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ORIGINAL ARTICLE

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Accidental dural puncture during labor analgesia and obstetric outcomes in nulliparous women

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ABSTRACT

Background: The effect of accidental dural puncture during labor epidural analgesia on obstetric outcomes remains unexplored. In this retrospective cohort study, we tested the hypothesis that accidental dural puncture is associated with prolonged second stage of labor.

Methods: Anesthetic and obstetric data from nulliparous parturients who suffered an accidental dural puncture at term labor (n=89) during the years 2006–2012 were compared with randomly selected parturients with uncomplicated epidural analgesia (n=232). The primary outcome was the proportion of parturients with prolonged second stage of labor: secondary outcomes were the proportion of instrumented and cesarean deliveries. Statistical analysis included student t-test for continuous variables, chi-square test for binary variables, and logistic regressions for associations between accidental dural puncture and outcomes.

Results: Demographic and obstetric characteristics of parturients were comparable except for a non-significant increase in prolonged second stage of labor in the accidental dural puncture group (27% vs. 17%, P=0.06). After adjusting for known potential confounders, multivariate logistic regression analyses revealed a significant association between accidental dural puncture and prolonged second stage of labor (adjusted risk ratio [aRR] 1.99, 95% CI 1.04 to 3.82; P=0.037). This was not accompanied by an increase in instrumented (aRR 0.57, 95% CI 0.27 to 1.21; P=0.15) or cesarean delivery (aRR 1.83, 95% CI 0.89 to 3.77; P=0.10).

Conclusion: Accidental dural puncture during labor analgesia was associated with prolonged second stage of labor in nulliparous parturients. Prospective studies are needed to assess the relationship between the quality of neuraxial block after accidental dural puncture and obstetric outcomes.

Keywords: Accidental dural puncture; Labor analgesia; Obstetric outcomes; Prolonged second stage of labor; Nulliparous women

Introduction

An accidental dural puncture (ADP) occurs in approximately 0.5–1.5% of all parturients receiving neuraxial analgesia for labor.[1] Though complications from ADP such as the incidence of post-dural puncture headache and the need for an epidural blood patch are well studied,[2–5] little is known about its impact on obstetric outcomes. Following an ADP, either an intrathecal or a repeat epidural catheter is placed for analgesia. Both interventions appear to provide effective analgesia,[6] without significant differences in obstetric outcomes.[7] However, direct comparison of obstetric outcomes between patients with ADP and those with uncomplicated epidural analgesia is lacking. This is important because ADP is not uncommon, and there is evidence to suggest that there may be differences in the quality of analgesia after a dural puncture, either intentional or accidental.[7–10] For example, infusion of local anesthetics through an intrathecal catheter is associated with a higher incidence of motor block.[11,12] Similarly,

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repeat epidural analgesia following an ADP is associated with a lower rate of failure,[7] with numerous studies suggesting that epidural analgesia is more efficacious after a preceding dural puncture.[8–10] Although this suggests that the quality of post-ADP epidural analgesia is likely to be better, this has not been qualitatively examined. Importantly, the relationship between neuraxial blockade after an ADP and subsequent obstetric outcomes remains unexplored.

We hypothesized that nulliparous parturients whose birthing experience was complicated by an ADP would have prolonged second stage of labor, a higher incidence of instrumented vaginal delivery and also cesarean delivery due to failure of labor progress. To investigate this hypothesis, we conducted a retrospective cohort study in which we extracted maternal, anesthetic and obstetric outcome data from our departmental repository of recorded ADPs and compared these data with that from randomly-selected parturients who had received uncomplicated epidural analgesia.

