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Review

Postdural puncture headache in obstetric neuraxial anaesthesia: Current evidence and therapy

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ABSTRACT

Postdural puncture headache (PDPH) may occur after inadvertent dura mater puncture during obstetric neuraxial anaesthesia. The potentially debilitating nature of the symptoms necessitates prompt and effective prevention and treatment modalities to minimize the distress to the mother as well as her subsequent care and bonding with the newborn. Improving ultrasound guidance may aid in the prevention of accidental dural puncture. However, despite the epidural blood patch being recognized as the gold standard in the treatment of PDPH, it is not without risk and can potentially fail. Nerve blocks and newer therapies have been reported that could be efficacious, easy to administer and with less risks. We present this recent evidence and potential alternative therapies in the treatment of PDPH in this review.

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1. Introduction

Postdural puncture headache (PDPH) was first described in the late 19th century with the use of spinal anaesthesia and is a significant complication of neuraxial anaesthesia. Though usually self-limiting, the symptoms can be severe and incapacitating. Despite advances in needle design and technique, it remains the most frequent complication of neuraxial blockade – especially as this method has become the preferred choice for both regional analgesia and anaesthesia in the obstetric patient. The detrimental features of the headache compound the distressing experience of the patient, increase the duration and cost of hospital stay and may lead to complaints or litigation. With this background, the measures to help prevent and treat PDPH have been evolving over the years. In recent times, improving ultrasound technology has shown promise in the prevention of accidental dural puncture (ADP). With regards to the treatment of PDPH, the epidural blood patch (EBP) has been the longstanding benchmark. However, it is not without risk and there are few alternatives that have been deemed effective. However, this may be changing as evidence has suggested that ganglion and nerve blocks are efficacious in the symptomatic relief of PDPH.

2. Pathophysiology

The volume of human cerebrospinal fluid (CSF) may be up to 150 ml at any one time, half of which is intracranial. Approximately 500 ml of CSF is produced per day and the lumbar CSF pressure is 5–15 cm of water but increases to 40 cm of water when standing erect.

The precise aetiology of PDPH after dural puncture remains unclear, but it is thought to relate to leakage of CSF from the subarachnoid space through the dural breach – the leak of CSF via the dural perforation being faster than its production. There are several proposed mechanisms for the subsequent headache. Firstly, the CSF leak leads to traction and sagging of intracranial structures and stretching of sensory and intracranial nerves in the upright position– causing pain and potential cranial nerve palsies [1]. Secondly, the loss of CSF results in compensatory venous expansion to maintain a constant volume of intracranial contents [2] – the Monro-Kellie doctrine. Levine et al. have also postulated that an altered distribution of craniospinal elasticity could be a possible mechanism [3].

3. Incidence and risk factors

3.1. Incidence

Inadvertent dural puncture with a large bore epidural needle complicates approximately 1.5% of epidural insertions among parturients [4] and up to 88% may develop a PDPH [5]. The incidence subsequent to spinal anaesthesia varies considerably depending on the type and size of needle used, but has been quoted as being at less than 3% with non-cutting smaller gauge spinal needles.

3.2. Risk factors

3.2.1. Patient factors

Parturients are at a higher risk of developing PDPH due to the widespread use of neuraxial anaesthesia. Female gender [6,7] and younger age [8,9] augment this. Following ADP, pushing in the second stage has been highlighted as an additional risk factor for PDPH compared to those that undergo caesarean section [10] - presumably the bearing down leads to increased CSF leak. Furthermore, it has been postulated that those with a higher BMI ($\geq$31.5 kg/m^2) have lower incidence of PDPH (even after controlling for pushing during labour) [11]. However, this association has not been demonstrated in other studies [12]. In addition, previous history of PDPH has also been suggested a risk factor [13]. Smokers have a lower incidence – possibly by promoting clot formation and closure of the dural defect [14]. However, the study proposing this was a retrospective chart review in a non-obstetric population undergoing continuous cerebrospinal fluid sampling.

3.2.2. Procedural factors

The main factor determining the frequency of PDPH following spinal anaesthesia is the type and size of the needle. There is overwhelming evidence to suggest that pencil-point spinal needles, e.g. the Whitacre and Sprotte®, are superior compared to cutting spinal needles (Quincke) of the same size regarding the incidence of PDPH [15–17]. Additionally, Xu et al. concluded that not only are pencil-point spinal needles significantly superior regarding the frequency of PDPH, but also in PDPH severity and the subsequent need for EBP [18]. Interestingly, Zorrilla-Vaca et al. recently observed that although a significant relationship existed between needle gauge and PDPH for cutting-needle design, a similar association was not shown for pencil-point needles [19]. Hence, the use of pencil-point needles is recommended for spinal anaesthesia, though smaller gauge needles may be technically more difficult to use.

