Spinal anaesthesia in young patients: evaluation of needle gauge and design on technical problems and postdural puncture headache

Shah VR, DA, MD
Bhosale GP, DTCD, MD
Department of Anaesthesia and Critical Care, Institute of Kidney Diseases and Research Centre and
Institute of Transplantation Sciences, Ahmedabad, Gujarat, India
Correspondence to: Dr Veena R. Shah, e-mail: drveenarshah@yahoo.co.in; drveenarshah@gmail.com
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Abstract

Background: The well-known complication of spinal anaesthesia, postdural puncture headache (PDPH), is especially troublesome in young patients. The needle gauge and configuration of needle tip appear to be the important factors in reducing the incidence of PDPH; however it may increase the incidence of technical problems.

Objective: To evaluate the role of 25 and 27 gauge Quincke and Whitacre spinal needles on technical difficulties and incidence of PDPH in patients between 16 and 40 years of age.

Methods: Eight hundred patients receiving spinal anaesthesia for urological surgery were divided into four groups of 200 each according to spinal needle used. Group Q-25 and group Q-27 received spinal anaesthesia with 25 gauge and 27 gauge Quincke needles whereas in group W-25 and group W-27, 25 gauge and 27 gauge Whitacre needles were used. The parameters observed were technical problems in terms of number of attempts, failure rate, time to cerebrospinal fluid (CSF) detection and incidence and severity of PDPH.

Results: Subarachnoid space was successfully located at first attempt in 92% cases of group Q-25, 89% cases of group W-25, 63.5% cases of group Q-27 and 61% cases of group W-27. Failure rate was 4% in group Q-27 and 7% in group W-27. Time to CSF detection was comparable between group Q-25 and group W-25 and between group Q-27 and group W-27. PDPH was observed in 14% cases of group Q-25 and 7% of cases of group Q-27 respectively.

Conclusion: A 25G Whitacre needle seems to be a suitable choice in young patients because of its ease of handling without an introducer and low incidence of PDPH.

Introduction

Spinal anaesthesia has been widely practised for surgery below the umbilicus since its introduction by August Bier in 1898.[1] Even with its obvious advantages, postdural puncture headache (PDPH) remains a troublesome complication, especially in young patients, leading to patient distress and morbidity, prolonged hospital stay and increased cost.[2] Factors reported to influence the incidence of PDPH are age, sex, pregnancy, previous history of PDPH,[3] needle size,[3,4] needle tip shape,[4,5] bevel orientation to the dural fibres,[3,6] the number of lumbar puncture attempts,[3] midline versus lateral approach,[7] the type of local anaesthetic solution,[8] and clinical experience of the operator.[9] Among these, the gauge and configuration of the needle tip seem to be of great importance.

Two strategies have evolved to reduce the incidence of PDPH: first, to reduce the gauge of the needle and second, to change the design of the needle tip. Studies have indicated that decreasing the needle gauge reduces the incidence of PDPH; however, it increases the technical difficulty, leading to an increase in the failure rate.[10–14] Research aimed at altering the needle design was done as early as 1926, when Greene proposed rounding off the needle tip, which would separate rather than cut the longitudinal dural fibres.[15] This idea was rediscovered and modified in 1952 by Hart and Whitacre, who developed a pencil-point needle that led to the current availability of smaller-gauge pencil-point needles.[16] The question is how thin a needle can be used in clinical practice to achieve the lowest incidence of PDPH without compromising success rate.

The aim of this prospective randomised blinded study was to evaluate the influence of available needle gauge and design on technical problems and incidence of PDPH.

Methods

After obtaining approval from the relevant hospital's ethics committee and informed written consent, 800 young patients (16 to 40 years old) with ASA risk I/II scheduled for endoscopic urological procedures under spinal anaesthesia between January 2008 and December 2009 were enrolled in this study. Patients were randomly divided by computer-generated random numbers into four groups of 200 patients each. The needles used were Quincke 25 gauge (0.50 x 90 mm) in group Q-25, Quincke 27 gauge (0.40 x 90 mm) in group Q-27, Whitacre pencil-point 25 gauge (0.50 x 90 mm) in group W-25 and Whitacre 27 gauge (0.40 x 90 mm) in group W-27. All needles were by Becton Dickinson (Madrid, Spain) and had a transparent hub without introducer. Spinal anaesthesia was performed by anaesthesiologists of all grades with prior experience of a minimum of 50 spinal anaesthesias.

