

# Postdural Puncture Headaches: An Overview

**Christopher L Wu, Paul Christo, Jeffrey M Richman, and Wesley Hsu**

Department of Anesthesiology and Critical Care Medicine, The Johns Hopkins University, Baltimore, MD, USA

**Postdural puncture headache (PDPH) is a relatively common complication that may be incapacitating for the patient. Pain specialists and anesthesiologists are often consulted for the management of these patients. The clinician should be aware of the other potential diagnoses masquerading as PDPH. We review the pathophysiology, risk factors for development, and the treatment options of PDPH.** *Int J Pain Med Pall Care* 2004;3(2):53–9.

Postdural puncture headache (PDPH) is a common complication after lumbar puncture. Although many physicians (e.g. radiologists, neurologists, pediatricians, and internal medicine and emergency medicine specialists) perform lumbar punctures, anesthesiologists and pain physicians are the most likely to be consulted for the treatment of PDPH. The presence of PDPH can be debilitating for a patient and can significantly interfere with functional capacity (e.g. activities of daily living) and quality of life [1].

The diagnosis and treatment of PDPH poses many challenges for the anesthesiologist and pain physician. Despite the relatively straightforward diagnosis of PDPH in many cases, other etiologies for headache may mimic or coexist with the condition. This article reviews the pathophysiology of PDPH, factors that may increase the risk of its development, and the currently available treatment options.

## Pathophysiology of PDPH

The presumed etiology of PDPH is the leakage of cerebrospinal fluid (CSF), which plays an important role in the mechanical support and chemical homeostasis of the brain [2]. CSF is produced by the choroid plexus in the ventricles of the brain, from where it is distributed to fill the subarachnoid spaces surrounding the brain and spinal cord [2]. It has been estimated that an average human has approximately 150 mL of CSF within the subarachnoid space [3]. In patients with PDPH, the loss of CSF (which may be as much as 12 mL/min) is greater than the rate of replacement

(approximately 0.35 mL/min) [4,5]. The resultant low intracranial (IC) pressure and relative deficit in CSF may result in traction on pain-sensitive cranial structures (e.g. blood vessels, meninges, and cranial nerves). The pain associated with PDPH is most prominent when the patient assumes the upright position. This position exacerbates the traction on IC structures and increases transdural lumbar CSF pressure, promoting further loss of CSF [6].

Experimental and clinical evidence supports the hypothesis that loss of CSF results in the development of PDPH. Removal of CSF (approximately 20 mL) results in immediate onset of PDPH, which may be reversed by the restoration of IC pressure with injection of intrathecal (IT) saline [7]. Magnetic resonance imaging (MRI) after dural puncture reveals an IC reduction in CSF volume in patients with PDPH [8,9]. Myelography and myelography also demonstrate leakage of CSF into the epidural space in these patients [10]. A decrease in IC pressure due to CSF leakage will affect other physiological functions that require adequate CSF pressure. For instance, a decrease in CSF pressure will reduce cochlear function because of the fall in intralabyrinthine pressure. Accordingly, disturbances in auditory function have been shown in patients with PDPH [11–13]. The severity of hearing loss is related to the severity of PDPH, and resolution of hearing loss occurs after epidural blood patch (EBP) treatment [12,14,15].

Other mechanisms may contribute to the severity of PDPH. Cerebrovasodilation with an activation of adenosine receptors may result in a vascular component of PDPH in some patients [16,17]. Compensatory cerebrovasodilation occurs secondary to CSF volume loss according to the Monro–Kellie hypothesis, where the sum of brain, CSF, and IC blood volumes is constant, meaning that a decrease in

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Address for correspondence: CL Wu, The Johns Hopkins Hospital, 600 North Wolfe Street, Carnegie 280, Baltimore, MD 21287, USA. Email: chwu@jhmi.edu

one component should cause an increase in one or both of the remaining two components [18]. Thus, a decrease in CSF volume will result in an increase in cerebral blood volume and/or cerebrovasodilation, which may contribute to the severity of PDPH [19–21]. A recent positron emission tomography study in headache patients demonstrated brain activation in the region of the major basal arteries, likely due to vasodilation of these vessels during the headache [21].

