

Comparison of the effects of sagittal versus transvers 25-gauge quincke needle insertion on post-dural puncture headache development

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Abstract

Objective: Post-dural puncture headache (PDPH) is one of the most important complications after spinal anesthesia. This study aimed to investigate the effect of the sagittal or transverse application of 25-gauge Quincke spinal needle on PDPH development in patients undergoing cesarean section.

Material and Methods: A total of 295 patients with a planned cesarean section between the ages of 18-40 years with an American Society of Anesthesiologists score of 1 or 2 were included in the study. For the spinal intervention, 25-gauge Quincke spinal needle was used in all patients. Patients were included in one of two groups according to the spinal needle cutting direction of the dura mater fibers as sagittal (parallel to dura mater fibers, Group S; n=145) or transverse group (perpendicular to dura mater fibers, Group T; n=150).

Results: PDPH developed in 27 (9.2%) patients. Patients in Group T had significant higher ratio of PDPH compared to patients in Group S (16% vs. 2.1%, $p<0.001$). Additionally, patients with PDPH had a significantly higher frequency of ≥ 2 spinal puncture attempts compared to patients without PDPH (22.2% vs. 4.5%, $p=0.003$). Multivariate logistic regression analysis demonstrated that transverse needle direction (OR: 11.40, 95% CI: 2.73-34.71; $p<0.001$) and ≥ 2 spinal puncture attempts (OR: 9.73, 95% CI: 3.13-41.55; $p<0.001$) and were independent predictors for PDPH development.

Conclusion: Transverse insertion of the 25-gauge Quincke needle into spinal cord fibers and repeated interventions are independently associated with the development of PDPH in cesarean section patients undergoing spinal anesthesia.

Key words: Spinal anesthesia, cesarean section, post-dural puncture headache, Quincke needle, cutting direction

Introduction

Spinal block is a frequently used regional anesthesia method in cesarean deliveries. The local anesthetic solution is administered to the subarachnoid space and sensory and motor block is created within the surgical field in this anesthesia method (1). The spinal needles used for this procedure are of different thicknesses and pointcuts. Post-dural puncture headache (PDPH) is one of the most important complications after spinal anesthesia, which is a discomforting complication for the physician and the patient (2). It is defined as a headache developing within 5 days of dural puncture, which cannot be explained by any other reason. Its incidence varies between 2%-40%, depending on the needle thickness, needle type, and patient population (3-5). Several mechanisms related to PDPH formation have been proposed. All of these theories implicate the basic pathology as cerebrospinal fluid (CSF) leakage after rupture of the dura mater due to the spinal intervention.

As high CSF leakage occurs, intracranial pressure decreases, resulting in the dilation of the intracerebral arteries and veins. Also, CSF loss causes tension in intracranial pain-sensitive structures, leading to PDPH (2,6,7).

Previous studies demonstrated that different spinal needle thicknesses and tips (e.g. pencil point) affect PDPH development (8-12). Dura mater penetration with the spinal needle at different angles (sagittal or transverse) might also have effects on PDPH development (13,14). However, to the best of our knowledge, there is no study evaluating the effect of dura penetration angle of the 25-gauge Quincke spinal needle on the development of PDPH in patients undergoing cesarean section. The primary aim of our study was to investigate the effect of sagittal or transverse insertion of 25-gauge Quincke spinal needle on PDPH formation in patients undergoing cesarean section.



Besides, the secondary aim of our study was to determine the effect of sagittal or transverse insertion of 25-gauge Quincke spinal needle on hemodynamic parameters including mean arterial pressure (MAP), heart rate (HR) and peripheral oxygen saturation (SpO₂).

