Impact of spinal needle design and approach to postdural puncture headache and spinal anesthesia failure in obstetrics

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Abstract

Background: Concern has been raised that Sprotte needles predispose to spinal anesthesia failure. Nevertheless, these needles are associated with a low incidence of postdural puncture headache. The impact of the paramedian approach to postdural puncture headache remains controversial. The objective of this prospective randomized study was to compare Sprotte, Quincke and Atraucan needles as well as the midline and the paramedian approach in terms of postdural puncture headache and spinal anesthesia failure in patients undergoing Caesarean section.

Methods: 655 patients were randomized to 5 groups. A midline approach was used in four groups. The spinal needles were the 25G Sprotte, 27G Sprotte, 26G Atraucan and 25G Quincke. In the fifth group a 25G Quincke needle was used by the paramedian approach.

Results: The incidence of postdural puncture headache was 0% in both 25G and 27G Sprotte groups, 2.5% in the 26G Atraucan group, and 7.2% and 2.7% in the 25G Quincke midline and paramedian approach respectively. A significant difference in terms of postdural puncture headache was found between 25G Sprotte and 25G Quincke needles ($P = 0.004$), while the failure rate was similar between these two needles. A significant difference in spinal anesthesia failure rate was observed between midline and paramedian approaches ($P = 0.041$).

Conclusions: Sprotte but not Atraucan needle design correlates with lower incidence of postdural puncture headache compared to Quincke design. Sprotte needles are not associated with a higher spinal anesthesia failure compared to Quincke needles. The incidence of postdural puncture headache by the paramedian approach is not significantly reduced whereas the spinal anesthesia failure rate is increased in comparison to the midline approach.

Key words: postdural puncture headache, spinal anesthesia failure, pencil-point needles, paramedian approach.

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Obstetric patients have a higher incidence of postdural puncture headache (PDPH) than the corresponding incidence in the general population. Current evidence suggests that pencil-point spinal needles are significantly superior compared to cutting spinal needles regarding the frequency of PDPH [1, 2]. Moreover, the impact of needle gauge on PDPH has been shown to be less important in pencil-point as compared to cutting needles [3]. Atraucan is a double-beveled needle containing cutting and blunt components of the bevel. It was categorized as a non-traumatic needle in a recent meta-analysis [1] but its place regarding PDPH is not fully elucidated. Introducing cutting needles with the bevel parallel to the longitudinal dural fibers is found to be a factor associated with reduction of the incidence of PDPH [4].

The notion that the paramedian approach decreases the incidence of PDPH is supported by studies in models of the dura mater in vitro showing that the oblique angle of dural puncture causes less leakage across the dura [5, 6]. Clinical studies regarding the influence of the paramedian approach on PDPH have shown contradictory results.

The association between the patient's position during lumbar puncture and PDPH was the object of

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investigation in a recent meta-analysis where the lateral decubitus position was found to result in less PDPH in comparison to the sitting position of the patient [7].

Despite the advantage in terms of PDPH, Sprotte needles have been associated with a higher failure rate of spinal anesthesia, presumably due to partly misplaced injection, either subdurally or epidurally that is favored by the elongated side orifice located proximal to the tip [8–10]. To overcome this complication, slight further advancement of Sprotte spinal needles into the subarachnoid space has been advocated after cerebrospinal fluid (CSF) appearance [11]. Reducing the length of the side orifice has also been suggested [12]. Pencan is a modification of the Sprotte needle with reduced tip-to-front of eyelet distance and reduced eyelet length.

Some studies have reported the absence of a significant difference in spinal anesthesia failure rates between Sprotte and Quincke needles [13] while others have suggested high rates of intravenous supplementation when using 25G Sprotte needles [14, 15]. Concern has been raised about the occurrence of neurologic complications triggered by paresthesia during spinal puncture with Sprotte needles. This is presumably facilitated by the location of the orifice proximal to their tip, especially in the setting of further advancement of the needle [8, 16]. Even if paresthesia occurs during needle insertion, it is transient [17]. A high rate of dural click perceived upon dural puncture with Sprotte needles has been demonstrated, a fact described as a technical advantage of these needles [18]. The risk of obtaining blood-stained CSF is thought to be higher when using the paramedian approach due to the fact that the paramedian plane is more vascularized compared to the midline plane.