Another mechanism that may contribute to the severity of PDPH is the presence of air within the subarachnoid space or pneumocephalus. Although this etiology may not be as prevalent in punctures that do not require epidural injection (which usually employs a “loss-of-resistance” technique, where an intermittent pressurized syringe of air or saline is used to locate the epidural space), there are instances where air may be entrained during ordinary lumbar punctures [22–24]. The potential role of air in the development of PDPH was shown in a trial of 3730 patients undergoing epidural anesthesia who were randomized to either air or saline for the “loss-of-resistance” technique [25]. The incidence of PDPH was significantly higher in the air group (32 of 48, 66.7%) than the saline group (five of 51, 9.8%), despite a similar incidence of accidental dural puncture between the groups (2.6% vs. 2.7%). In addition, the onset time of PDPH was significantly more rapid in the air group. Computed tomography (CT) of the brains of PDPH patients in this group demonstrated that 30 of the 32 patients had air in the subarachnoid space.

#### Clinical and radiological findings

The pathognomonic characteristic of PDPH is the postural nature of the headache. Consistent with the presumed etiology of PDPH (leakage of CSF), the severity of PDPH increases when the patient is upright and decreases (to the point of being absent) when the patient is supine. The patient may also note musculoskeletal (neck or back stiffness), vestibular (nausea, vomiting, dizziness, vertigo), cochlear (tinnitus, decreased hearing, hearing loss), or ocular (diplopia, photophobia, blurred vision, visual field defects, transient visual obscurations, nystagmus) symptoms [11,26]. Auditory symptoms may be present in 3.5–12%, and ocular symptoms may be seen in 3.4–13% of patients with PDPH [11–13]. Traction on cranial nerves III, IV, and VI, due to decreased CSF pressure, may result in diplopia and difficulty with accommodation. Although typically a nonfatal complication of neuraxial regional anesthesia, rare complications of PDPH include subdural hematoma [27,28].

The severity of PDPH varies and is partially influenced by other factors, such as the size and type of the needle used for the lumbar puncture. The severity of PDPH may generally be categorized as [11]:

**Table 1.** Differential diagnosis for postdural puncture headache.\*

Caffeine withdrawal
Cluster
Cortical vein thrombosis
Meningitis
Migraine
Subdural hematoma
Subarachnoid hemorrhage
Tension

\*Consultation with a neurologist may be appropriate depending on the specific clinical presentation.

- Mild: little interference with daily activities, not confined to bed, no associated symptoms.
- Moderate: some interference with daily activities, confined to bed for part of the day, associated symptoms may be present.
- Severe: bedridden, unable or unwilling to stand, associated symptoms always present.

Approximately 70–90% of patients will develop symptoms within 48 h of dural puncture, with 40–65% exhibiting signs of PDPH within the first 24 h [11,26]. The median duration of PDPH in patients who experience spontaneous recovery is approximately 5 days, with approximately 70% of patients spontaneously recovering within 1 week [11,26]. However, some patients may experience PDPH for several months. Although diagnosis of PDPH is straightforward in most cases, due to the postural character of the headache after dural puncture, it is a diagnosis of exclusion, and other etiologies of headache must be considered (Table 1). It is important to remember that these may mimic PDPH, and a missed diagnosis (e.g. meningitis, subdural hematoma, cortical vein thrombosis) with a delay to proper treatment is potentially fatal for the patient. Consultation with a neurologist may be appropriate to facilitate workup of the headache.

Although not typically a part of the routine workup for PDPH, radiological findings on MRI may also be revealing. Many of the MRI abnormalities seen after depletion of CSF volume are consistent with the Monro–Kellie hypothesis, and may include meningeal enhancement, subdural fluid collections, engorgement of cerebral venous sinuses, prominence of the spinal epidural venous plexus, and enlargement of the pituitary gland [29]. Cardinal MRI features include diffuse pachymeningeal enhancement (100%), subdural collections of fluid (69%), and evidence of descent of the brain (62%) that may resemble type I

**Table 2.** Risk factors for the development of postdural puncture headache

Patient related	Needle related
Age (younger > older)	Diameter (large > small)
	Needle tip (cutting > noncutting)
	Direction of bevel insertion (perpendicular > parallel)
	Angle of insertion (midline > paramedian)

Chiari malformation [29]. Abnormal dural venous sinus (suggesting compensatory venous expansion) and pachymeningeal gadolinium enhancement (in the absence of abnormal leptomeningeal enhancement, which might indicate an inflammatory process) of the supratentorial and infratentorial IC dura (including convexities, interhemispheric fissure, tentorium, and falx) are often present [30].