Spinal needles should be inserted with its bevel parallel to the longitudinal axis of the spine, as this results in separation rather than cutting of dural fibres. This is thought to facilitate closure of the dural defect on needle withdrawal. Hence, a longitudinal orientation of the needle bevel may significantly reduce the risk of PDPH [20]. Prior to needle withdrawal, reinsertion of the stylet with pencil point needles may lower the risk of PDPH [21], though this remains inconclusive with cutting needles.

For labour epidurals, multiple insertion attempts significantly increase the rate of ADP and PDPH. This is likely because it is an indicator of technical difficulty or procedural related issues. Other factors that have been identified include patient movement during the procedure and a distance of epidural space of between 8 and 10 cm [22,23]. There is, however, conflicting evidence about the level of experience of the anaesthetist and the incidence of ADP and PDPH as this may be influenced by confounding variables such as operator fatigue, shift work etc. [22].

Regarding the loss of resistance medium used to detect the epidural space, Aida et al. showed that the incidence of headache in the first 24 h is higher using air [24]. The features of this headache are not typical of PDPH and are probably related to the creation of pneumocephalus. However, another study reported no difference in ADP or complications between either loss of resistance methods [25]. From this, we can infer that if air is to be used for loss of resistance, the smallest volume possible should be utilised. Interestingly, the incidence of ADP and PDPH after combined spinal-epidural (CSE) analgesia or anaesthesia are similar to epidural technique alone [26].

Ultrasound guidance in neuraxial blocks has been gaining popularity in recent times. Grau et al. demonstrated that with the help of ultrasound for structure detection, there was a significant reduction in the number of puncture attempts and necessary puncture levels. Furthermore, there was a higher success rate with complete analgesia achieved in more patients with the utilisation of ultrasound guidance [27]. From this, we can infer that ultrasound guidance can potentially help to reduce the risk of ADP and subsequent incidence of PDPH.

Finally, the position of the patient in which spinal anaesthesia is administered has been studied by Davoudi et al. [28]. They concluded that spinal anaesthesia performed in the sitting position

is associated with an increased risk of PDPH compared to the left lateral decubitus position for patients undergoing elective caesarean section.

4. Clinical features

The International Headache Society has most recently defined PDPH as "headache occurring within five days of a lumbar puncture, caused by cerebrospinal fluid (CSF) leakage through the dural puncture. It is usually accompanied by neck stiffness and/or subjective hearing symptoms. It remits spontaneously within two weeks, or after sealing of the leak with autologous epidural lumbar patch" [29]. Although PDPH is typically thought to be aggravated by an upright posture and relieved by lying down, there are a minority of patients in which the opposite may in fact be a feature [30]. The headache itself is severe and is classically fronto-occipital, spreading to the neck and shoulders and sometimes involving neck stiffness and visual disturbance. Nausea, vomiting, pain in arms and legs, hearing loss, tinnitus, vertigo, dizziness and scalp paraesthesia are common [31]. The symptoms of PDPH start within 5 days of dural puncture in 90% of cases. The duration of PDPH is usually self-limiting to approximately 5–7 days and seldom lasts longer than 2 weeks [32]. However, these time frames are not fixed in stone, and wide variations have been reported [33,34].

5. Differential diagnosis

The diagnosis of PDPH is often clear from the history of dural puncture and a convincing clinical picture. However, it should be noted that the majority of headaches occurring in the postpartum period, however, are due to tension - with preeclampsia being the second most common reason [35]. Other factors such as sleep deprivation, dehydration, caffeine withdrawal and irregular diet may compound these symptoms. It is important to consider alternative diagnoses as serious intracranial pathology may mimic PDPH. Pathology such as intracranial haemorrhage, cerebral vein thrombosis, and meningitis amongst others, have all been reported [31]. Table 1 shows a summary of all the differential diagnoses for postpartum headache and its associated features [36]. Neurological opinion and radiological investigation should be sought if there are any doubts about the diagnosis; the symptoms remain unresolved, or worsen.