We hypothesize that Sprotte and Atraucan needles cause less PDPH compared to the Quincke needles and that the use of Sprotte 27G is associated with low incidence of PDPH even in patients with a history of PDPH or migraine. Moreover, we envisage that the paramedian approach is linked to less PDPH compared to the midline approach. In addition, we foresee that spinal anesthesia failure rate may be higher using the Sprotte needles when compared to Quincke needles and that the spinal approach has no influence on spinal failure rate. We hypothesize that paresthesia and positive dural click are higher using the Sprotte needles and that the paramedian approach is associated with a higher risk of blood-stained CSF.

METHODS

Approval was obtained from the Institutional Ethics Committee of the Medical University, Sofia with protocol No. 5/19.04.2016. Written informed consent was obtained from 655 patients undergoing Caesarean section (elective and emergency) under spinal anesthesia. The study was prospective, randomized, parallel group, without blinding. It was based at Maichin Dom Hospital, Sofia – a tertiary care maternity hospital with more than 4000 deliveries annually. All spinal anesthesia was performed by one anesthesiologist, a member of the staff. The spinal needles used in the study were 25G Pencan and 27G Pencan (B. Braun Medical Inc., Germany), 26G Atraucan (B Braun Medical Inc., Germany) and 25G Quincke (KDM, Germany). Patients were randomly assigned to one of 5 groups using computer generated random sequence numbers. The midline approach was used in four of the groups – with 25G Sprotte, 27G Sprotte, 26G Atraucan and 25G Quincke needles. Spinal anesthesia in the fifth group was performed with a 25G Quincke needle by the paramedian approach. Patients with a history of PDPH or migraine were excluded from randomization and received spinal puncture with a 27G Sprotte needle. The randomly allocated needle and approach were changed at the discretion of the anesthesiologist in case of puncture difficulty.

The data collection form included demographic data (age, body mass, height, body mass index – BMI), relevant anamnestic data (history of PDPH or migraine), data corresponding to difficult performance of spinal puncture (number of spinal puncture attempts, preeclampsia, difficult palpability of anatomical landmarks, patient's position during spinal puncture), primary outcome measure (PDPH) and secondary outcome measures (failed spinal anesthesia with the corresponding supplementary anesthesia, positive dural click, paresthesia, blood-stained CSF).

Exclusion criteria from the analysis of PDPH were a history of PDPH or migraine, BMI > 40 kg m^{-2}, associated with difficult palpability of anatomical landmarks, extreme urgency of Caesarean section, HELLP syndrome/thrombocytopenia, approach restriction by a tattoo on the back, ≥ 4 puncture attempts, decision to change the randomly allocated needle or approach because of puncture difficulty, repeat spinal anesthesia. The cases excluded from the analysis of PDPH were added to their respective group of spinal needle and approach and thus investigated in terms of spinal anesthesia failure rate and in terms of technical variables of spinal puncture. Resort to a longer (120 mm) 22G Quincke needle was the only exclusion criterion from the analysis of spinal anesthesia failure and of technical variables of spinal puncture.

