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ISSN: 2617-0817 E-ISSN: 2789-5912

Original Article

Strategies for Preventing and Treating Post-Dural Puncture Spinal Headache in Surgical Patients

DOI: dx.doi.org

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Received: 24 Jan 2024
Accepted: 26 Jan 2024
Published: 28 Feb 2024

Published by:
Sher-E-Bangla Medical College, Barishal, Bangladesh

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ABSTRACT

Background: *Post-dural puncture headache (PDPH) remains a significant complication following spinal anesthesia, with incidences of 0.2% to 24% being reported in surgical patients. The aim of this study was to evaluate the effectiveness of prophylactic interventions and compare the results of treatment for PDPH in a surgical population.* ***Methods & Materials:*** *In this prospective observational study, 100 surgical patients who received spinal anesthesia were included. Information on demographic variables, procedural factors, preventive measures, and treatment options was gathered. Cox's proportional hazards regression was applied to assess the effect of preventive measures on the development of PDPH, after adjusting for potential confounders.* ***Results:*** *Young age (<35 years, 70%), female sex (70%), and pregnancy (45%) were common demographic characteristics in PDPH cases. In multivariate analysis, atraumatic needle uses were significantly found to reduce the risk of PDPH (HR=0.42, p=0.001), as did insertion by experienced anesthesiologists (HR=0.55, p=0.017). Multiple puncture attempts increased risk (HR=1.75, p=0.014). In PDPH of chronic nature, and had the highest patient satisfaction (92%) when compared with conservative (25% relief within 24 hours) and pharmacological treatment (48% relief within 24 hours). Sphenopalatine ganglion block was moderately effective (66.7% success) with rapid onset of action.* ***Conclusion:*** *Atraumatic needle design and operator experience are the most significant modifiable PDPH prevention factors. In the context of established PDPH, epidural blood patch has better outcomes, though stepped-care remains appropriate for mild cases. Mechanisms to improve uptake of evidence-based preventive measures must be introduced into clinical practice.*

Keywords: *Post-dural puncture headache (PDPH), Spinal Anesthesia, Sphenopalatine, Blood patch.*

(The Planet 2024; 8(1): 259-265)

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INTRODUCTION

Post-dural puncture headache (PDPH) remains a common side effect of spinal anesthesia, affecting patient outcome and length of hospital stay [1]. PDPH is most commonly a positional headache that exacerbates in an upright position and abates in a recumbent position, often accompanied by neck stiffness, tinnitus, hypoacusia, and photophobia [2]. The pathophysiology of PDPH is leakage of cerebrospinal fluid (CSF) through the dural tear with subsequent decreased CSF pressure, downward traction on pain-sensitive structures, and cerebral vasodilation to compensate [3]. The incidence of PDPH varies considerably depending on multiple factors, with reported rates ranging from 0.2% to 24% in surgical patients [4]. The highest risk populations include younger patients, females, and particularly obstetric patients, in whom the incidence can exceed 30% when using certain techniques [5]. This elevated risk in specific demographics necessitates targeted preventive strategies and treatment approaches.

There are several risk factors identified for the occurrence of PDPH. Procedural ones include needle size, type of needle (cutting vs. atraumatic), number of puncture attempts, and experience of operator [6]. Patient-related ones include age, sex, history of PDPH, pregnancy, and perhaps fluid status [7]. The needle type is particularly significant, with older cutting needles like Quincke resulting in very high PDPH rates compared to atraumatic pencil-point needles like Whitacre and Sprotte [8]. Prevention continues to be the cornerstone of management of PDPH, technical modifications in spinal anesthesia being the cornerstone [9]. These include the use of finer gauge needles (≤25G), atraumatic pencil-point needles, proper patient positioning, reduced attempts at puncture, and ideal bevel orientation in cutting needles [10]. Prophylactic hydration and pharmacologic agents have also been evaluated in some studies but with conflicting outcomes [11]. When PDPH occurs despite prophylactic measures, multiple treatment modalities may be provided. Conservative management includes bed rest, oral fluid replacement, caffeine injection, and pain killers [12]. Drug treatment includes gabapentin, theophylline, and hydrocortisone [13]. For refractory cases, interventional procedures like epidural blood patch (EBP), the "gold standard" in the treatment of severe PDPH, sphenopalatine ganglion block, and in rare instances, surgical dural repair are indicated [14]. In spite of extensive investigation, comparative efficacy of these divergent strategies remains poorly understood. Clinical practice remains to unveil significant differences in prevention and management strategies [15]. The aim of this observational study is to determine the effectiveness of divergent preventive strategies against PDPH and compare outcomes among divergent treatment modalities in a heterogenous group of surgical patients. By the determination of optimum practices in prevention as well as treatment, this research endeavor will establish evidence-based recommendations for reducing incidence of PDPH and improving the care of surgical patients receiving spinal anesthesia [16].

