

# Effect of High Altitude on the Incidence of Postdural Puncture Headache in Young Males: A 5-year retrospective study

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## Abstract

**Background:** Postdural puncture headache (PDPH) is a serious and debilitating complication and a major cause of postoperative morbidity occurring after spinal anesthesia (SA) or inadvertent dural puncture after epidural anesthesia. The understanding of pathophysiology of PDPH has improved over the last few decades and its occurrence is now on decrease with use of better techniques and smaller gauge needles. Over the past several years, many of the risk factors attributable to PDPH have been identified and studied extensively, but only few studies have evaluated the effect of increasing altitude on the occurrence of PDPH. As a significant proportion of population undergo surgery in such elevations, we retrospectively evaluated the effect of high altitude on the incidence of PDPH following SA. **Materials and Methods:** This study was conducted at a single center, retrospective observational study in the high altitude and cold climate region, for a period of 5 years. The data collected were evaluated for the occurrence of PDPH. **Results:** The total number of cases undergoing surgery under SA in our center was 440 over a period of 5 years. The cumulative incidence of PDPH in this cohort was 6.6%. The incidence was 7.15% and 5.56% with use of 26G and 27G Quincke needle, respectively, which is higher than that observed in the low-lying areas. **Conclusions:** The incidence of PDPH is higher in patients undergoing surgery under SA at high altitude.

**Keywords:** Cerebrospinal fluid leak, high altitude, postdural puncture headache, spinal anesthesia

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## INTRODUCTION

High altitude is defined differently by different authors with few considering 1500 m and above as high altitude.<sup>[1,2]</sup> However, most authors consider only altitudes above 2500 m significant enough to cause considerable physiological changes.<sup>[3]</sup> High altitude is associated with physiological changes in the body primarily to adapt the body to low oxygen levels and decreasing atmospheric pressure. These significantly affect the human body, especially the cardiopulmonary, hematological, and nervous systems and many studies have enunciated the same. Over the years, internal development and the population explosion has resulted in the inhabitation of remote locations, especially higher altitudes. This has resulted in a greater number of people being exposed to surgery and anesthesia in these extreme locations. Anesthetic management of any patient involves major physiological changes in the body, which needs to be carefully and diligently managed, which is even more challenging in extremes of altitudes. In high

altitude, central neuraxial blockade (CNB) in the form of spinal anesthesia (SA) or combined spinal epidural analgesia (CSE) is commonly performed procedure and preferred over general anesthesia (GA) as it has minimum effect on hypobaric hypoxia-associated ventilatory changes.<sup>[4]</sup> However, CNBs are not devoid of complications, of which postdural puncture headache (PDPH) is the most common.<sup>[5]</sup> Better understanding of the pathophysiology and improved techniques and needles have helped reduce the incidence over the last few decades. The incidence of PDPH described in literature varies from 0.1% to 36%, implying that a multitude of factors affects the incidence.<sup>[6,7]</sup> A recent systemic review and network meta-analysis reported an overall PDPH incidence of 11%

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when conventional (cutting) needles was used.<sup>[8]</sup> Numerous studies have studied the mechanism of PDPH, but studies relating to high altitude and its effect on CNBs are scarce. Since cerebrospinal fluid (CSF) leakage is key pathogenesis implicated in the development of PDPH, it is likely that a hypobaric environment and its associated physiological adaptations would influence its occurrence and outcomes. This retrospective observational study was carried to study the effect of high altitude on the incidence of PDPH in patients undergoing surgery under SA.

## MATERIALS AND METHODS

Retrospective data of all cases done under SA at a peripheral hospital located at 9600 ft between January 2015 and December 2019 were collected. As the study was retrospective, informed consent for the study was waived off by the committee. All the patients undergoing surgical intervention under SA were included in this study. All the patients were administered SA in L3–L4 or L4–L5 space in sitting position with 26G or 27G Quincke cutting spinal needle. SA was provided with hyperbaric bupivacaine 0.5%. Records were searched for anesthesia consults in the postoperative period. The primary outcome recorded was complaints of headaches reported by patients. The duration of headache, location, associated symptoms, severity, number of attempts, and type of surgical procedure were also analyzed.