Material and Methods

Patient Selection

This randomized prospective study was initiated after the approval of the local ethics committee. The study protocol is also registered in a clinical trial registry (www.anzctr.org.au number, ACTRN12619000553178). Three-hundred patients with a planned cesarean section in Sanliurfa Research and Training Hospital between the ages of 18-40 years, with an American Society of Anesthesiologists (ASA) score of 1 or 2 were enrolled in the study. Emergency cases and patients with contraindications for spinal anesthesia (non-compliance with the intervention or refusal to consent, infection at the intervention site, hematological abnormalities, hemodynamically unstable patients, preclampsia, and patients with a diagnosis of increased intracranial pressure or with similar symptomatology) were excluded. Patients were informed about the study procedures and their written informed consent was obtained. Five patients developed perioperative agitation requiring deep sedation, resulting in the exclusion of these patients from the study groups. Consequently, 295 patients were assessed in the study. The sealed envelope method was used for randomization.

Management of Anesthesia

A peripheral intravenous (iv) line was placed with a 20-gauge iv cannula and used for the preoperative administration of 10 ml/kg Ringer's lactate solution to all patients. No pharmacological premedication was used. Patients were monitored NIBP, ECG, and SpO₂ in the operating theater. Spinal needle insertion (intervention) was performed in the sitting position according to the routine spinal anesthesia protocol. For the spinal intervention, a 25-gauge Quincke spinal needle was used in all patients. Patients were divided into two groups as sagittal insertion (parallel to the fibers of dura mater; Group S, n=145) or transverse insertion (perpendicular to dural fibers; Group T, n=150) regarding the dural cutting direction of the spinal needle. After the free flow of CSF was observed, two ml of 0.5% hyperbaric bupivacaine was administered intrathecally to both patient groups. After the intervention, the patients were placed in supine position and supported from the back and hip regions with 15 degrees left lateralization. Sensory block was determined with pinprick test and surgery was initiated when the block reached T4-T6 spinal level. Hypotension was defined as a $\geq 20\%$ decrease in baseline mean arterial pressure (MAP) and 5 to 10 mg iv ephedrine was administered when detected, whereas bradycardia was defined as a heart rate (HR) below 45 beats per minute and iv atropine was administered at a dose of 0.015 mg/kg for HR correction.

Data Collection

Age, weight, height, body mass index (BMI), and preoperative hemoglobin levels along with previous spinal anesthesia and PDPH history of the patients were recorded. MAP, HR, and SpO₂ values were obtained preoperatively and at 1 minute, 5 minutes, 10 minutes, and at 5-minute intervals thereafter following the intervention. Spinal intervention level (L3-4 or L4-5), the dural cutting direction of the spinal needle (sagittal or transverse), and the number of intervention attempts were recorded. Patients were contacted by the study investigators via telephone to determine the headache complaints one week following the cesarean section. The followed questions were used to diagnose the PDPH: the onset time, localization, and positional dependence of the headache. Patients with PDPH were evaluated and severity of headache was recorded according to the visual analog scale (VAS).

Statistical Analysis

Statistical analysis was performed with Statistical Package for Social Sciences (SPSS, version 23 for Windows; SPSS Inc. an IBM Company, Chicago, USA). Kolmogorov-Smirnov test was used to examine the normality of continuous variables. Continuous variables with a normal distribution were expressed as mean \pm standard deviation (SD) and compared with Student's t-test. Categorical variables were expressed in numbers and percentages and compared by chi-squared test. Variables with a p-value of < 0.1 were defined as variables possibly related with PDPH in univariate analysis. Multivariate logistic regression analysis was performed to determine the independent predictors of PDPH (presented as odds ratio [OR] with 95% confidence interval [CI]). A p-value of < 0.05 was considered as statistically significant.

Results

A total of 295 pregnant women were included in this randomized prospective trial. The baseline characteristics of the study groups are presented in Table 1. There was no significant difference between the groups in terms of baseline characteristics. MAP, HR, and SpO₂ values at each point of time during the procedure are listed in Table 2. They were also comparable in both groups.