Materials and methods

After Institutional Review Board (IRB) approval (protocol 2012P002256), we collected data on term nulliparous parturients with a singleton pregnancy who either had uncomplicated epidural analgesia or documented ADP at the time of initiation of epidural analgesia for labor. The cohorts delivered at a tertiary, large volume, academic obstetric hospital between January 2006 and December 2012. We included ADPs that were either recognized at the time of needle placement, after catheter insertion, or after administration of the test dose. Parturients meeting these criteria were identified from our postpartum database, an ongoing prospective data collection of all women who suffer anesthetic complications during labor and delivery; and their medical records were reviewed. We excluded those cases where the diagnosis or documentation of ADP was unclear. In addition, we excluded women who received combined spinal-epidural or dural puncture epidural (DPE) analgesia, who underwent emergency cesarean delivery for maternal or fetal compromise, and those with fetal macrosomia (birth weight >4000 g). Cases were compared with randomly selected parturients who received uncomplicated epidural analgesia during the period of the study. We collected data on age, body mass index (BMI), parity, gestational age, duration of second stage of labor and the mode of delivery. In addition, we collected data on a priori risk factors that have been shown to influence obstetric outcomes. This included information on the mode of onset of labor (spontaneous versus induced), premature rupture of membranes and maternal comorbidities. Because of the limited sample size, maternal comorbidities of interest (hypertensive disorders of pregnancy, cardiac disease, morbid obesity and diabetes mellitus including gestational diabetes) were collectively grouped as a dichotomous variable.

The primary outcome of interest was the proportion of parturients with prolonged second stage of labor. At our institution, second stage of labor starts with recognition of full cervical dilation and extends until delivery of the baby. Prolonged second stage of labor was defined according to the criterion proposed by the American College of Obstetricians and Gynecologists (ACOG) for laboring women with neuraxial analgesia (longer than three hours for nulliparous parturients) as this was in effect during the study period. This was necessary because most of the delivery decisions made during the study period were based on existing guidelines at that time. The proportion of instrument-assisted delivery and of unplanned cesarean delivery due to labor dystocia, either during the first or second stage of labor, was assessed as secondary outcomes. If the parturient underwent cesarean delivery prior to or during the second stage of labor (failure of descent), the variable 'prolonged second stage of labor' was neither defined as 'yes' nor 'no'.

Eighty-nine nulliparous parturients who met our criteria for ADP were compared with those that had uncomplicated labor epidural analgesia during the same study period. For the 'control' cohort, we queried our electronic medical record database, generated a list of medical record numbers of women who had received neuraxial analgesia each year, and randomly selected 50 per year (the average number receiving neuraxial analgesia for labor was approximately 5000 per year). After excluding those parturients with incomplete or absent data, those who received combined spinal-epidural analgesia, and those who met our exclusion criteria, we analyzed 232 nulliparous parturients with uncomplicated epidural analgesia in the control cohort. With this sample size, we estimated that we had 83% power to detect a relative risk difference of 2 between the two groups, with alpha set to 0.05, assuming a 14% incidence of prolonged second stage of labor in nulliparous parturients who receive epidural analgesia.[13] Demographic and clinical characteristics of parturients were compared according to the presence or absence of ADP. Continuous variables (age, BMI) were compared using student t-test. Binary variables (prolonged second stage of labor, instrumented delivery, cesarean delivery, mode of labor induction, premature rupture of membranes, maternal morbidity) were compared using either chi-square or Fisher's exact tests. We first performed univariate analyses to evaluate the associations between ADP and outcomes, followed by multivariate models including known potential confounders, and reported the adjusted risk ratios (aRR) with 95% confidence intervals (CIs). Because our previous study showed no difference in obstetric outcomes when an ADP was managed either with an intrathecal or a repeat

epidural catheter,[7] we analyzed the ADP group dataset without regard to the final mode of analgesia used. Two-sided *P*-values <0.05 were accorded statistical significance. All statistical analyses were performed using R software 3.4.0 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Overall, we included 89 and 232 parturients, with and without dural puncture, during labor analgesia (ADP and no ADP (control) cohorts respectively). In the ADP group, 61/89 (69%) patients received an intrathecal catheter while 28/89 (31%) received a repeat epidural catheter. Patient characteristics by presence or absence of dural puncture are detailed in Table 1. Basic demographic and obstetric variables were comparable between the two groups at baseline. Prolonged second stage of labor was not significantly different between groups (27% vs. 19%, ADP and no ADP groups respectively; *P*=0.06).