Lybecker classification of severity for PDPH was used to classify PDPH as mild moderate and severe:

- i. Mild PDPH
  - Postural headache with slight restriction of daily activities
  - Not bedridden
  - No associated symptoms.
- ii. Moderate PDPH
  - Postural headache with significant restriction of daily activities
  - Bedridden part of the day
  - Associated symptoms may or may not be present.
- iii. Severe PDPH
  - Postural headache with complete restriction of daily activities
  - Bedridden all day
  - Associated symptoms present (photophobia, diplopia, tinnitus, nausea, vomiting)

All patients had been monitored and discharged on the 7–10<sup>th</sup> postoperative day as per the hospital policy. The incidence of these complications was calculated and compared with the incidence described in the literature. Patients who were converted to GA were excluded from this study.

## Statistical analysis

Distribution of the continuous data was tested with the Kolmogorov–Smirnov one-sample test. Continuous variables with a normal distribution were expressed as mean  $\pm$  standard

deviation. Dichotomous data were expressed as numbers and percentages. For continuous variables, *t*-test was used for comparing two groups. Chi-square/Fisher's exact test was used for the categorical variables. Statistical analysis was performed using SPSS software (IBM SPSS Statistics 21, Chicago, IL, USA). *P* < 0.01 was considered statistically significant.

## RESULTS

Over a span of 5 years, 572 patients underwent surgery under SA, out of which the data for 132 patients were incomplete and could not be analyzed. 440 patients received SA for various surgical procedures. Among them, in 279 patients, 26G Quincke spinal needle was used, and in the remaining 161, 27G Quincke spinal needle was used. The preoperative characteristics of the patients, duration of surgery, and PDPH incidence are presented in Table 1.

A total of 29 patients out of 440 (6.6%) experienced symptoms of PDPH. Of these 29 patients, 20 (7.16%) patients belonged to 26G spinal needle group and 9 patients (5.56%) to 27G spinal needle group. On carrying out the Chi-square test to compare the effect of the size of the needle on PDPH, the difference was not statistically significant (*P* > 0.01) [Table 2].

The earliest presentation of headache was within 8 h of the surgery. The mean number of days for onset of symptoms was  $1.27 \pm 0.45$  days. The average duration of headache was

**Table 1: Patient characteristics and surgical duration**

Parameter	Total	26G (n=279)	27G (n=161)	T/ $\chi^2$ *	P
Age (years), n (%)	33.45 $\pm$ 8.83	33.26 $\pm$ 8.92	33.78 $\pm$ 8.78	1.64	0.54
<20	5 (1.1)	4	1		
21–40	355 (80.7)	225	130		
41–60	73 (16.6)	45	28		
>60	7 (1.6)	5	2		
Weight (kg)	68.52 $\pm$ 7.84	68.01 $\pm$ 7.84	69.40 $\pm$ 7.78	1.64	0.07
ASA status (n)					
1	244	159	85	0.727	0.39
2	196	120	76		
Duration (min)	54.72 $\pm$ 31.01	52.25 $\pm$ 30.4	59.16 $\pm$ 31.2	0.8	0.42
Outcomes, n (%)					
PDPH	29 (6.6)	20 (7.16)	9 (5.56)	0.413	0.52

\*The values are of Student-t test / Chi square test as applicable.

The values were added as part of calculation of p-value. ASA: American Society of Anesthesiologists, PDPH: Postdural puncture headache

**Table 2: Patients developing postdural puncture headache on using 26G and 27G needle**

Needle gauge	PDPH, n (%)	No PDPH, n (%)	$\chi^2$	P
26G	20 (7.16)	259 (92.83)	0.413	0.52
27G	9 (5.56)	152 (94.40)		

PDPH: Postdural puncture headache

72 ± 0.8 h. 72.4% of patients with PDPH ( $n = 21$ ) reported headache in occipitofrontal region with 82.7% ( $n = 24$ ) reporting postural aggravation of headache. As described in Figure 1, 19 patients reported mild PDPH, 8 reported moderate PDPH, and 2 patients reported severe PDPH. In our study, we observed no cases of photophobia, vertigo, tinnitus, or paresthesia in the scalp. There were no differences between the groups with respect to age, weight, ASA grading and duration, and PDPH.