6. Management

Most treatment options relieve the symptoms of PDPH by attempting to replace lost CSF, minimize cerebral vasodilatation, or seal the dural puncture site. The severity of the headache may be described as mild, moderate or severe - depending on the patient's ability to function. Patients who can perform activities of daily living and can tolerate being upright are considered to have a mild PDPH. Conversely, patients who are unable to mobilise or are unable to perform activities of daily living are considered to have moderate to severe PDPH [37].

6.1. Non-invasive

6.1.1. Conservative therapies: abdominal binder, bed rest and hydration

There is limited evidence for the use of a binder [38]. It acts by raising the intraabdominal pressure which is subsequently transmitted to the epidural space to provide relief from the symptoms of headache. Its use is not widely advocated and may be impractical with an abdominal incision. There is no evidence suggesting that bed rest, hydration and maintaining supine position prevent the onset of PDPH.

6.1.2. Pharmacological therapies

6.1.2.1. Simple analgesics. Simple analgesics may provide symptomatic pain relief but there is no evidence to suggest one of them or any combination of analgesics to be superior to another [39].

6.1.2.2. Methylxanthine derivatives. These block adenosine receptors and cause cerebral vasoconstriction. Caffeine has been utilised for a number of years, though the evidence supporting its use is poor [40,41] - either as a sole agent or as a component of combination therapy [42]. It has, however, been proposed to have advantages when compared to placebo, though caution has been advocated with these conclusions [43]. It may be considered for treatment of PDPH where simple analgesics are ineffective, EBP is contraindicated or to prevent withdrawal symptoms in patients who regularly drink caffeinated beverages. Unfortunately, most of the studies suggest that the improvement from caffeine is transient and there is no reduction in the overall rate of EBP administration. The dose recommended for PDPH is 300–500 mg oral or IV once or twice daily. However, therapeutic doses have been associated with adverse events e.g. seizures [44] and may cross into breast milk at high doses.

Limited evidence has suggested that theophylline may be modestly effective. However, it has been shown to decrease PDPH pain when compared to acetaminophen and its use has been advocated before proceeding to invasive techniques [45]. Furthermore, Wu et al. have recently proposed that intravenous aminophylline may yet have a role in the treatment of PDPH [46,47].

6.1.2.3. Triptans. The triptan group of drugs are used in the treatment of migraine headaches. Sumatriptan and the related frovatriptan have shown conflicting evidence of any benefit [48–50].

6.1.2.4. ACTH and synthetic analogues. ACTH and its synthetic analogues, cosyntropin or Synacthen are believed to work by stimulating the adrenal gland and possibly increasing CSF secretion and/or increase the pain threshold by raising β-endorphin output. There has been conflicting reports as to the benefits of use in PDPH [51,52] and questions have been raised regarding dosing and safety [53,54]. However, Hanling et al. reasoned that it may be appropriate to consider cosyntropin where EBP is unfeasible [55].

6.1.2.5. Gabapentin and pregabalin. For the reduction of pain severity in patients with PDPH, gabapentin and pregabalin are newer therapies that have been studied. They have a relatively good safety profile and well-tolerated side effects. Pregabalin appears to be the most effective when compared in studies [56] and may be useful in patients who do not respond to conventional treatments and/or refused EBP [57]. However, the evidence is still limited.

6.1.2.6. Steroids. There are several publications describing the potential preventative effect of dexamethasone on PDPH. Unfortunately, none of them are well-designed or well-conducted. Yousefshahi et al. have in fact proposed the opposite [58]. Alam et al. have postulated that very short-term use of IV hydrocortisone may be effective in reducing headache following spinal anaesthesia despite not knowing its clear mechanism of action [59].

6.1.2.7. Hyperbaric Oxygen Therapy. Hyperbaric Oxygen Therapy (HBOT) has been successfully used to treat epidural anaesthesia-induced severe pneumocephalus [60]. Kracoff et al. have suggested that HBOT may have a role in the management of PDPH by improving fibroblast proliferation at the site of the dural tear and facilitating its closure [61]. Further work needs to be done to

Table 1
Differential diagnoses and features of postpartum headache.