Univariate analysis showed that ADP did not confer a higher risk of either prolonged second stage of labor (Table 2), instrumental delivery (Table 3), or cesarean delivery (Table 4). By contrast, age was associated with prolonged second stage of labor (RR 1.06, 95% CI 1.01 to 1.13; Table 2) but not with cesarean delivery (Table 4). Higher BMI was associated with an increased risk for cesarean delivery (RR 1.11, 95% CI 1.04 to 1.18; Table 4) but not prolonged second stage of labor or instrumental delivery. Labor induction, premature rupture of membranes and a maternal comorbidity were not associated with either prolonged second stage of labor, instrumental or cesarean delivery.

For multivariate analyses, we adjusted for age, BMI, induction of labor, premature rupture of membranes and presence of maternal comorbidities. Presence of ADP was significantly associated with a higher risk of prolonged second stage of labor (aRR 1.99, 95% CI 1.04 to 3.82; *P*=0.037, Table 2) but not instrumental delivery (Table 3) or cesarean delivery for failure of labor progress (Table 4). Increasing maternal age was associated with both a delay in second stage of labor (aRR 1.07, 95% CI 1.01 to 1.13; *P*=0.02, Table 2) and with cesarean delivery (aRR 1.07, 95% CI 1.01 to 1.14; *P*=0.02, Table 4) in this model. Higher BMI was associated only with an increased risk for cesarean delivery (aRR 1.13, 95% CI 1.05 to 1.21; *P*=0.001, Table 4). Labor induction, premature rupture of membranes and maternal comorbidities were not associated with an increased risk of any of the outcomes.

Discussion

In this retrospective cohort study, we provide evidence that an ADP, managed either with an intrathecal or repeat epidural catheter, is associated with prolonged second stage of labor but not with instrumental or cesarean delivery. To our knowledge, this is the first study to directly address the question of obstetric outcomes following an ADP during labor epidural analgesia.

Though clinical management and complications of an ADP have been thoroughly studied, little is known about the quality of neuraxial block following an ADP. Limited evidence suggests that intrathecal catheters are associated with a higher incidence of motor block.[11,12] More importantly, a new line of evidence from DPE studies suggests that epidural catheters placed after a dural puncture generally prove more effective than uncomplicated epidural labor analgesia and demonstrate greater blockade of the S1 nerve root.[8–10] Whether a dural puncture predisposes parturi-

Table 1 Demographic data according to exposure in nulliparous parturients

Maternal and obstetric characteristics	Dural puncture (n=89)	No dural puncture (n=232)	*P*-value
Age (y)	29.1 (5.68)	29.44 (5.85)	0.6
Body mass index (kg/m^2)	28.6 (4.9)	29.6 (4.7)	0.06
Labor induction (n, %)	37 (42)	75 (32)	0.11
Maternal co-morbidity (n, %)	15 (17)	43 (18)	0.87
Premature rupture of membranes (n, %)	15 (17)	40 (17)	1
Duration from epidural analgesia to second stage (min)	427 (268)	385 (247)	0.18
Duration of second stage of labor (min)[a]	109 (86)	103 (72)	0.58
Prolonged second stage of labor (n, %)	20 (27)	35 (17)	0.06
Delivery outcomes			
Uncomplicated vaginal delivery (n, %)	64 (72)	164 (71)	0.85
Instrumental vaginal delivery (n, %)	10 (11)	41 (18)	0.16
Non-emergency cesarean delivery – first stage of labor (n, %)	11 (12)	19 (8)	0.28
Non-emergency cesarean delivery – second stage of labor (n, %)	4 (4)	8 (3)	0.74

Data presented either as mean ± standard deviation or number (percent) as appropriate.
[a]Only patients who had successful vaginal delivery (n=74 and 205, respectively).