The procedure was explained to all patients during their preoperative visits. Patients with a history of headache, use of oral opioids or non-steroidal anti-inflammatory drugs, or contraindications to spinal anaesthesia were excluded from the study. After recording base line pulse, non-invasive blood pressure (NIBP), respiration rate (RR) and SaO_2, all patients received 250 to 500 ml of lactated Ringer's solution over 10 minutes before the block was performed. A lumbar puncture was performed in the midline between L2/L3 or L3/L4 intervertebral space, with the patient in the right/left lateral position, under strict aseptic precautions. The Quincke needles were introduced with their bevel facing parallel to the direction of the dural fibres. If the subarachnoid space could not be located in the midline, the needle was withdrawn up to the subcutaneous tissue and redirected in the same space. This was considered to be the first attempt. If the difficulty in locating the space continued, the introducer (20 gauge 0.9 mm x 25 mm PrecisionGlide needle, Becton-Dickinson) was used in the same space, and this was considered to be the second attempt. If the difficulty persisted, the space was changed and the introducer was used from the beginning; this was considered the third attempt.

After piercing the dura, the stylet was removed and time for cerebrospinal fluid (CSF) appearance at the end of the hub of the needle was noted. After demonstrating free flow of CSF, hyperbaric bupivacaine 12.5–17.5 mg was injected over a period of 30 seconds with the needle's bevel facing upwards. Patients were kept in the supine position for 30 minutes, after which they were placed into the lithotomy position for the surgical procedure. Failure of spinal anaesthesia was defined as inadequate anaesthesia after 30 minutes of drug injection, requiring supplementation with intravenous drugs or conversion to general anaesthesia.

Once the surgical procedure had been completed, patients were shifted to the postanaesthesia care unit. They were mobilised as soon as all signs of motor blockade had disappeared and were moved to a ward when they could walk without support and were haemodynamically stable. Urination was not taken into consideration for discharge criteria since all patients were catheterised. Postoperatively, all patients were visited successively for three days by a staff member, who was unaware of the type of needle used, to inquire about headache. PDPH was defined as an occipital or frontal headache brought on by erect position and relieved when the supine position was assumed. The severity of the headache was judged as mild when no interference with normal activity was noted, moderate when the headache compelled the patient to lie down, and severe when accompanied by vomiting or visual disturbances. Treatment of the headache was individualised, and ranged from bed rest, hydration and non-opioid analgesics to an epidural blood patch.

Statistical analysis

Assuming the difference in PDPH incidence between needles to be 3%,[17] an α of 0.05 and a β of 0.8, 200 patients per needle group would be required for each needle to detect this difference. Data are expressed as mean ± standard deviation (SD) or as percentages. Demographic data, surgical time and time to CSF detection were compared using the analysis of variance (ANOVA) test. Failure rate and incidence of PDPH were analysed using the χ^2 test. A p-value $\leq$ 0.05 was considered significant.

Results

Demographic data were comparable in all groups (see Table I). CSF detection time was significantly higher with 27 gauge needles than with 25 gauge needles (p < 0.0001). Technical problems in the form of multiple attempts and failure rate are presented in Table II. The success rate in terms of location of the subarachnoid space at first attempt was significantly higher with 25 gauge needles than with 27 gauge needles (p < 0.0001), irrespective of the tip design. A total of 22 patients out of

800 (2.75%) had inadequate anaesthesia after 30 minutes. Eight of these patients were managed with intravenous supplementation while 14 patients were given general anaesthesia. The incidence of spinal headache was 14% and 7% with 25 gauge and 27 gauge Quincke needles, respectively, whereas it was only 1% and 0.5% with 25 gauge and 27 gauge Whitacre needles respectively (p < 0.0001) (see Table III). The headache was mild to moderate in nature, occurred on the second postoperative day and was relieved by rest, hydration and analgesics. None of the patients required an epidural blood patch for relief of the headache.