## DISCUSSION

PDPH earlier called as postlumbar puncture headache is defined as headache occurring within 5 days of lumbar puncture caused by CSF leak through the dural puncture. The headache is usually of a dull, throbbing nature with a fronto-occipital distribution, usually aggravated by sitting or standing, and is reduced by lying down.<sup>[9]</sup> It is accompanied by neck stiffness and/or subjective hearing symptoms with spontaneous recovery within 2 weeks or after sealing the leak with autologous epidural blood patch.<sup>[10]</sup>

### Needle, gender, and age

The incidence of PDPH is influenced by numerous factors, namely age, sex, size of the needle, type of needle, direction of needle, and number of attempts.<sup>[11]</sup> In the early era, the incidence of PDPH was an alarming 66%, which could be largely attributed to large bore of the needle with cutting tip.<sup>[5]</sup> With better understanding of the anatomy of dural fibers and the pathophysiology of PDPH, the needle sizes were reduced and tip modified. This led to decreased incidence of PDPH to the current estimate of about <10%.<sup>[11]</sup>

It is known that cutting needles have a higher incidence of PDPH when compared with atraumatic needles.<sup>[12-14]</sup> In two recent systemic reviews, one by Nath *et al.* reported an overall incidence of PDPH for conventional cutting needle as 11% for needles >20G and an incidence of 3.3% for >26G needles, whereas Zhang *et al.* reported a cumulative incidence of 6.4% with no subgroup analysis.<sup>[8,15]</sup> It is pertinent to note that the above meta-analysis reported an incidence with needles ranging from 20G to 29G Quincke. Our study reported a cumulative incidence of 6.6% patients while using only 26G and 27G

Quincke needle. Further analysis revealed that the incidences were 7.16% (20 patients in 279) and 5.56% (9 patients in 161) among patients who were given SA using 26 and 27 G Quincke, respectively.

The observed incidence of PDPH for 26G and 27 G cutting needle has been reported variedly by different authors with Turnbull *et al.* quoting an incidence of 0.3%–20% and 1.5%–5.6% respectively; however, their data were based on very few studies which were two to three decades old.<sup>[16]</sup> Most recent studies have reported a far lesser incidence of PDPH than that of our study.<sup>[17-27]</sup> However, few studies reported higher incidence when compared to our data; notably, a recent systemic review and network meta-analysis by Maranhao *et al.* reported an incidence of 7.85% for 26G and 4.01% in 27G cutting needle.<sup>[28-30]</sup>

All these studies were conducted at normal altitude and barometric pressures, had mixed gender patients of varying age groups. It is a known fact that the incidence of PDPH is higher in the younger age group with 2–3 times higher female preponderance.<sup>[12,31-36]</sup> In comparison, our study included only young males who underwent surgery under SA in high altitude with reported outcome.

### Severity

PDPH is usually self-limiting and can be managed conservatively with rest, hydration, and analgesics resulting in good recovery in most patients.<sup>[8]</sup> Invasive measures like an epidural blood patch with autologous blood with the intent to seal the dural defect have a high success rate, but are reserved as a rescue measure for the most severe cases.

In our study, out of 29 cases of PDPH, 65.51% of cases had only mild PDPH with no additional symptoms, 27.58% had moderate PDPH associated with significant restriction of daily activities and nausea, and 6.89% were having severe PDPH associated with complete restriction of daily activities and nausea and vomiting. All our patients were managed conservatively with no case requiring an epidural blood patch.

Owing to the remote location and poor connectivity, a longer inpatient management was preferred for most postsurgical cases with the usual discharge time ranging between 7 and 10 days after the suture removal. This institutional policy may have ensured better nursing care and compliance to conservative measures leading to favorable outcomes, thus restricting the need for more aggressive management.