#### Risk factors for PDPH development

There are several factors that may contribute to the development of PDPH (Table 2). These may generally be categorized as either patient- or needle-related.

##### Patient-related factors

The main patient characteristic that contributes to the development of PDPH is age. Randomized data suggest that, compared with younger subjects, older subjects have a significantly lower incidence of PDPH [31]. A multivariate analysis of 1021 spinal anesthetics found similar results, demonstrating a significant correlation between frequency of PDPH and younger age [32]. The reason for this is not clear. Compared with younger subjects, older subjects may have a clinically significant reduction in the intensity of pain perception or symptoms (e.g. silent myocardial ischemia is more common in the elderly) [33,34]. Elderly subjects have decreased A- $\delta$ - and C-fiber function, attenuated central sensitization, elevated pain thresholds, and decreased sensitivity to low-intensity noxious stimuli [33–37]. In addition, older subjects may theoretically have a decreased elasticity of dural fibers or diminished reactivity of cerebral vessels; however, these anatomical possibilities have not been validated [38,39]. Research suggesting that elderly patients have a significantly lower percentage of hearing loss after spinal anesthesia than younger patients provides indirect evidence that older patients experience less CSF loss [40].

Traditionally, females were thought to have a higher incidence of PDPH; however, these earlier data did not adjust for gender, which was a significant confounding

factor, as relatively more females (parturients) receive lumbar punctures than males in the same age group [26]. More recent data suggest that there is no significant difference between males and females in the incidence of PDPH. At least three trials with >2500 patients undergoing spinal anesthesia noted no association between gender and incidence of PDPH [15,32,41]. Data also suggest that neither the menstrual cycle nor hormone levels influence the incidence of PDPH [42].

##### Needle-related factors

Although patient-related characteristics are often beyond the control of the physician performing the lumbar puncture, there may be some control over the choice of needle. The main spinal needle characteristics that influence PDPH development are needle size and shape, with other factors (needle angle and direction of bevel insertion) playing a less important role. When comparing needles of the same design, those with a smaller diameter are associated with a lower incidence and severity of PDPH [43]. Larger spinal needles generally create larger dural punctures and greater rates of transdural fluid leakage [44–46]. A meta-analysis demonstrated a significantly lower incidence of PDPH when a smaller needle was used compared with a larger needle of the same design [43]. There was also a significant reduction in the severity of PDPH with smaller needles. A recent meta-analysis of 51 articles examining PDPH in parturients also noted that larger needles resulted in a higher incidence of PDPH, with an 18 G needle resulting in a 41.3% incidence of PDPH compared with only a 6.3% incidence with a 25 G needle [47].

Needle-tip design is another important determinant in the development of PDPH. Noncutting blunt-tip, pencil-point needles (e.g. Whitacre [Becton, Dickinson and Company, Franklin Lakes, NJ, USA]) are consistently associated with a lower incidence of PDPH than cutting needles (e.g. Quincke [Becton, Dickinson and Company]) [43]. Many randomized trials and meta-analyses of these trials have demonstrated a lower incidence of PDPH with the blunter, noncutting needles than with the sharper, cutting spinal type [43,47]. The most recent meta-analysis demonstrated that a 25 G noncutting spinal needle (Whitacre) had a 2.2% incidence of PDPH versus a 6.3% incidence for a 25 G cutting spinal needle (Quincke). Even a larger 24 G noncutting needle (e.g. Sprotte) had a lower incidence of PDPH (3.5%) than a 25 G Quincke cutting spinal needle [47]. The reasons for the lower incidence of PDPH with a noncutting needle are not clear; however, recent data suggest that the blunter, noncutting spinal needles result in “flaps” around the dural holes. The trauma from the blunter needle may cause a resultant inflammatory

response, which may facilitate closure of the dural hole faster than that caused by a cutting needle [48].