Discussion

Our data show that a 25 gauge Whitacre needle would be the best choice with regard to high success rate and low PDPH rate as compared to other needles, since it was associated with low incidence of PDPH without adding technical difficulties. The 27 gauge needles were difficult to use as they required multiple attempts and the use of an introducer in the majority of patients. The 25 gauge Quincke needle was technically easy to use but produced a high incidence (14%) of PDPH.

Although smaller-gauge needles reduce the incidence of PDPH, attempts to eliminate it by using needles as small as 29 to 32 gauge have had limited success since they are associated with a high incidence of failed anaesthesia[11,18–20] or multiple attempts. If there are multiple holes in the dura, no matter how small, they will increase the incidence of headache[3,21] and defeat the purpose of using the smaller-gauge needle. In the current study, successful subarachnoid puncture at first attempt decreased progressively with smaller-gauge needles as well as with pencil-point needles, as compared to cut bevel needles of the same gauge. This might be expected as bending of the finer-gauge needles can occur due to tough interspinous ligaments if proper digital support of the needle shaft is not provided or when more force is required with pencil-point needles, as such needles are blunter.[22] The most appropriate solution in clinical practice is to insert fine-gauge needles through an introducer.[23,24] This protects the spinal needle tip from unnecessary damage sustained by the penetration of superficial tissue and maintains the needle along the axis of insertion.

Failure to achieve subarachnoid block in the current study was observed in 4% and 7% of patients on whom 27 gauge Quincke and 27 gauge Whitacre needles were used respectively. A similar study by Lynch et al in orthopaedic patients showed a 8.5% failure rate with a 27 gauge Quincke needle and a 5.5% failure rate with a 27 gauge Whitacre needle.[13] One possible explanation is that some leakage of local anaesthetic into the subdural or epidural space might have occurred in the case of the Quincke needle, if the needle bevel was not completely within the subarachnoid space[14] or due to straddling of the dura by side-port in the pencil-point needle.[25] This means that the utmost care is required with all finer-gauge needles to avoid dislodging the needle tip from the subarachnoid space, which may be made more difficult by poor fit between the syringe tip

Table I: Demographic data and time to CSF detection

	Q-25 (n=200)	W-25 (n=200)	Q-27 (n=200)	W-27 (n=200)
Age (years)	30 ± 8.2	27.80 ± 9.4	29 ± 7.7	28.31 ± 8.8
Weight (kg)	59.31 ± 14.8	57.3 ± 11.6	56.52 ± 13.3	59.56 ± 11.8
Sex (M/F)	122/78	118/82	130/70	125/75
Surgical time (minutes)	44.56 ± 11.9	48.42 ± 8.98	45.21 ± 13.6	42.34 ± 12.7
Time to CSF detection (seconds)	20.90 ± 4.57	22.85 ± 6.94	35.15 ± 17.64*	33.43 ± 15.27*

CSF = Cerebrospinal fluid. Values are mean ± SD. * : *p-value* < 0.0001

Table II: Technical problems

	Q-25 (n=200)	W-25 (n=200)	Q-27 (n=200)	W-27 (n=200)
First attempt	184 (92%)*	178 (89%)*	127 (63.5%)	122 (61%)
Second attempt	14 (7%)	16 (8%)	50 (25%)	42 (21%)
Third attempt	2 (1%)	6 (3%)	15 (7.5%)	22 (11%)
Failure rate	-	-	8 (4%)	14 (7%)

*: *p-value* < 0.0001

Table III: Incidence and severity of headache

	Q-25 (n=200)	W-25 (n=200)	Q-27 (n=200)	W-27 (n=200)
Mild	24 (12%)	2 (1 %)	11 (5.5%)	1 (0.5%)
Moderate	4 (2%)	-	3 (1.5%)	-
Severe	-	-	-	-
Total incidence	28 (14%)*	2 (1 %)	14 (7%)*	1 (0.5%)