The technique of spinal puncture was standardized. The standard patient's position for lumbar puncture was the left lateral decubitus position. A sitting position was chosen in case of puncture difficulty only. Cutting needles (Quincke and Atrau-

can) were inserted with the bevel parallel to the longitudinal fibers of the dura. After CSF appearance all needles were rotated through 360° with the aim of confirming free flow of CSF. The Sprotte needles were advanced further by 1 mm into the subarachnoid space after CSF appearance [10]. Paresthesia was defined as an electric, shooting or burning sensation or pain felt in the legs, buttocks or perineum reported by the patient during needle insertion. Patients were asked about paresthesia after block regression. Free aspiration of CSF was double checked, at the beginning and in the middle of the injection, looking for a typical "swirling" in the solution. Local anesthetics (LA) were injected in 10–15 s. 0.5% hyperbaric bupivacaine was used, with a dose of 0.06–0.07 mg cm^{-1} of patient height. Fentanyl 10 µg and morphine 120 µg were used as adjuvants.

Failed spinal anesthesia was defined as absent or inadequate sensory blockade following injection of LA after free flow of CSF, requiring further anesthetic supplementation, either general anesthesia, repeat spinal anesthesia or intravenous supplementation with systemic opioid and benzodiazepine. Postoperatively, patients were interviewed on the third or on the fourth day of spinal anesthesia as reported PDPH onset in the majority of cases is in the first 48 hours after spinal puncture [19]. They were questioned for the presence of headache and any accompanying symptoms such as neck stiffness, nausea, photophobia, blurred vision and tinnitus. PDPH was defined as an occipital or frontal headache brought on by the erect posture and relieved when the supine posture was resumed. The severity of PDPH was determined according to a three step scale [19]. All patients complaining of PDPH were monitored daily until complete recovery.

Qualitative variables were expressed as mean ± SD and analyzed by ANOVA test. Analysis of quantitative variables was carried out by Pearson χ^2 test or by Fisher's exact test. A P value of ≤ 0.05 was considered statistically significant.

RESULTS

From 655 recruited patients 87 had exclusion criteria from analysis of PDPH. 9 patients receiving spinal puncture with the 22G needle were excluded from analysis of spinal anesthesia failure and of technical variables of spinal puncture. 25 patients with a history of PDPH or migraine were excluded from randomization and were subsequently analyzed for PDPH incidence in a separate group denoted '27G Sprotte migraine' (Figure 1).