Two other factors — direction of needle bevel insertion and angle of spinal needle insertion — are less important in the development of PDPH. Although the exact arrangement of the dural fibers is still somewhat controversial, data suggest that the majority of dural fibers run in a longitudinal (cephalad to caudad) course [49]. If this is indeed the case, a longitudinal bevel ("parallel") insertion rather than a transverse bevel ("perpendicular") insertion of a cutting needle might decrease the incidence of PDPH, as dural fibers would less likely be cut, resulting in less CSF leakage and a lower incidence of PDPH [44,50,51]. *In vitro* data corroborate this impression, as a cutting spinal needle inserted with the bevel parallel to the dural fibers resulted in a lower rate of CSF leakage than perpendicular insertion ( $11.9 \pm 3.5$  mL/min vs.  $15.5 \pm 3.3$  mL/min) [44]. Several clinical studies have demonstrated a decreased incidence of PDPH with a "parallel" bevel insertion of cutting spinal needles [32,50,51].

There is also some suggestion that a paramedian (versus midline) insertion of a spinal needle will decrease CSF leakage and possibly lower the incidence of PDPH [44,52–54]. *In vitro* human dural models have demonstrated a lower rate of CSF leakage when the spinal needle is inserted at an angle (paramedian approach) rather than perpendicular (midline approach) to the spine, with CSF leakage rates decreasing from  $3.3 \pm 1.6$  mL/min at  $90^\circ$  (midline approach) to  $0.3 \pm 0.4$  mL/min at  $30^\circ$  (paramedian approach) [44]. Although the reasons for this are not clear, a paramedian or tangential entry is thought to create a series of overlapping dural flaps that may decrease CSF leakage, whereas a perpendicular approach would create a "tin lid" flap, which would allow for unimpeded transdural outflow of CSF [54].

#### Treatment of PDPH

The treatment of PDPH generally falls into two categories (Table 3):

- Conservative therapy (e.g. pharmacological intervention), which alleviates the symptoms until the dural puncture closes spontaneously.
- Invasive therapy (e.g. EBP), which attempts to stop the leakage of CSF.

Although there are no guidelines for the exact timing of these interventions, many clinicians will attempt at least 24–48 h of conservative therapy prior to using invasive options [55]. In addition, the clinician should take the patient's preferences and situation into consideration.

**Table 3.** Treatment options for postdural puncture headache.

Conservative	Invasive
Analgesics (e.g. nonsteroidal anti-inflammatory drugs, opioids)	Epidural blood patch (15–20 mL of autologous blood)
Hydration	Other epidural injection (e.g. saline, dextran, fibrin glue)
Bedrest	
Methylxanthines (e.g. caffeine, 500 mg of caffeine sodium benzoate or oral intake)	

Conservative therapy typically involves the administration of analgesics, fluids, and caffeine. Patients with mild PDPH may only require nonsteroidal anti-inflammatory agents for relief of PDPH; however, some patients will require opioids. Additionally, conservative therapy usually includes maintenance of adequate hydration and bedrest, as needed, for relief of symptoms. However, the clinician should realize that these measures will not decrease the incidence or duration of PDPH. Prospective studies have demonstrated that the incidence of PDPH is not related to the duration of recumbency, and increasing oral fluid intake *per se* has not been shown to decrease the incidence of PDPH, as there does not seem to be a direct correlation between CSF production and intravascular volume status [56–58]. Further, methylxanthines, such as caffeine, are effective in treating the symptoms of PDPH. The cerebral vasoconstriction they cause opposes the cerebrovasodilation of PDPH and produces temporary relief of headache, through not only vasoconstriction, but possibly also by blocking peripheral adenosine receptors and other central mechanisms [59,60]. Although the use of caffeine may have an efficacy of approximately 75%, the analgesic effects are generally only temporary [61]. Caffeine may be administered orally (as tablets or beverages) or as an intravenous infusion (500 mg of caffeine sodium benzoate). It may even be effective when given prophylactically after a dural puncture. A randomized trial in patients receiving spinal anesthesia with a 22 G Quincke needle noted that those randomized to receive 500 mg of caffeine sodium benzoate (versus no caffeine) had a significantly lower incidence of moderate-to-severe headache (10% vs. 37%;  $p=0.03$ ) [62]. Case reports or series of other pharmacological treatments have been reported, including the use of sumatriptan and cosyntropin [63,64].