Differential Diagnosis	Features
Cortical venous thrombosis	- Non-specific headache - May have postural component - Focal neurological deficits - Seizures - Best confirmed on MRI and MR venography
Subarachnoid haemorrhage	- Acute onset of intense, incapacitating unilateral headache - Altered level of consciousness - Nausea and vomiting - Neck stiffness - Associated with HTN, AVM, aneurysms, PDPH (rare) - Confirm diagnosis with urgent CT scan
Meningitis	- Severe headache within first few days postpartum - Fever - Photophobia - Neck stiffness - Altered mental state - Positive Kernig's sign - Leukocytosis - Petechial rash - Confirm diagnosis with CSF examination and culture
Space occupying lesion (brain tumour, subdural haematoma)	- Dull headache secondary to mass effects/edema - Signs of raised intracranial pressure: - Altered level of consciousness - Nausea and vomiting - Seizures - Focal neurological deficits
Pre-eclampsia/eclampsia	- Presence of condition during gestation - Pre-eclampsia – hypertension, edema, proteinuria - Headache is a serious premonitory sign (present in >50% of women who go on to develop eclampsia) - Peripheral edema - Brisk reflexes - HELLP syndrome (haemolysis, elevated liver enzymes, low platelets) - Eclampsia – characterized by pulsating bilateral headache aggravated by physical activity, visual disturbance, nausea and vomiting, seizure and stupor/coma
Post-dural puncture headache	- Frontal or occipital headache - Onset first 72 h after dural puncture - Severity increases on sitting or standing, straining; improves on lying down, abdominal compression over the liver with the patient lying at 45° (Gutsche's test) - Associated symptoms - Nausea/vomiting - Visual disturbances - Diplopia/CN6 palsy - Photophobia/difficulty in accommodation - Hearing loss/hyperacusis/tinnitus - Complications - Neurological symptoms may precede seizures, SDH/ICH (intracranial hypotension causing tearing of bridging dural veins), cerebral herniation, death
Migraine	- May have history of migraines - Dull throbbing headache, recurring in nature - Commonly unilateral - Lasts 4–72 h - Associated symptoms - Preceding 'aura' - Visual disturbances (flashing lights, zig zag lines or even temporary blindness) - Nausea/vomiting - Photophobia - Numbness, tingling sensations - Slurred speech
Non-specific/Tension headache	- Dull throbbing headache - Mild to moderate 'band-like' headache lasts 30min to 7 days - Self-remitting - Not aggravated by physical activity - May have history of regular caffeine intake, sleep deprivation - Relieving factors - food/fluid intake and sleep - Usually not associated with nausea/vomiting, neurological deficits
Sinusitis	- Frontal headache, particularly over the sinuses - Worse in the morning - Sinus tenderness on palpation - Purulent nasal discharge - Anosmia - Fever
Posterior reversible leukoencephalopathy syndrome	- Severe diffuse headache - May be acute or gradual onset - May be associated with pre-eclampsia - Associated with:

(*continued on next page*)

Table 1 (*continued*)

Differential Diagnosis	Features
	- Focal neurological deficit - Seizures - Altered level of consciousness - Neuroradiological imaging shows symmetrical areas of cerebral oedema, predominantly in white matter regions of the posterior circulation
Cerebral infarction/ischemia	- Sudden onset of headache, vomiting, seizures and focal neurological deficit - Diagnosis requires cerebral angiography as CT/MRI is often normal

elucidate any potential benefits of this therapy.

6.1.2.8. Other medications. Other pharmacological interventions have been postulated with mixed results e.g. desmopressin [62], ondansetron [63] and even mannitol [64].

6.2. Invasive

6.2.1. Epidural blood patch

EBP has been the treatment of choice for moderate to severe PDPH. It offers complete resolution of symptoms in a large proportion of patients. In the remaining patients, it reduces headache severity and allows them to return to their everyday activities [65]. Up to 95% of patients will exhibit immediate short-term relief, with up to 70% headache free several days later [66]. However, up to 28% of parturients undergoing therapeutic EBP after ADP with a large bore epidural needle require more than one patch [67]. The appropriate timing of when to perform an EBP remains confusing. Various time frames have been postulated as appropriate, though the studies have been varied in their populations, needle size and delivery method i.e. vaginal or operative [68–70]. Although a prophylactic epidural blood patch (PEBP) was deemed to be effective in some studies [71], others have concluded that there is insufficient evidence or flawed methodology to support its use as a preventative procedure [72,73]. It has been suggested that the effectiveness of a PEBP may decline when CSF leak is at its greatest i.e. soon after dural puncture [74]. Despite this, it has been postulated that certain high-risk patient groups may derive potential benefit from PEBP such as those who deliver vaginally or have prolonged pushing times, as their risk of headache is increased and their number needed to treat (NNT) is lower [75]. However, reliable conclusions cannot be drawn with the current available evidence and methodology.