Table 2 Prolonged second stage of labor

	Prolonged second stage of labor			
	Univariate		Multivariate (n=279)	
	Risk ratio	*P*-value	Risk ratio	*P*-value
Dural puncture				
No	Reference	–	Reference	–
Yes	1.81 (0.96 to 3.39)	0.065	1.99 (1.04 to 3.82)	0.037
Age (y)				
	1.06 (1.01 to 1.12)	0.031	1.07 (1.01 to 1.13)	0.023
Body mass index (kg/m^2)				
	1 (0.94 to 1.07)	0.971	1.02 (0.95 to 1.1)	0.563
Induction				
No	Reference	–	Reference	–
Yes	0.99 (0.53 to 1.86)	0.982	0.92 (0.46 to 1.8)	0.799
Premature rupture of membranes				
No	Reference	–	Reference	–
Yes	0.6 (0.25 to 1.42)	0.243	0.61 (0.25 to 1.47)	0.272
Maternal comorbidity				
No	Reference	–	Reference	–
Yes	1.09 (0.51 to 2.36)	0.82	1.13 (0.48 to 2.66)	0.776

Table 3 Instrumental vaginal delivery

	Instrumental vaginal delivery			
	Univariate		Multivariate (n=321)	
	Risk ratio	*P*-value	Risk ratio	*P*-value
Dural puncture				
No	Reference	–	Reference	–
Yes	0.59 (0.28 to 1.24)	0.166	0.57 (0.27 to 1.21)	0.146
Age (y)				
	1.03 (0.98 to 1.08)	0.298	1.03 (0.97 to 1.08)	0.357
Body mass index (kg/m^2)				
	0.97 (0.9 to 1.03)	0.317	0.96 (0.9 to 1.03)	0.314
Induction				
No	Reference	–	Reference	–
Yes	0.83 (0.44 to 1.58)	0.578	0.89 (0.45 to 1.77)	0.75
Premature rupture of membranes				
No	Reference	–	Reference	–
Yes	1.42 (0.68 to 2.98)	0.355	1.41 (0.66 to 3)	0.378
Maternal comorbidity				
No	Reference	–	Reference	–
Yes	0.8 (0.36 to 1.81)	0.596	0.97 (0.4 to 2.36)	0.943

ents to better quality analgesia has not been systematically investigated, but limited evidence suggests that it may do so when performed as part of a CSE or DPE technique. In support of this theory, we reported an epidural replacement rate of only 2% in parturients experiencing an ADP,[7] compared to the historical epidural replacement rate of 6–13% when performed without a dural puncture.[10,14] Therefore, we surmised that neuraxial analgesia following an ADP would influence labor and delivery outcomes. We had hypothesized that an ADP would prolong the second stage of labor and influence the incidence of instrumental and cesarean delivery. Confirming our primary hypothesis, we found evidence that an ADP was associated with more parturients having a prolonged second stage of labor, but without a significant effect on instrumented or cesarean

Table 4 Cesarean delivery

	Cesarean delivery			
	Univariate		Multivariate (n=321)	
	Risk ratio	*P*-value	Risk ratio	*P*-value
Dural puncture				
No	Reference	–	Reference	–
Yes	1.55 (0.78 to 3.07)	0.212	1.83 (0.89 to 3.77)	0.103
Age (y)				
	1.06 (1 to 1.12)	0.059	1.07 (1.01 to 1.14)	0.022
Body mass index (kg/m^2)				
	1.11 (1.04 to 1.18)	0.001	1.13 (1.05 to 1.21)	0.001
Induction				
No	Reference	–	Reference	–
Yes	1.86 (0.97 to 3.58)	0.064	1.55 (0.76 to 3.17)	0.232
Premature rupture of membranes				
No	Reference	–	Reference	–
Yes	0.47 (0.16 to 1.38)	0.171	0.44 (0.14 to 1.37)	0.159
Maternal comorbidity				
No	Reference	–	Reference	–
Yes	1.72 (0.81 to 3.65)	0.161	0.92 (0.38 to 2.22)	0.858