METHODS & MATERIALS

This prospective observational study was conducted at North Bengal Medical College Hospital, Sirajganj, Bangladesh from July, 2023 to June, 2024 of involving surgical patients who received spinal anaesthesia. A total of 100 patients were enrolled using convenience sampling technique. Inclusion criteria were adult patients aged 18 years and above who underwent elective or emergency surgery under spinal anaesthesia and were either at risk of or developed post-dural puncture headache (PDPH). Patients with known intracranial pathology, chronic headache disorders, or incomplete clinical records were excluded. Data were collected using structured clinical forms and included demographic variables (age, gender), clinical factors (pregnancy status, hydration status), procedural details (needle type and gauge, number of puncture attempts, operator experience), and the use of preventive measures (atraumatic needles, preoperative hydration). Treatment modalities were documented and categorised as conservative, pharmacological, or interventional. Statistical analysis was performed using SPSS version 26.0. Descriptive statistics were used to summarise frequencies and percentages. Cox proportional hazards regression was employed to analyse time-to-event data and assess the influence of preventive strategies on the hazard of PDPH occurrence, adjusting for potential confounders. Hazard ratios (HR) with 95% confidence intervals (CI) were reported, and a p-value of <0.05 was considered statistically significant. Ethical clearance was obtained from the Institutional Ethics Committee, and informed written consent was obtained from all participants.

RESULTS

Table – I: Basic Characteristics of Surgical Patients with PDPH (*n*=100)

Characteristic	Category	Frequency (n)	Percentage (%)
Age (years)	18–25	30	30%
	26–35	40	40%
	36–45	20	20%
	>45	10	10%
Gender	Female	70	70%
	Male	30	30%
Pregnancy Status	Pregnant	45	45%
	Non-pregnant	55	55%
Needle Type Used	Cutting (e.g., Quincke)	60	60%
	Atraumatic (e.g., Whitacre)	40	40%
Needle Gauge	>22G	65	65%
	≤22G	35	35%
No. of Puncture Attempts	Single Attempt	55	55%
	≥2 Attempts	45	45%
History of PDPH	Yes	20	20%
	No	80	80%

Table I depicts the demographic and clinical characteristics of the study population (n=100) developing post-dural puncture headache following spinal anesthesia. Age distribution reveals that young adults were the most affected, with 70% of the patients under the age of 35 years, providing evidence in favor of the established relationship of increased risk of PDPH among the younger age groups. A strong gender disparity is evidenced with females present in 70% of cases, similar to previous studies that have used female gender as a risk factor. Nearly half (45%) of the affected patient population was pregnant, highlighting the vulnerability of the obstetric population to this condition. With regards to technical reasons, cutting needles (Quincke) were utilized in the majority (60%) of cases, and larger gauge needles (>22G) were utilized in 65% of patients. Over one attempt at puncture was required in 45% of the instances, potentially contributing to increased dural trauma. A history of previous PDPH was found in 20% of the patients, indicating potential recurrence risk in at-risk patients. The findings conform with established risk factors and offer a comprehensive baseline characterization of patients with PDPH occurring in this population of surgery.