The number of spinal puncture attempts is demonstrated in Table 3. Two or more spinal puncture attempts were performed in 18 patients (6.1%). The mean number of the spinal puncture attempts (1.1 ± 0.4 vs. 1.1 ± 0.3 , $p = 0.351$) and patients with ≥ 2 spinal puncture attempts (6.9% vs. 5.3%, $p = 0.575$) were similar between Group S and Group T, respectively.

PDPH developed in 27 patients (9.2%): three patients (2.1%) in Group S and 24 patients (16%) in Group T. It was found that the incidence of PDPH was significantly lower in Group S compared to Group T ($p < 0.001$). There was no difference between the two groups in terms of VAS scores for headache and day of the PDPH onset (Table 4). The baseline and procedural characteristics of the patients according to the development of PDPH are shown in Table 5. Patients who developed PDPH had statistically significant higher frequency of ≥ 2 spinal puncture attempts compared to patients who did not develop PDPH

(22.2% vs. 4.5%, $p = 0.003$). In addition to PDPH, the frequency of transverse needle direction was significantly higher in patients who developed PDPH (88.9% vs. 47.0%, $p < 0.001$). In univariate analysis, ≥ 2 spinal puncture attempts and transverse needle direction were found to be associated with increased risk of PDPH development.

Multivariate logistic regression analysis demonstrated that ≥ 2 spinal puncture attempts (OR:9.73, 95% CI:3.13-41.55, $p < 0.001$) and transverse needle direction (OR:11.40, 95% CI:2.73-34.71, $p < 0.001$) were the independent predictors of the PDPH development (Table 6).

Table 1. Comparison of baseline characteristics of the study groups

	Group S (n = 145)	Group T (n = 150)	p value
Age, years	28.2 ± 5.8	28.6 ± 5.8	0.469
Body mass index, kg/m ²	30.2 ± 3.4	30.1 ± 2.8	0.796
ASA status, n (%)			0.656
I	97 (66.9)	105 (70.0)	
II	48 (33.1)	45 (30.0)	
Hemoglobin, g/dL	11.6 ± 1.5	12.7 ± 8.5	0.119

ASA: American Society of Anesthesiologists, S: sagittal, T: transvers

Table 2. Comparison of mean arterial pressure, heart rate and peripheral oxygen saturation of the study groups

Time	Group S (n = 145)			Group T (n = 150)			p value for MAP	p value for HR	p value for SpO ₂
	MAP (mmHg)	HR (bpm)	SpO ₂ (%)	MAP (mmHg)	HR (bpm)	SpO ₂ (%)			
0 min.	95 ± 13	104 ± 19	99 ± 1	93 ± 11	106 ± 18	99 ± 3	0.114	0.452	0.518
1 min.	87 ± 14	106 ± 21	99 ± 1	85 ± 13	106 ± 15	99 ± 2	0.176	0.860	0.184
5 min.	79 ± 15	105 ± 19	99 ± 1	76 ± 11	106 ± 19	98 ± 4	0.116	0.719	0.597
10 min.	75 ± 13	104 ± 18	99 ± 1	77 ± 20	107 ± 18	99 ± 1	0.415	0.088	0.118
15 min.	78 ± 13	103 ± 16	99 ± 1	79 ± 10	104 ± 14	99 ± 1	0.436	0.539	0.118
20 min.	79 ± 11	101 ± 16	99 ± 1	81 ± 10	99 ± 12	99 ± 1	0.065	0.269	0.130
25 min.	80 ± 11	104 ± 13	99 ± 1	80 ± 11	99 ± 15	99 ± 1	0.828	0.082	0.353

Bpm: beat per minute, Min: minute, MAP: mean arterial pressure, HR: heart rate, SpO₂: peripheral oxygen saturation, S: sagittal, T: transvers

Table 3. Comparison of the number of the dural puncture attempts of the study groups

