesthesia on the fetus, the hemodynamic effects of neuraxial blockade can affect the fetus. Several studies have used neonatal acid–base status to assess the impact of anesthetic techniques and vasopressor administration on the fetus as one meta-analysis suggested that low neonatal umbilical artery pH may be associated with adverse neonatal outcomes.[2]

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Correspondence to: Ashraf S. Habib, Duke University Medical Center, Department of Anesthesiology, Box 3094, Durham, NC 27710, USA.
E-mail address: habib001@dm.duke.edu

Neonatal acid–base status reflects the fetal condition immediately before delivery,[3] and is therefore useful when assessing fetal perfusion and the impact of vasopressor administration on the fetus. Another meta-analysis, which included 27 studies, reported significantly lower neonatal umbilical artery pH with the use of spinal anesthesia for cesarean delivery compared to general or epidural anesthesia and questioned the safety of spinal anesthesia for the fetus.[4] However, ephedrine was used to treat hypotension in the majority (63%) of the studies included in this meta-analysis. The authors suggested that larger ephedrine doses contributed to the lower umbilical artery pH with spinal anesthesia compared with epidural or general anesthesia. Another retrospective study suggested a correlation between the type of anesthesia and neonatal mortality; spinal anesthesia was associated with an increased risk of neonatal mortality in preterm infants when compared with general or epidural anesthesia.[5] This study, however, did not record details of maternal hemodynamic management.

The use of ephedrine for the management of hypotension in women undergoing cesarean delivery under

spinal anesthesia is associated with lower umbilical artery pH compared with phenylephrine.[6–8] This is likely the result of greater placental transfer and less fetal metabolism of ephedrine compared with phenylephrine, as well as increased metabolic activity from stimulation of fetal beta-adrenergic receptors.[9] While phenylephrine is now considered by many to be the vasopressor of choice in obstetric patients,[8] no previous study has compared neonatal umbilical artery pH with different anesthetic techniques in the setting of phenylephrine utilization. We therefore performed this study to re-evaluate the effects of anesthetic technique for cesarean delivery on fetal umbilical artery pH now that phenylephrine has replaced ephedrine in our practice as the vasoactive agent of choice for the management of hypotension in parturients.

Methods

After Institutional Review Board approval, a search was performed within the perioperative database for the period of January 1, 2002 through April 30, 2012 for patients with singleton gestation who underwent cesarean delivery and had umbilical cord gases measured. We excluded patients who were enrolled in research studies with blinded vasopressor administration. Data extracted from the electronic medical record included: type of anesthesia, indication for cesarean delivery, umbilical artery pH, umbilical artery base excess, gestational age, birth weight, maternal comorbidities, pregnancy complications, fetal anomalies or growth restriction, non-reassuring fetal heart tracing (NRFHT), and perioperative details [phenylephrine or ephedrine use including dose and mode of administration (prophylactic infusion or boluses for the treatment of hypotension), occurrence of hypotension defined as systolic blood pressure <90 mmHg, block height, and times from skin and uterine incision to delivery]. For patients who received general anesthesia, we collected information on the indication to perform general anesthesia and divided this into two categories: insufficient time to use a neuraxial anesthetic (including insufficient time to perform a block or dose an existing epidural catheter) and contraindications to placement or failure of the neuraxial anesthetic. The indication for cesarean delivery and the indication to perform general anesthesia were confirmed by review of the anesthetic record, operative note and discharge summary of included patients. We graded the urgency of the cesarean delivery according to the classification recently modified by the Royal College of Obstetricians and Gynaecologists.[10] Category I is a clinical situation that presents immediate threat to life of the woman or fetus; category II indicates maternal or fetal compromise which is not immediately life-threatening; category III indicates need for early delivery but no maternal or fetal compromise; and category IV indicates cesarean delivery at a time that suits the patient and maternity team. We decided *a priori* to test separately cases where cesarean delivery was performed emergently for fetal or maternal indications (category I and II) and those with non-emergent indications (category III and IV).

During the study period phenylephrine was the main vasopressor used for the management of hypotension in women undergoing cesarean delivery. Our practice evolved from using phenylephrine boluses for the treatment of hypotension with all anesthesia types to using a prophylactic phenylephrine infusion with spinal anesthesia. In our institution, hypotension in patients receiving a phenylephrine infusion is managed by increasing the rate of infusion or administration of a bolus of phenylephrine. For patients having their cesarean delivery performed under epidural or general anesthesia, a phenylephrine infusion is rarely used and generally added only if there is recurrent hypotension after the administration of phenylephrine boluses.

Statistical analysis

The primary outcome of the study was umbilical arterial pH. The Kruskal–Wallis rank test and Chi-square test or Fisher exact test were used to compare patient characteristics and perioperative variables among the three anesthetic types. Preoperative characteristics, co-morbidities and perioperative details were tested for association with umbilical artery pH. Continuous variables were tested using linear regression and categorical variables using ANOVA. Those with an association of $P < 0.10$ were included in a multivariable analysis of covariance (ANCOVA) model with anesthesia type as the predictor of interest. Non-significant terms were removed one at a time using a backward elimination technique until only those simultaneously significant at $P < 0.05$ remained. Diagnostic tests were inspected to rule out collinearity among predictors. The raw values for umbilical artery pH were analyzed and were then transformed to provide a reasonably normal distribution. The transformation was a Box-Cox power function, which was then rescaled to the mean and standard deviation of the raw values. The effect of type of anesthesia on umbilical artery pH was tested in ANCOVA models with this set of covariables, with $P < 0.05$ accepted as statistically significant. The Tukey–Kramer test was used to adjust for multiple pairwise group comparisons among types of anesthesia. We also explored the impact of the method of phenylephrine administration on umbilical artery pH in women who received spinal anesthesia in a multivariable model, with umbilical artery pH as the outcome and administration method of phenylephrine as predictor (no phenylephrine administered, boluses, infusion, or both boluses and infusion). Data were analyzed using SAS Version 9.3 (SAS Institute, Cary, NC, USA).