delivery, compared to uncomplicated epidural analgesia. Because of the absence of formal assessments of visual analogue scale scores and maternal motor blockade, the mechanism behind this association remains to be elucidated. We posit that it is likely due to high quality sacral analgesia in patients with ADP, either as a result of transdural spread of local anesthetic infused epidurally or due to preferential sacral pooling of dilute local anesthetic when infused intrathecally. This speculation is partly supported by evidence for higher quality sacral analgesia with a DPE technique compared to epidural analgesia.[8,9] We exclude gross motor blockade as a possible reason because, anecdotally, we have not observed this at our institution after intrathecal infusion of 0.125% bupivacaine and 2 μg/mL fentanyl at 1–2 mL/h. In addition, maternal motor blockade appears to correlate poorly with labor outcomes; the rates of instrumented vaginal delivery in patients receiving different modalities of epidural analgesia with varying degrees of motor block are comparable.[15,16] Despite this corroborative evidence, the possibility of subtle blockade of the pelvic floor muscles, especially the levator ani, cannot be ruled out.

The association between labor analgesia and obstetric outcomes, especially associated with epidural and CSE techniques, has been well studied. Most studies comparing epidural versus CSE analgesia found no significant differences in obstetric outcomes,[17,18] but the effects of intrathecal infusion of local anesthetic after an ADP remains poorly studied. Arkoosh et al. found no differences in obstetric outcomes in parturients whose analgesia was maintained with either an epidural or an intrathecal microcatheter,[19] but the intrathecal infusate used in that study was opioid-based and free of local anesthetic. Considering that approximately 70% of patients in the ADP group were managed with an intrathecal catheter, we surmise that our findings are due to the continuous presence of bupivacaine in the cerebrospinal fluid, and possibly better quality sacral block. Though regular assessment of pain scores would have been required to confirm this assumption, being a retrospective study, those data were not collected in a reliable manner, and only documented when there was a need for rescue analgesia. In addition, some variables in our model, such as premature rupture of membranes or maternal comorbidity, did not show an association with prolonged second stage of labor as previous studies have.[20–22] Though the exact reasons are unclear, we attribute this lack of association between a priori variables and prolonged second stage of labor to variability in the patient population and in obstetric management.

A particular strength of this study is the large sample size, which allowed us to adjust for known covariates that influence obstetric outcomes. However, our study has a few limitations. The first is the association between labor analgesia and the occiput posterior fetal head position, a significant factor for prolonged labor.[23] Due to a lack of standardization in how an occiput posterior fetal head position was documented, we were unable to reliably collect these important data. Nevertheless, both our groups received neuraxial analgesia and are likely to have had similar rates of occiput posterior position. Secondly, we used the previous and not the current criterion for prolonged labor because of the strong likelihood that decisions regarding delivery were influenced by the criterion that prevailed during

the study period. We were unable to determine if the latest criterion for prolonged second stage of labor (jointly recommended by the Eunice Kennedy Shriver National Institute of Child Health and Human Development, Society for Maternal-Fetal Medicine, and ACOG) will affect our conclusions,[24] because: (i) this policy has not been consistently applied at our institution; (ii) the limited small sample size due to shorter duration of study period with new criterion (2014-present); and (iii) practice variability among obstetric providers. Thirdly, it is possible that variations in oxytocin augmentation might have altered the outcomes. Although we did not collect these data, most nulliparous parturients receive protocol-driven oxytocin augmentation at our institution regardless of the provider, thereby minimizing this possibility. Fourthly, results for our secondary outcomes were probably underpowered. Post-hoc power analyses revealed that we had greater than 80% power only if the odds of cesarean delivery were 50% higher in the ADP cohort (assuming a cesarean delivery rate of approximately 30% in laboring nulliparous parturients), and only 55% power to detect a real difference in instrumented delivery. Finally, it remains to be seen if similar results hold true in multiparous women for whom the second stage of labor is considerably shorter.

In conclusion, we have shown for the first time that an ADP during labor epidural analgesia is associated with a prolonged second stage of labor in nulliparous women. Because this finding cannot be confirmed with a randomized trial, meticulous observational studies that assess the efficacy of analgesia and the degree of motor blockade after ADP are warranted, along with investigation of all obstetric outcomes of interest.

Conflict of interest/disclosure statement

The authors report no conflicts of interest.

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