### Confounding factor: High altitude

High altitude itself is known to cause headache due to primary intracranial hypotension or hypoliquorrhoeic headache. Hyperventilation caused by hypoxia leads to intracranial dehydration, cerebral and retinal venous vasodilatation, and brain engorgement.<sup>[37-39]</sup> This may be complicated by intentional dural puncture procedures like SA/CSE. Few case reports and studies have discussed effects of high altitude on anesthesia management and even fewer focused on its effects on SA and PDPH. Being a retrospective study the incidences

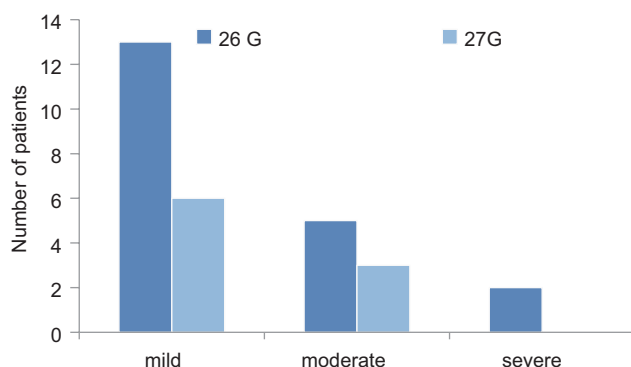


Figure 1: Severity of headache

of prior headaches before the administration of SA could not be taken into consideration.

High altitude induces physiological alterations in the human body in response to hypobaric hypoxia. These changes lead to cerebral vasodilatation and increased CSF pressure and volume. Along with low atmospheric pressure, this may be the cause of increased incidence of PDPH in high altitudes.<sup>[40]</sup> In a landmark study, Singh *et al.* invasively studied CSF pressure and observed that CSF pressures increased by about 6–20 cm H<sub>2</sub>O compared to the baseline values, although all these patients were having symptoms of acute mountain sickness (AMS). Consequently, they concluded that CSF pressure regulatory mechanism is impaired with rapid altitude changes.<sup>[41]</sup>

In 1964, Safar studied in detail the effects of high altitude on human physiology and its implication on anesthesia. He reported a very high incidence of PDPH at higher altitudes, though at that time, the use of large bore 22G spinal needles was common and could have been a confounding factor.<sup>[42]</sup> Incidental induction and aggravation of PDPH has been reported in patients who had a history of air travel following a lumbar puncture indicating the association of PDPH and high altitude.<sup>[43,44]</sup> During air travel, irrespective of flying altitudes the cabin pressures are regularized to maximum pressures which are equivalent to atmospheric pressures of 2438mts (8000ft), which qualifies as high altitude.<sup>[45]</sup> These patients reportedly had headache soon after takeoff which improved after landing. They speculated that sudden decompression due to take off would have altered the pressure gradient between dural and barometric pressures sufficient enough to exacerbate PDPH.

In a prospective, multicentric study by Arslan *et al.*, it was observed that PDPH occurs more frequently in high-altitude region when compared to low-lying areas. They reported an incidence almost 30%, which was significant higher when compared with a low altitude group.<sup>[46]</sup> Similarly, Aksoy *et al.* reported a PDPH incidence of 7.14% in moderately high altitude.<sup>[47]</sup> Surprisingly, both these studies were carried out at a modest elevation of 1890 mts (6200 ft), which is not known to cause significant physiological changes, though symptoms of AMS have been reported at altitudes <2400 m. In comparison, our study was carried out at an altitude of about 2900 mts (9500 ft) in male patients with a mean age of  $33.45 \pm 8.8$  years.

### Limitations

There are several limitations to this study, besides being a single-center retrospective study, all the confounding variables could not be considered due to its retrospective nature. SA was administered by different anesthesiologists over the period of 5 years, which was the period of study. Pain perception and evaluation is subjective, so the results may have not been reflected correctly. Since the CSF pressures were not measured by invasive methods, this hypothesis requires to be objectively proven. A multicentric prospective controlled trial in the high altitudes may yield better results and help in better understanding of PDPH in such areas.

## CONCLUSIONS

This maiden study in a peripheral hospital at high altitude suggests an increased incidence of PDPH among young male patients, possibly due to CSF leak during a state of chronic hypoxia. The use of finer gauge needles has reduced the incidence, frequency, duration, and severity of PDPH. It is suggested that they be used routinely in high altitude areas where the risk of PDPH is apparently higher. Since high altitude physiological changes are primarily associated with a state of chronic hypoxia, intervention in the form of perioperative oxygen administration could be studied to ascertain its correlation with incidence of PDPH. Further randomized controlled trials are needed to establish the effects the high altitude on incidence of PDPH.

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### Conflicts of interest

There are no conflicts of interest.

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