	Group S (n = 145)	Group T (n = 150)	p value
Mean number of the dural puncture attempts	1.1 ± 0.4	1.1 ± 0.3	0.351
Number of attempts, n (%)			
1 attempt	135 (93.1)	142 (94.7)	0.575
≥ 2 attempts	10 (6.9)	8 (5.3)	

S: sagittal, T: transvers

Table 4. Comparison of the incidence and severity of postdural puncture headache of the study groups

	Group S	Group T	p value
PDPH, n (%)	3 (2.1)	24 (16)	< 0.001
VAS	6.7 ± 1.5	7.2 ± 1.0	0.431
Day of PDPH onset			
1	2	14	0.680
2	1	8	
3	0	2	

PDPH: postdural puncture headache, VAS: visual analog scale

Table 5. Comparison of baseline and procedural characteristics of the study groups according to the presence of postdural puncture headache

	PDPH [+] (n = 27)	PDPH [-] (n = 268)	p value
Age, years	29.9 ± 6.4	28.3 ± 5.7	0.151
Body mass index, kg/m ²	30.4 ± 2.8	30.1 ± 3.1	0.796
ASA status, n (%)			
I	19 (70.4)	183 (68.3)	0.824
II	8 (29.6)	85 (31.7)	
Mean number of puncture attempts	1.3 ± 0.5	1.1 ± 0.3	0.063
Number of attempts, n (%)			
1	21 (77.8)	256 (95.5)	0.003
≥ 2	6 (22.2)	12 (4.5)	
Spinal anesthesia interval, n (%)			
L ₃ -L ₄	17 (63)	179 (66.8)	0.688
L ₄ -L ₅	10 (37)	89 (33.2)	
Previous history of spinal anesthesia, n (%)	18 (66.7)	179 (66.8)	0.990
Previous history of PDPH, n (%)	4 (14.8)	33 (12.3)	0.759
Quincke needle direction, n (%)			
Sagittal	3 (11.1)	142 (53)	<0.001
Transverse	24 (88.9)	126 (47)	

ASA: American Society of Anesthesiologists, PDPH : postdural puncture headache

Discussion

In this study, we investigated the effects of the transverse or sagittal use of 25-gauge Quincke spinal needle insertion on PDPH development in patients undergoing cesarean section. The main finding of the study was that the 25-gauge Quincke spinal needle caused a lower rate of PDPH with the sagittal approach when compared to the transverse approach.

Spinal block is a commonly preferred anesthesia method in cesarean operations due to its fast and effective pain relief feature (16). Although this anesthesia method has many advantages, PDPH stands an important complication (2). PDPH incidence varies between 2% to 40% in relation to needle thickness, needle type, and patient group (3-5). Similar to these findings, PDPH developed in 27 patients (9.2%) in our study.

Several studies were conducted to determine the factors that may affect PDPH development with findings implicating that changes in needle technology have a major effect on PDPH development. In particular, thinner spinal needles and needles with a pencil-point tip have proven to be associated with lower PDPH development (8-12). However, Quincke needles are relatively cheaper and therefore more commonly used in spinal anesthesia. It causes a larger hole formation in dura mater due to their design, leading to more CSF leakage and more frequent PDPH formation (17). To eliminate this disadvantage of Quincke needles, sagittal applications of the needle are emphasized and it is stated that PDPH development risk may be alleviated with sagittal insertion (13,14).

Flaatten et al. (13) examined the effect of sagittal and transverse applications of 27-gauge Quincke spinal needle on PDPH formation in 212 patients undergoing minor non-obstetric surgery.

The frequency of PDPH development with transverse insertion was significantly higher (22.6%) than that of sagittal insertion (3.8%). Salik et al. (18) examined the effect of sagittal versus transverse application of 26-gauge Quincke spinal needle on PDPH formation in 100 patients undergoing obstetric surgery. They found a trend for a higher incidence of PDPH development with transverse administration (14%) when compared with sagittal administration (8%). This finding of a statistically insignificant trend may be explained by the small number of patients included in the study of Salik et al (18). Although the relationship between the insertion directions of 27- and 26-gauge Quincke spinal needles and PDPH development has been investigated, to our knowledge, there is no study examining the relationship between the 25-gauge Quincke spinal needle direction and the frequency of PDPH development in patients undergoing obstetric surgery.

