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Title of Project: Reducing the risk of preventable postpartum lower extremity nerve injuries

Principal Investigator and Team Members: Paloma Toledo, MD, MPH; William A. Grobman, MD, MBA; Julia Lee, PhD; Jane Holl, MD, MPH

Organization: Northwestern University

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1. **Structured Abstract:**

Purpose: Approximately 40,000 women experience lower extremity nerve injuries after childbirth. The incidence ranges between 0.1% and 1% and is largely attributed to nerve compression or stretch injuries. Previous studies have evaluated maternal and labor characteristics associated with nerve injury, but few have evaluated anesthetic-related factors.

Scope: The objective of this study was to investigate whether anesthetic factors are associated with new-onset postpartum lower extremity nerve injuries.

Methods: In this single-center, retrospective, nested case-control study, the electronic medical record for all patients who delivered between January 1, 2006, and December 31, 2016, were queried. Nerve injuries were identified through International Classification of Diseases (ICD) codes, physiatry and therapy consults, and anesthesia complication notes. All nerve injuries were verified by chart review and matched with three controls who delivered on the same day and by the same mode of delivery. A multivariable logistic regression model was estimated to evaluate the association among nerve injuries, demographic, and clinical factors. Variables included in the final model were parity, macrosomia, diabetes, percentage change in mean arterial pressure, and paresthesias during neuraxial placement. $P < 0.05$ was significant.

Results: A total of 385 women experienced new nerve injuries (incidence 0.3%), and anesthetic factors were associated with new injuries. Overall, 1155 control patients who delivered on the same day and via the same mode of delivery were matched. The incidence of paresthesias was 14.9% among women with nerve injuries versus 6.5% in controls ($P < 0.001$).

The median percentage change in mean arterial pressure (MAP)was larger in patients who experienced nerve injuries vs. controls (25.0% vs.15.5%, $P < 0.001$). In the multivariable logistic regression model, the presence of a paresthesia was associated with an increased odds of nerve injury (adjusted odds ratio: 2.8, 95% confidence interval: 1.73 – 4.65).

Key words: Nerve injury, neuropathy, paresthesias, obstetric complications, neuraxial anesthesia, neuraxial analgesia

2. Purpose:

Childbirth is the most common reason for admission to a hospital in the United States. Though most women anticipate an uneventful delivery, many experience a complication during delivery. One type of complication that affects nearly 40,000 women each year is lower extremity nerve injury. Nerve injuries can have a significant impact on new mothers' lives, as some women may not be able to walk unassisted and, therefore, may be unable to independently care for their newborn infant. Though half of these injuries resolve within 6-8 weeks, the remainder can take up to a year to resolve or can become permanent. These complications can be extremely distressing to a new mother, disrupt mother-infant bonding, and result in strain in family or social relationships.

Most nerve injuries are related to stretching or compression of the lower extremity peripheral nerves during childbirth. Yet, little progress has been made to reliably identify at-risk women or to develop interventions to potentially prevent these injuries, many of which are thought to be due to improper positioning during labor.

There has been an increase in the use of neuraxial (spinal, epidural, or combined spinal-epidural) analgesia for relief of labor pain in the US. Although it is the best form of pain relief for labor, it may be contributing to postpartum nerve injuries in several ways. Patients with neuraxial anesthesia may develop postpartum nerve injuries because they (1) may not feel symptoms of impending nerve injury and fail to change position; (2) may not perceive pain as they hyperflex their thighs during the second stage of labor (pushing) and, therefore, may be more likely to develop a stretch injury; and/or (3) may be less likely to change position during labor compared to women not using neuraxial labor analgesia, resulting in external pressure and compression of the nerves. The objective of this study was to investigate anesthetic factors associated with peripartum peripheral nerve injuries.

3. Scope:

The data were derived from deliveries that occurred at Northwestern Memorial Hospital's Prentice Women's Hospital over a 10-year period (delivery date between January 1, 2006, and December 31, 2016). Prentice is the largest delivery hospital in Illinois, with a delivery volume of approximately 12,500 infants per year. All women who deliver at Northwestern are evaluated by the anesthesiology service prior to delivery, and the electronic medical record contains demographic, obstetric, and anesthetic variables. All patients who experience a new-onset lower extremity nerve injury are evaluated by the anesthesiology service, physical therapy, and/or physiatry. A total of 127,000 women delivered over the 10-year period, and 385 new postpartum lower extremity nerve injuries were identified (incidence 0.3%).