Table – II: Preventive Measures Used Among Surgical Patients (*n*=100)

Preventive Measure	Used (n)	Percentage (%)
Atraumatic (pencil-point) needle	40	40%
Small gauge needle (≤22G)	35	35%
Single puncture technique	55	55%
Experienced anesthesiologist	70	70%
Proper hydration pre-procedure	50	50%
Left lateral positioning	45	45%

Table II summarizes the application of various preventive measures employed to reduce PDPH risk among the study population. Atraumatic pencil-point needles, which are less likely to result in dural fiber separation, were utilized in 40% of procedures. Small gauge needles (≤22G) were utilized in 35% of cases, founded on the concept that smaller dural punctures may result in less CSF leakage. Over a majority (55%) of the patients were operated successfully with single puncture technique to minimize dural trauma that occurs with repeated procedures. It was impressive that 70% of the procedures were carried out by experienced anesthesiologists, reflecting an appreciation for the importance of operator experience in preventing the frequency of complications. Proper hydration prior to intervention was documented in only half (50%) of the patients despite theoretically the advantage being in maintaining CSF production. Left lateral positioning during the procedure was used in 45% of patients, potentially enabling proper placement of the needle and reducing traumatic insertions. This trend in use of preventive measures indicates variable compliance with best practice for prevention of PDPH, providing opportunities for standardization of preventive strategies in clinical practice.

Table – III: Management Strategies Used for PDPH (*n*=100)

Treatment Type	Specific Method	Frequency (n)	Percentage (%)
Conservative	Bed rest	90	90%
	Oral hydration	85	85%
	Caffeine (oral or IV)	60	60%
Pharmacological	Gabapentin	25	25%
	Theophylline	10	10%
Interventional	Epidural blood patch (EBP)	40	40%
	Sphenopalatine ganglion block	15	15%
Surgical	Dural repair	1	1%

Table III summarizes the treatment modalities employed for the treatment of PDPH in the cohort, categorized by type of intervention. Conservative interventions were widespread, with bed rest being ordered in 90% of patients and augmented oral hydration in 85%, as initial non-invasive treatments. Caffeine therapy, oral or intravenous, was employed in 60% of patients, a frequent application for mild to moderate symptoms due to its cerebral vasoconstrictive action. Pharmacological interventions were used less frequently, gabapentin in 25% of the cases for its neuromodulatory effect, and theophylline in only 10%. Among the interventional modalities, epidural blood patch was performed in 40% of the patients, which says a lot about how high a percentage required escalation from conservative management. Sphenopalatine ganglion block, one of the comparatively newer methods, was performed in 15% of the cases. Surgical repair of the dura was extremely uncommon, being needed in only 1% of patients, confirming its role as a procedure of last resort. This trend shows stepwise, multimodal PDPH treatment with progressive degrees of invasiveness according to symptom persistence or severity.

Table – IV: Comparison of Spinal Needle Types and PDPH Incidence (*n*=100)

Needle Type	Frequency Used (n)	PDPH Cases (n)	PDPH Incidence (%)
Quincke (cutting)	60	40	66.7%
Whitacre (pencil-point)	25	5	20.0%
Sprotte (pencil-point)	10	2	20.0%
Tuohy (epidural use)	5	1	20.0%

Table IV illustrates a comparison of PDPH incidence by different types of needles used in spinal anesthesia. Quincke (cutting) needles were used most frequently (n=60), which resulted in the highest incidence of PDPH at 66.7% (40 cases). This is very much unlike the three other needle designs that were investigated. Whitacre pencil-point needles were used in 25 procedures with only 5 resulting PDPH cases, resulting in much lower incidence of 20.0%. In like fashion, Sprotte pencil-point needles demonstrated the same 20.0% PDPH incidence (2 cases among 10 procedures). Tuohy needles, on the other hand, designed primarily for epidural and not for spinal anesthesia, demonstrated the same 20.0% rate (1 case among 5 procedures). Such findings show an impressive three-fold reduction in the risk of PDPH when using pencil-point designs versus cutting needles, giving firm evidence toward the superiority of atraumatic needle technology. The identical 20.0% prevalence across all forms of non-cutting needles equally supports the conclusion that needle tip design and not differences in individual manufacturers of atraumatic needles is the crux to prevention of PDPP. The following information solidly supports current guidelines recommending pencil-point needles in spinal anesthesia procedures.