*: *p-value* < 0.0001

Table IV: Incidence of PDPH in various studies

Needle	First author (Reference)	n	PDPH %	Bevel direction
25 G Quincke	Buettner (17)	200	8.5	Parallel
	Devcic (18)	98	7.1	Parallel
	Tarkkila (19)	99	4.5	Parallel
	Tarkkila (19)	100	17.9	Perpendicular
	Vallejo (20)	172	8.7	Parallel
25 G Whitacre	Buettner (17)	200	3	-
	Vallejo (20)	201	3.1	-
27 G Quincke	Mayer (21	147	3.5	Parallel
	Kang (22)	336	1.5	Parallel
	Lynch John (6)	199	1.1	-
	Santanen U (23)	259	2.7	-
	H. Flaatten (15)	148	8.1	Parallel
27 G Whitacre	Lynch John (6)	99	0.5	-
	Santanen U (23)	270	0.37	-
	H. Flaatten (15)	153	2	-

and the needle hub, leading to some loss of local anaesthetic.

Time to the appearance of CSF is important particularly in busy operating schedules or ambulatory surgery. In the current study, CSF detection time was significantly prolonged (p < 0.0001) with smaller-gauge needles, irrespective of the tip design, which is related to a smaller internal diameter of the needle. Another study has shown that the Whitacre needle design has a relatively faster flash-back of CSF through the needle shaft into the hub as compared to Quincke needles[26]; however, such a difference was not observed in the current study. Lynch et al observed the average time for CSF detection as 10.8 ± 6.9 seconds with a 27 gauge Quincke needle and 10.7 ± 6.8 seconds with a 27 gauge Whitacre needle, both these times were much less than what we found in the current study.[13] This may be related to the fact that they calculated the time until CSF appeared in the transparent hub of the needle, whereas in the current study researchers calculated the time until CSF formed a drop at the end of the hub of the needle, which added the time required to fill the dead space of the needle hub. This is not clinically significant, because in most of the studies first sight of CSF appearance is sufficient to proceed with an injection.

PDPH is an iatrogenic complication of spinal anaesthesia and results from the loss of CSF through puncture of the dura mater, traction on the cranial contents, and reflex cerebral vasodilatation.[27] The incidence of PDPH after spinal anaesthesia has been reported to vary from 0%[28,29] to over 30%.[30] This variation may result from differences in the patient population, intraoperative variables such as patient position, bevel orientation, midline or paramedian

approach, type and baricity of local anaesthetics, the definition of PDPH used and the method of patient follow-up employed. In the current study the researchers controlled most of these variables except needle size and tip design. Several studies have addressed the issue of PDPH with cutting and non-cutting needles. These studies are summarised in Table IV.[31-37] The results of the current study show that a Quincke needle, even when introduced with bevel parallel to the direction of the dural fibres, results in higher frequency of PDPH compared to pencil-point needles.

Extensive medical research on the aetiology of PDPH over the last few decades has centred around needle gauge, which determines the size of the hole in the dura, and the configuration of the needle tip, which determines the extent of the damage to the dura. Fluid loss tails off with time as the elasticity of the dural fibres reduces the size of the hole.[26] An in vitro study reported by Cruickshank and Hopkinson clearly demonstrated an increase in CSF leakage using larger needles (22 gauge vs 26 gauge vs 29 gauge).[38] Westbrook et al and Holst et al showed that the CSF leakage from pencil-point needles is significantly less than that from Quincke needles of the corresponding size.[22,39] Pencil-point needles are thought to produce less damage to dural fibres, allowing the hole to close up more readily. When viewed under an electron microscope, a sharply delineated, persistent perforation channel was found with the Quincke needles, which may explain the high CSF loss. With pencil-point needles, which push the tissue apart bluntly, a large opening on the inside was found, with some tearing of the dura; however, in contrast to the cutting needles, a persistent perforation channel was not manifested.[39]

The two possible shortcoming of the current study are that the spinal anaesthesia was performed by persons with different levels of experience and that the introducer was used after failure of the first attempt. Both these factors might have affected the incidence of technical problems in terms of the number of attempts and failure rate. The results presented here should be interpreted in the light of these shortcomings.

Conclusion

Pencil-point needles are associated with a lower incidence of PDPH compared to Quincke cutting needles in young patients. Among the pencil-point needles, the 25 gauge Whitacre needle appears to be the preferred choice in terms of high success rate and low incidence of PDPH.

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