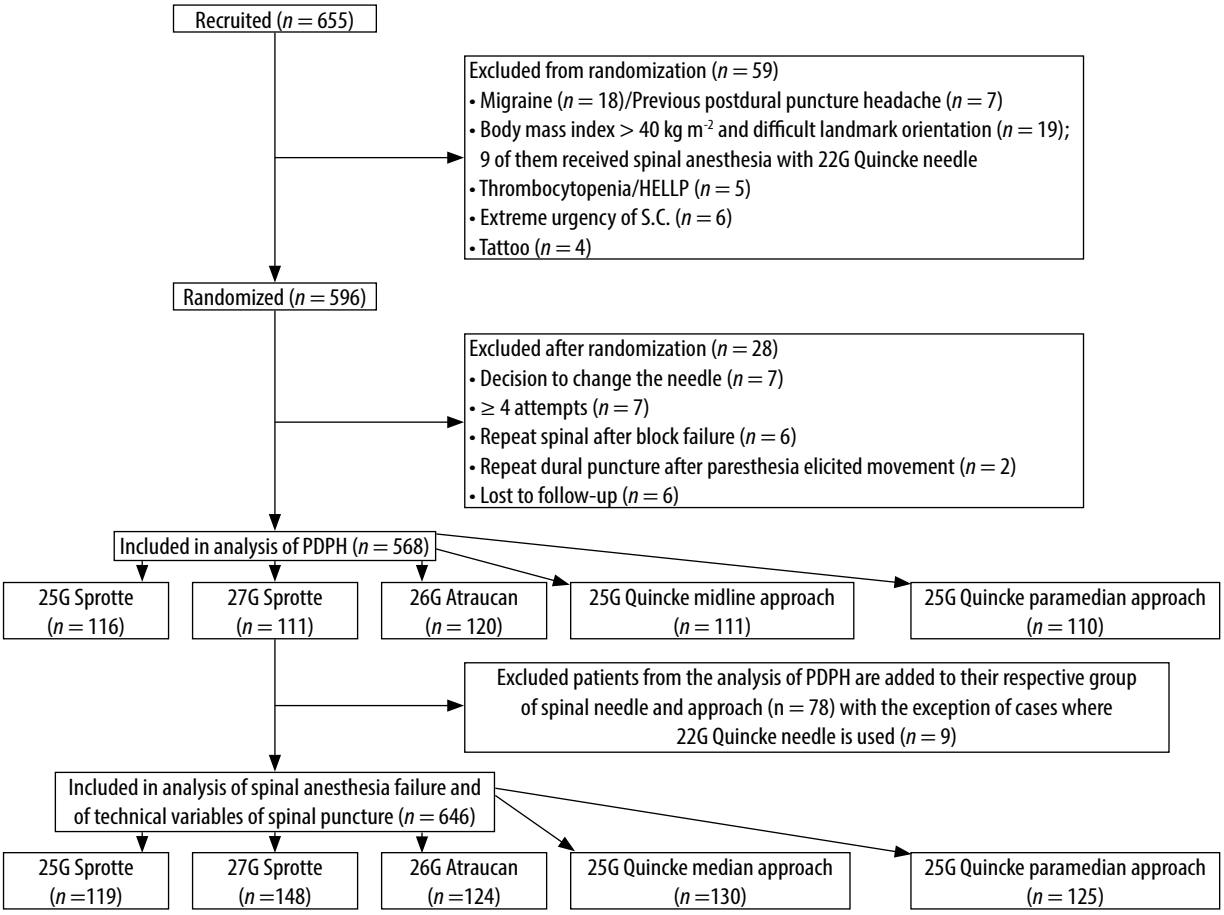

FIGURE 1. Flow diagram showing inclusion/exclusion of patients

Patient characteristics

Demographic characteristics of patients showed no difference in the study groups with the exception of 'height,' which differed significantly between the 25G Sprotte and 25G Quincke paramedian approach. The variable 'BMI' did not reflect this difference (Table 1). Variables corresponding to difficult performance of spinal puncture showed no difference in all five study groups (Table 1).

Primary outcome

The incidence of PDPH was 0% in both 25G and 27G Sprotte groups, 2.5% in the 26G Atraucan, and 7.2% and 2.7% in the 25G Quincke midline and 25G Quincke paramedian approach respectively. A higher rate of PDPH was observed in the group with the 25G Quincke midline approach compared to both 25G Sprotte and 27G Sprotte groups ($P = 0.004$). Although the incidence of PDPH was lower when using the paramedian in comparison to the midline approach, the difference was not found to be significant. No significant difference was detected when comparing 25G Quincke midline to 26G Atraucan, 25G Sprotte to 26G Atraucan and 25G to 27G Sprotte needles. There were no cases of PDPH in the 27G Sprotte migraine group. 8 patients met the criteria for mild PDPH, 5 for moderate and 1 for severe PDPH. All patients were treated conservatively. No blood patch was considered necessary (Table 2). 12 out of a total of 14 patients with PDPH had successful placement of spinal anesthesia at the first attempt. Spinal puncture in all patients with PDPH was done in the lateral decubitus position.

Secondary outcomes

There was no significant difference in the incidence of failed spinal anesthesia between 25G Sprotte, 27G Sprotte, 25G Quincke midline and 26G Atraucan groups. However, a significant difference was demonstrated between the midline and the paramedian approach, with a higher failure rate in the latter approach ($P = 0.041$). The overall rate of spinal anesthesia failure was 2.3% ($n = 15$). Supplementary anesthesia was distributed accordingly: intravenous supplementation – 4 cases, repeat spinal anesthesia – 6 cases, and general anesthesia conversion – 5 cases (Table 3). No cases of PDPH were observed amongst patients with spinal anesthesia failure, including those having received repeat spinal anesthesia.