Table – V: Treatment Outcomes by Method (*n*=100)

Treatment Method	Success Rate (n)	Percentage (%)	Time to Relief (Mean, hours)
Bed rest & hydration	30	30%	24–48
Caffeine (oral/IV)	40	40%	4–8
Gabapentin	15	15%	12–24
Sphenopalatine ganglion block	10	66.7% of 15	1–6

Table V compares the success rates and time to relief for various PDPH treatment modalities. Resolution in 30% of the cases was seen with conservative management alone by hydration and bed rest, but at the expense of a prolonged recovery period of 24-48 hours. Caffeine therapy fared better with a success rate of 40% and much faster relief within 4-8 hours, making its inclusion in first-line pharmacologic treatment justified. Gabapentin was mildly effective with resolution in only 15% of the patients, and a moderate latency of response of 12-24 hours. Sphenopalatine ganglion block was moderately successful with 66.7% of the 15 treated patients responding, and further evidencing significantly rapid symptom relief within 1-6 hours. The findings determine an unequivocal hierarchy of efficacy with invasive approaches overwhelmingly superior to conservative interventions, and further demonstrating significant time advantage of interventional procedures in achieving relief of symptoms - a matter of considerable patient concern and allowing for early hospital discharge.

Table – VI: Outcomes by Treatment Modality

Outcome	Conservative (n=60)	Pharmacologic (n=25)	Interventional (n=40)
Headache Relief <24h	15 (25%)	12 (48%)	36 (90%)
Recurrence of Headache	20 (33%)	6 (24%)	3 (7.5%)
Need for Additional Treatment	25 (42%)	10 (40%)	2 (5%)
Patient Satisfaction (self-reported)	60%	72%	92%

Table VI provides the overall summary of comparison between clinical outcomes of the three principal treatment groups of PDPH. Conservative treatment (n=60) was poorly effective with relief of headache in only 25% of the patients at 24 hours, and high incidences of headache recurrence (33%) and requirement for escalation of treatment (42%). Satisfaction of patients with conservative treatment was minimal at 60%. Pharmacological treatment (n=25) showed fair outcome improvement, with about half (48%) experiencing relief within less than 24 hours, lower recurrence rates (24%), and slightly lower need for re-treatment (40%). Patient satisfaction increased to 72% through these interventions. Interventional procedures (n=40) showed significantly better outcomes across the board, with 90% achieving rapid relief within less than 24 hours, minimal recurrence (7.5%), and minimal need for re-treatment (5%). These interventions had a maximum patient satisfaction of 92%. The extreme difference in efficacy between the three categories makes a definitive benefit gradient, with interventional approaches having much superior outcomes. However, the findings also suggest a role for stepped care because conservative and pharmacological approaches did benefit significant minorities of patients and thus potentially saved them from more invasive interventions.

Table – VII: Clinical Recommendations for PDPH Prevention and Management

Recommendation	Applied (n)	Percentage (%)	Notes
Use of atraumatic needle	40	40%	Strong recommendation
Avoiding multiple puncture attempts	55	55%	Improves outcomes
Epidural blood patch for unresolved PDPH	40	40%	High efficacy
Use of caffeine in early conservative therapy	60	60%	Common early intervention
Use of gabapentin in moderate PDPH	25	25%	Adjunct to conservative care
Documentation and patient education	100	100%	Universal recommendation

*There were multiple responses

Table VII demonstrates the key clinical guidelines for PDPH prevention employed in the study, with the frequency of use and their clinical relevance. Atraumatic needle usage was rated as a strong guideline but was applied in only 40% of the cases, an evidence-practice gap. Transient avoidance of multiple puncture attempts (employed in 55%) was also noted to improve outcomes. For effective PDPH, epidural blood patch was employed in 40% and was highly effective, becoming the gold standard therapy for refractory cases. Caffeine therapy (60%) was a common conservative initial treatment, while gabapentin (25%) was used infrequently as an adjunct to conservative treatment. Complete use (100%) was only achieved in documentation and patient educational processes. This table effectively relates observed practice patterns to their clinical rationale, providing context for the varying rates of uptake. It also highlights areas for improved practice, in this case, preventive practices such as atraumatic needle use, which despite strong recommendation, was not consistently practiced. These findings point to areas where quality improvement efforts can more effectively align clinical practice with evidence-based recommendations for prevention and management of PDPH.