In our study, the effect of the sagittal and transverse application of 25-gauge Quincke needle on the formation of PDPH in patients undergoing cesarean section was investigated. Supporting the findings of Flaatten et al., the incidence of PDPH following transverse administration of the 25-gauge Quincke spinal needle was significantly higher in our study. While Flaatten et al. did not perform a regression analysis to determine whether the needle direction was an independent factor for PDPH development, we performed a multivariate logistic regression analysis to determine whether there was an independent relationship between spinal needle direction and PDPH development. Indeed, transverse needle direction was an independently associated factor, increasing the risk for PDPH development by 11.4 times. The possible mechanism between transverse needle direction and increased risk of PDPH can be explained with a higher

number of dural fiber cut, leading to increased CSF leak and higher chance for PDPH formation. Supporting this theory, in vitro experiments with 22-gauge Quincke needle found increased CSF leakage with transverse placement when compared with parallel needle placement (15.5 mL/min vs. 11.9 mL/min) (19). When all these findings are evaluated together, it can be concluded that the needle should be applied with a sagittal approach to reduce the risk of PDPH development in patients with a plan for 25-gauge Quincke spinal needle use.

Other important factors that may play a role in the PDPH development are patient position, physician experience, and the number of puncture attempts for successful dural penetration. The effect of patient position in spinal anesthesia is still controversial. Some studies showed that the lateral decubitus position was more effective compared with sitting position (20-22), whereas the other studies showed that sitting position was better than lateral decubitus (23,24). The advantages of the sitting position may be explained as follows: sitting position facilitates the identification of the midline structure and allows better spinal flexion (23, 25). In addition to these advantages, our experiences with sitting position is more. We, therefore, preferred sitting position preferred in our study. A recent study also demonstrated that patient position during spinal anesthesia does not affect PDPH incidence and one of them may be preferred according to the experience of anesthetists (26). However, it should not be forgotten that there are some situations in which the lateral decubitus position should be preferred. On the other hand, it has been reported that the incidence of PDPH is higher in younger patients aged between 25 and 40 years compared to older patients, and the incidence of PDPH decreases with physician experience (27,28). Our study consisted of a young population aged between 18 and 40 years in whom PDPH was common, but the incidence of PDPH development was found to be relatively low. This finding can be explained by the fact that the practicing physician in our study had 10 years of experience with spinal anesthesia. Finally, it has been shown that, the increased number of attempts for dural puncture may increase the incidence of PDPH (29). In our study, the number of patients who underwent two or more attempts for dural puncture was only 18 (6.1%). The multivariate analysis showed that two or more dural puncture attempts had an independent effect on PDPH development. These findings show that, in addition to the direction of spinal needle bevel, the number of attempts to perform dural puncture also has a significant effect on PDPH development.

Our study had some limitations. Patients with primary headache syndrome may have a higher incidence of PDPH. However, we did not evaluate the frequency of migraine/tension type headache history in this study. It could be useful to evaluate the primary headache syndrome in this study. Also, we did not exclude patients with the previous history of PDPH. It may be better to exclude these patients from the study. Nevertheless, we found no significant difference between patients with and without PDPH in terms of the previous history of PDPH. Also, the previous history of PDPH was not an independent predictor

of PDPH development. We think that this information may provide an additional contributions to our study.

Conclusion

As a conclusion, transverse insertion of the spinal needle through the spinal cord fibers and repeated interventions are independently associated with PDPH development in patients undergoing spinal anesthesia for cesarean section. Further clinical studies are needed on this subject.

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