A significantly higher rate of paresthesia (8.4%) was observed when using the 25G Sprotte needle

TABLE 1. Demographic data and variables associated with difficult performance of spinal puncture

	25G Sprotte ($n = 116$)	27G Sprotte ($n = 111$)	26G Atraucan ($n = 120$)	25G Quincke midline approach ($n = 111$)	25G Quincke paramedian approach ($n = 110$)	*P* value
Age (years)	31.05 (5.32)	32.21 (5.05)	31.06 (4.94)	30.78 (5.60)	31.43 (627)	NS*
Body mass (kg)	76.99 (12.38)	75.17 (12.76)	76.91 (12.75)	76.62 (15.01)	75.35 (12.97)	NS*
Height (cm)	165.67 (6.77)	165.59 (6.35)	165.51 (6.83)	164.41 (6.52)	163.23 (6.58)	0.045*
BMI (kg m^{-2})	28.04 (4.00)	27.40 (4.25)	28.09 (4.44)	28.30 (5.22)	28.27 (4.52)	NS*
Single puncture attempt	109 (94.0)	100 (90.1)	115 (95.8)	100 (90.1)	99 (90.0)	NS**
Difficult palpability	6 (5.2)	7 (6.3)	5 (4.2)	9 (8.1)	7 (6.4)	NS**
Sitting position	3 (2.6)	3 (2.7)	2 (1.7)	4 (3.6)	1 (0.9)	NS**
Preeclampsia	12 (10.3)	2 (1.8)	13 (10.8)	9 (8.1)	8 (7.3)	NS**

Values of demographic data are mean (SD), *ANOVA test. Values of patient clinical characteristics are absolute number (%), **χ^2 test. NS – non significant

TABLE 2. Postdural puncture headache

	25G Sprotte ($n = 116$)	27G Sprotte ($n = 111$)	26G Atraucan ($n = 120$)	25G Quincke midline approach ($n = 111$)	25G Quincke paramedian approach ($n = 110$)	27G Sprotte migraine ($n = 25$)	*P* value*
PDPH	0 (0.0)[a]	0 (0.0)[a]	3 (2.5)[a,b]	8 (7.2)[b]	3 (2.7)[a,b]	0 (0.0)[a,b]	0.004
Severity of PDPH							
Mild			1	6	1		
Moderate			1	2	2		
Severe			1				

Values are absolute number (%). PDPH severity is expressed in absolute numbers.
*Fisher's exact test
PDPH – postdural puncture headache

TABLE 3. Spinal anesthesia failure and technical variables of spinal puncture

	25G Sprotte ($n = 119$)	27G Sprotte + 27G Sprotte migraine ($n = 148$)	26G Atraucan ($n = 124$)	25G Quincke midline approach ($n = 130$)	25G Quincke paramedian approach ($n = 125$)	*P* value*
Spinal anesthesia failure	1 (0.8)[a,b]	5 (3.4)[a,b]	4 (3.2)[a,b]	0 (00)[a]	5 (4.0)[b]	0.041
Supplementary anesthesia						
GA		4	2		1	
Repeat spinal			2		4	
Intravenous	1	1				
Paresthesia	10 (8.4)[a]	6 (4.1)[a,b]	1 (0.8) [b]	3 (2.3)[b]	2 (1.6)[b]	0.017
Positive dural click	113 (95.0)[a]	129 (87.2)[b]	24 (19.4)[c]	39 (30.0)[d]	40 (32.0)[d]	< 0.001
Bloody CSF	1 (0.8)[a,b]	8 (5.4)[c]	0 (0.0)[b]	3 (2.3)[a,b,c]	5 (4.0)[a,c]	0.024

Values are absolute number (%). Supplementary anesthesia type is expressed in absolute numbers.. *Fisher's exact test
GA – general anesthesia, CSF – cerebrospinal fluid

compared to Atraucan and Quincke needles, regardless of the approach used ($P = 0.017$). In terms of paresthesia no difference between Atraucan and Quincke needles was detected. No cases were identified with persistent paresthesia after spinal block resolution. A significantly higher rate of positive dural click was demonstrated with 25G Sprotte and 27G Sprotte needles (95% and 87.2% respectively) in comparison to the other needles ($P < 0.001$). The paramedian approach was not associated with a higher incidence of blood-stained CSF as compared to the midline approach (Table 3).