4. Methods:

In this single-center, retrospective, nested case-control study, the electronic medical record for all patients who delivered between from January 1, 2006, to December 31, 2016, was queried. Nerve injuries were identified in one of four ways: Nerve injuries were identified by an ICD code for nerve injury (ICD-9 codes: 344.9, 355.x, 356.8, 356.9; ICD-10 codes: G83.9, G57, G57.10-13, G57.2, G57.3, G57.4, G57.6, G57.7, G57.9, G58.9, G60.8, G60.9), a physical medicine & rehabilitation consult, a physical therapy consult, or an anesthesia complication note. Nerve injuries were verified by chart review. As components of the anesthesia record could not be extracted from the electronic medical record and required manual chart review, cases of new-onset nerve injuries were matched with three controls who delivered on the same date and by the same mode of delivery.

Data extracted from the medical record included demographic and clinical factors, including age, body mass index, gravidity, parity, multiple gestation, diabetes mellitus, mode of delivery, and suspected fetal macrosomia. The duration of the first and second stage of labor was extracted for women who labored, but positioning during the second stage of labor was not consistently documented; therefore, the duration of pushing in any one position could not be manually extracted from the chart. Data extracted from the delivery and anesthetic record included the percentage change in mean arterial pressure (MAP) relative to baseline blood pressure, the total amount of anesthetic medications used, and whether paresthesias (e.g., a sensation of burning or prickling, such as a “pins and needles” sensation) were documented during neuraxial placement.

A multivariable logistic regression model was estimated to evaluate the association between nerve injuries and demographic and clinical factors. Candidate independent variables were selected for model entry if their bivariate association with the dependent variable (new onset nerve injury) resulted in a P value < 0.1. Variables included in the final model included parity, macrosomia, diabetes, percentage change in mean arterial pressure, and paresthesias during neuraxial placement. $P < 0.05$ was used to determine statistical significance.

5. Results:

A total of 385 women experienced new confirmed nerve injuries (incidence 0.3%). The anesthesia record was not available for 12 patients with nerve injuries, so complete data on the anesthetic factors were available for 373 women. Overall, 1155 control patients who delivered on the same day and via the same mode of delivery were matched. The median percentage change in mean arterial pressure was larger in patients who experienced nerve injuries vs. controls (25.0% vs.15.5%, $P < 0.001$). The incidence of paresthesias was 14.9% among women with nerve injuries versus 6.5% in matched controls ($P < 0.001$). Among patients who utilized neuraxial labor analgesia, the total volume of local anesthetic infused for maintenance of labor analgesia was higher for patients who experienced a nerve injury compared to controls (140 mL vs. 92 mL, $P < 0.0001$). In the multivariable logistic regression model, the presence of a paresthesia was associated with a 2.8 times higher odds of nerve injury (adjusted odds ratio: 2.8, 95% confidence interval: 1.73 – 4.65).

The incidence of peripheral nerve injuries in our study was 0.3%, which was lower than in previous studies; however, the incidence of nerve injuries has been shown to be lower in retrospective compared to prospective studies. All three anesthetic factors investigated (total volume of bupivacaine, greater decreases in mean arterial pressure, and paresthesias) were associated with postpartum lower extremity nerve injuries. It is possible that women who experienced nerve injuries had denser blocks that masked nociceptive warning signs of nerve compression. Larger decreases in blood pressure may cause an increased incidence of nerve injury due to decreased blood supply and poor nerve perfusion. Insertion of epidural catheters or spinal needles can cause irritation to the nerve root, which is experienced as a paresthesia to the patient. No published studies have shown that paresthesias are sensitive for or specific marker for nerve injury. However, the anesthetic management of a paresthesia may vary. Common practice is to proceed if the paresthesia is mild and transient, but the needle should be removed and redirected if persistent.

Future work should evaluate whether needle redirection prior to injection may further reduce the incidence of nerve injuries. In the multivariable model, the only two anesthetic-related factors that remained significant were paresthesias and changes in blood pressure. Other factors associated with nerve injuries, such as nulliparity, fetal macrosomia, and maternal diabetes or gestational diabetes, were also associated with nerve injuries, but these are neither modifiable nor preventable. Our group continues to work toward further understanding and developing interventions to reduce peripartum lower extremity nerve injuries.

6. List of Publications and Products

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