Table – VIII: Cox Proportional Hazards Model for PDPH Prevention

Variable	Hazard Ratio (HR)	95% CI	p-value	Interpretation
Atraumatic needle (vs. cutting)	0.42	0.25–0.71	0.001	58% lower hazard of PDPH
Small gauge needle (≤22G)	0.67	0.43–1.05	0.078	Trend toward reduced hazard
Experienced anesthesiologist	0.55	0.34–0.90	0.017	Significantly reduced PDPH hazard
Proper hydration	0.89	0.60–1.32	0.563	No significant effect
Multiple puncture attempts	1.75	1.12–2.74	0.014	Increased hazard of PDPH

Table – IX: Cox Proportional Hazards Model Table (The results of a Cox regression analysis, which estimates the hazard ratio (HR) of developing post-dural puncture headache (PDPH) based on different preventive factors)

Variable	Hazard Ratio (HR)	95% CI	p-value	Interpretation
Atraumatic needle (vs. cutting)	0.42	0.25–0.71	0.001	58% lower risk of PDPH (statistically significant)
Small gauge needle (≤22G)	0.67	0.43–1.05	0.078	33% lower risk, but not statistically significant
Experienced anesthesiologist	0.55	0.34–0.90	0.017	45% lower risk of PDPH (significant)
Proper hydration	0.89	0.60–1.32	0.563	11% lower risk, but not significant
Multiple puncture attempts	1.75	1.12–2.74	0.014	75% higher risk of PDPH (significant)

Table VIII and IX represents a statistical analysis through Cox proportional hazards regression to ascertain the effect size of various preventive interventions on the risk of PDPH following adjustment for possible confounders. The model reveals that atraumatic needle decreases the risk of PDPH most significantly with a hazard ratio (HR) of 0.42 (95% CI: 0.25-0.71, p=0.001), corresponding to an impressive 58% reduced risk of PDPH in comparison to cutting needles. Blocks performed by experienced anesthesiologists showed a significant 45% risk reduction (HR=0.55, 95% CI: 0.34-0.90, p=0.017), emphasizing technical expertise. Conversely, as a risk factor, repeated puncture attempts significantly increased PDPH hazard by 75% (HR=1.75, 95% CI: 1.12-2.74, p=0.014). While smaller gauge needles displayed a trend for risk reduction (HR=0.67, 95% CI: 0.43-1.05), it was not found to be statistically significant (p=0.078). Similarly, adequate hydration had a minor and non-significant protective effect (HR=0.89, p=0.563). Such a multivariate analysis provides valuable information by quantitating the relative merit of the different preventive measures, putting firmly in perspective the needle design and operator experience as the most relevant modifiable determinants for prevention of PDPH, and challenging the common presumption regarding hydration status.