The definitive invasive therapy for the treatment for PDPH is EBP. The precise mechanism by which this provides relief of headache is unclear; however, it is thought that immediate relief of PDPH (within 30–60 min) occurs as a result of mass effect from injected epidural blood, which increases lumbar IT pressure and shifts CSF cephalad to decrease tension on the



pain-producing structures in the cranium [65]. In addition, there may be a reactive cerebrovasoconstriction, which may contribute to a decrease in the severity of PDPH [20]. This immediate relief may be followed by a period of more prolonged headache relief, resulting from a sealant effect of blood over the dural puncture, which allows replenishment of lost CSF [65]. The combination of CSF and blood may facilitate initiation of coagulation and clot formation, as fibroblastic activity and collagen deposition can be seen over the dural puncture site within 48 h and 2 weeks, respectively [66,67].

The amount of autologous blood injected into the epidural space for an EBP is somewhat controversial. The initial report by Gormley reported the use of only 2–3 mL of blood, with subsequent increases in the volume injected [68,69]. Although initial studies used lower volumes of blood (<10 mL) and were associated with higher failure rates, more recent studies recommend the use of approximately 15–20 mL of autologous blood [65,69]. A larger volume injected close to the original site of dural puncture may result in a primarily cephalad spread, covering an average of 9–10 spinal segments, with the majority of clot restricted to 3–5 segments around the injection site [65,70]. The efficacy of EBP is traditionally reported to be approximately 90–95%; however, more recent data suggest that complete relief may only occur in 75% of patients [69,71].

The (larger) diameter of the needle used to perform the dural puncture is a significant and independent risk factor for the failure of EBP [69]. Complications from EBP include common transient symptoms, such as [56,69,72]:

- Discomfort (78%).
- Back pain (35–54%).
- Lower extremity pain (12%).
- Lower extremity sensory disturbances and weakness in the lower extremities (18%).
- Neck discomfort.
- Radicular pain, most likely to be secondary to nerve root compression (as demonstrated on MRI).

Most symptoms resolve within 3 days. Other rare complications associated with the procedure include intraocular hemorrhage from rapid epidural injections, cranial nerve palsy, infectious meningitis, adhesive arachnoiditis, epidural abscess, pneumocephalus, radicular back pain, and permanent paraparesis and cauda equina syndrome [22,73–76]. Injection of blood intrathecally has been reported to cause hematoma and arachnoiditis [77].

Use of autologous blood for EBP may be contraindicated or controversial in some situations, such as the presence of leukemia or human immunodeficiency virus (HIV), where

seeding of the epidural space with potentially infectious or cancerous tissue may be dangerous. In a case report on a 27-year-old female with acute myelogenous leukemia who had a PDPH, the clinicians involved in the case declined to proceed with an EBP due to the potential risk of increased infectious complications and central nervous system leukemia [78]. In a case series of six HIV-seropositive patients who underwent EBP for treatment of PDPH, none of the patients had adverse neurological or infectious complications [79].

Other invasive treatment options, including the use of epidural saline, dextran, or fibrin glue, may be available if the clinician decides against an EBP with autologous blood [80–82]. Clinicians should exercise caution when performing EBP (or other neuraxial techniques) in patients taking anticoagulants. Recommendations for the use of neuraxial techniques in these patients have been provided elsewhere [83].

## Conclusion

PDPH is not an uncommon complication following dural puncture. Although the diagnosis of PDPH is straightforward in most cases, clinicians should be aware that the diagnosis of PDPH is, in reality, a diagnosis of exclusion and that there may be other more sinister causes of headache that may masquerade as PDPH. There are many factors that may predispose a patient to the development of PDPH, some of which are in the control of the clinician performing the dural puncture. Both conservative and invasive treatment options are available for the treatment of PDPH. Although EBP is the gold standard for the treatment of PDPH, there are risks associated with this technique.

## Disclosure

The authors have no relevant financial interests to disclose.

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