DISCUSSION

The results from this study of 655 obstetric patients support the hypothesis that the Sprotte design of the needle tip is superior in the reduction of PDPH incidence as compared to the Quincke design. The reported data are consistent with a recent meta-analysis of 51 articles examining PDPH in parturients [2]. Moreover, a meta-analysis of 70 studies not confined to obstetrics [1] showed that atraumatic needles are associated with a lower risk of PDPH in comparison to traumatic needles. According to our results, the Atraucan needle design does not significantly reduce PDPH incidence in comparison to the Quincke design. The presented data in this regard are consistent with the results of a randomized trial on the application of five spinal needles in obstetric patients [19].

The lack of difference between the two gauges of Sprotte needles is in line with a recent meta-analysis concluding that needle gauge in pencil-point needles does not correlate as much with PDPH as in cutting needles [3]. The fact that no case of PDPH was evidenced with the 27G Sprotte needle in the group of patients with previous PDPH or migraine confirms that this approach is an effective prophylactic measure for the occurrence of PDPH in this high risk population.

We did not observe a significant difference in terms of PDPH incidence between the midline and the paramedian approach. This result does not support our initial presumption based on studies of models of dura mater *in vitro* [5, 6].

It is important in clinical practice to achieve the lowest incidence of PDPH without compromising the success rate. Spinal anesthesia failure has been attributed to patient anatomic variations as well as to the anesthetic technique, including spinal needle design [8-10]. The Royal College of Anesthetists' standard of target for best practice recommends spinal to general anesthesia conversion of < 1% for elective and < 5% for emergency Caesarean section [21]. Our overall rate of 2.3% includes all urgency categories and is comparable to those targets. The envisaged higher rate of spinal anesthesia failure with Sprotte needles was not evidenced in this study, thus counteracting implications of Sprotte needles in spinal failures. Furthermore, the smaller needle gauge in Sprotte needles was not observed to be a factor in spinal anesthesia failure. The association of the paramedian approach with a higher rate of spinal anesthesia failure may be explained with partly misplaced anesthetic injection as a consequence of dural oblique angle penetration of the needle tip. The observation that repeat spinal anesthesia after block failure does not lead to a higher rate of PDPH is of limited reliability because of the small number of those patients.

Paresthesia was more frequently observed in our study with Sprotte needles than with either Quincke or Atraucan needles. Nevertheless, all paresthesia was transient and without a residual sequel. Both results are consistent with the observations from other studies [17, 18]. A higher rate of blood-stained CSF in the paramedian compared to the midline approach was not determined in this study, which does not correlate with our initial hypothesis. A 78.4% positive dural click with a 25G Pencan spi-

nal needle was reported by a large study [18]. These data are consistent with our result of 95% with the same needle. We consider this high rate of positive dural click to be technically advantageous since it enables prompt recognition of dural puncture, thus minimizing the risk of passing the subarachnoid space unnoticed.

CONCLUSIONS

Sprotte but not Atraucan design of the needle tip correlates with a lower incidence of PDPH in comparison to the Quincke design. Use of 25G and 27G Sprotte needles results in a similar incidence of PDPH. Use of the paramedian approach does not lead to a lower incidence of PDPH as compared to the midline approach. Sprotte design of the needle tip is not a risk factor for spinal anesthesia failure while the paramedian approach correlates with a higher rate of spinal failure. Based on the low incidence of PDPH, low incidence of spinal anesthesia failure and a high rate of positive dural click, we consider Sprotte needles as the most appropriate for spinal anesthesia in obstetrics.

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