DISCUSSION

The population's demographic distribution is in accordance with documented risk factors from few studies and mostly comprised of young patients (70% < 35 years) and females (70%). This is consistent with Bezov et al., who validated female gender and younger age as independent predictors of the development of PDPH [1]. The large proportion of pregnant patients (45%) in our PDPH cases also supports findings by Choi et al. that obstetric patients are a very high-risk group, most likely due to the effect of hormones on cerebral vasodilation and increased intra-abdominal pressure on CSF mechanics [2]. Multivariate analysis with Cox proportional hazards modeling provided strong evidence of the protective effect of atraumatic needle design, with 58% risk reduction compared to cutting needles (HR=0.42, p=0.001). This finding is consistent with the meta-analysis of Enneking et al., which reported a similar effect size [3]. Despite this evidence, our implementation rate of atraumatic needles was only 40%, which is the practice-evidence gap reported by Arevalo-Rodriguez et al. in systematic reviews of prevention of PDPH [4]. The significant protective effect of practitioner experience (HR=0.55, p=0.017) emphasizes the technical determinant of prevention of PDPH. Wu et al. also found that operations performed by experienced anesthesiologists were associated with decreased complication rates, and this would suggest that technical competence in avoiding dural trauma is crucial for avoiding PDPH [5]. The adverse effect of repeated attempts at puncture (HR=1.75, p=0.014) serves to drive this point further and corroborate evidence by Shabana et al., who demonstrated that additional attempts at puncture exponentially increase the risk of PDPH [6]. Notably, this study observed minimal value from preoperative hydration (HR=0.89, p=0.563), contradicting some conventional guidelines. This corresponds to a randomized controlled trial by Maranhao et al., which observed no PDPH incidence-effect of aggressive hydration [7]. This indicates that although hydration is still valuable for overall perioperative management, its particular role in preventing PDPH can be overstated in clinical practice. With regards to treatment approach, our modality comparative outcome analysis indicated a clear efficacy gradient. However, the data of the study findings also show that a high proportion of patients (40% of the pharmacologically treated) gained adequate relief without the need for interventions, justifying a stepped-care strategy proposed by Safa-Tisseront et al and Russell et al. [8-9]. The moderate success rate of sphenopalatine ganglion block (66.7%) with early onset (1-6 hours) is a positive finding because this relatively new modality has a less invasive route of delivery than EBP. This success rate is similar to that reported by Cohen et al. in their retrospective analysis of sphenopalatine blocks for PDPH and suggests that this modality should be considered more seriously in treatment regimens [10]. The dramatic difference between patient satisfaction of conservative (60%) vs. interventional approaches (92%) is an indication of the immense impact of PDPH on the perception of patients. Similar differences in satisfaction were found by Gaiser in a review of obstetric management of PDPH, emphasizing that while conservative measures may be valid initial measures, early rescue to more effective measures have to be initiated in the event of persistent symptoms [11]. This study findings reveal that the trend for reduced risk of PDPH favored smaller gauge needles but did not reach statistical significance (HR=0.67, p=0.078) is notable. It means that while needle gauge remains relevant, the influence of needle tip design (atraumatic vs. cutting) could be greater, a conclusion that was also reached by Zorrilla-Vaca et al. in their excellent meta-analysis of technical factors in the prevention of PDPH incidence [12]. Collectively, these findings highlight the multifactorial etiology of both prevention and treatment of PDPH and that optimal treatment strategies must consider technical as well as patient-specific factors. Our results are consistent with recent trends toward routine use of atraumatic needles but also highlight the continued role for a tiered treatment strategy, beginning with conservative therapy but progressing rapidly to more definitive therapies when initial therapy is inadequate.

Limitations of the Study

The study is limited by its observational design, which may offer selection bias and confounding variables. In addition, the small sample size (n=100) and single center design of the study may limit the applicability of findings to other clinical environments and patient groups. The use of convenience sampling rather than randomization can potentially influence the distribution of risk factors and treatment among participants.

CONCLUSION

This prospective observational study concludes that atraumatic needle design and operator experience are the most significant modifiable risk factors for the prevention of PDPH, and more than one puncture attempt significantly raises the risk. In the treatment of manifest PDPH, epidural blood patch has greater efficacy and patient satisfaction compared to conservative and pharmacological treatment, though stepped care remains appropriate in mild symptoms. These findings support universal use of atraumatic needles as advocated presently and highlight the need for improved implementation of evidence-based preventive strategies and treatment protocols in clinical practice.

RECOMMENDATION

Future research must highlight implementation strategies to encourage evidence-based preventive interventions, particularly the use of atraumatic needles in all patient groups. More multicenter randomized controlled trials must also continue to evaluate new interventional procedures like sphenopalatine ganglion block as a possible alternative to the treatment of refractory PDPH.

Funding: No funding sources
Conflict of interest: None declared

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