The epidural blood patch should be done at the same level or one level below the level of dural puncture if known. CT and MRI imaging of epidural blood patches in previous studies show that the spread of blood in the epidural space is more cephalad than caudad [76–79].

With respect to the amount of blood to inject, Paech et al. performed a prospective randomised clinical trial, assessing the success of three volumes - 15, 20 and 30 ml of autologous blood. They proposed that although the optimum volume of blood remained to be determined, an attempt to administer 20 ml should be made - pain during injection notwithstanding. They concluded that there was no advantage in attempting to administer larger volumes [66]. However, more recently, Booth et al. performed a 15 year retrospective review of their institutional EBP database. They have advocated a target volume of 30 ml unless limited by pain on injection – although this volume did not reduce the need for repeat EBP [80]. Although EBP remains the gold standard against which all other treatments for PDPH are compared, it should be remembered that it is an invasive therapy and has many potential side effects including further dural puncture, back pain, bradycardia, infection, cord compression, neurological complications [81–83] and even exacerbation of the headache we aim to treat [84]. Repeat EBP may also lead to devastating outcomes [85].

6.2.2. Leaving an intrathecal catheter in-situ

After witnessed ADP during attempted epidural, it has been advocated that the epidural catheter be threaded intrathecally and left in place for 24 h - the theory being that the catheter stimulates a fibrotic response, leading to a smaller dural defect [86]. Subsequent studies have had varying results e.g. Heesen et al. found no decrease in PDPH but a reduced risk of needing EBP [87], whereas Russell found that intrathecal catheter did not reduce the incidence of headache or the need for EBP and has proposed that any previously observed benefits may in fact be due the use of neuraxial opioids rather than the physical presence of the catheter [88]. A similar conclusion has also been drawn in the non-obstetric population [89]. Hence, although some studies suggest an intrathecal catheter may be beneficial, not all studies have supported this conclusion. Furthermore, intrathecal catheters after ADP may actually have a higher rate of failed analgesia compared with resited epidural catheters – however, they do not alter the course of labour and delivery [90].

Despite this, intrathecal catheters may be placed selectively – e.g. after a difficult epidural insertion to prevent repeated further epidural attempts and risk of additional ADP. Recently, Velickovic et al. have suggested that the intentional use of CSA (continuous spinal anaesthesia) should be considered in special circumstances where single shot subarachnoid block, CSE, or epidural block may be undesirable, such as prior spinal surgery, morbid obesity, or severe cardiac disease [91]. However, it should be noted that leaving an intrathecal catheter in situ may be hazardous – dangers range from inadvertent drug administration to meningitis [92].

6.2.3. Ganglion and nerve blocks

One of the emerging treatments for PDPH is sphenopalatine ganglion block (SPGB). The sphenopalatine ganglion is located in the pterygopalatine fossa and has both sympathetic and parasympathetic components. The SPGB has been used in the non-obstetric sphere for treating headaches of varying aetiologies. Its relative simplicity and effectiveness make it an attractive potential alternative to EBP and in some centres it is being offered as a first line treatment [93]. SPGB acts by blocking parasympathetic activity. This inhibits the cerebral vasodilatation secondary to dural puncture and causes symptomatic relief.

The patient needs to be in a supine or semi-sitting position with the neck extended. A long applicator with a cotton swab at the tip is soaked with 2%–4% lidocaine which is then inserted through each nostril until it contacts the posterior pharynx. The applicator should be retained in the nostril for at least 10 min and then removed. The swab does not come into direct contact with the ganglion; however the local anaesthetic infiltrates and spreads around it. Treatment is once a day for up to a week, either by attending the institution concerned, or by the patient performing the block themselves at home, following instruction.

Cohen et al. recently published a 17 year retrospective chart

review and concluded that greater number of patients experienced a quicker onset of headache relief, without any new complications, from treatment with SPGB versus EBP. They highlight SPGB as being a safe, inexpensive and well-tolerated treatment [94], that may avoid the need for EPB with its associated side effects and potential complications.

Greater occipital nerve block (GONB) has also been used to treat PDPH with positive results. GONB is the most widely used local anaesthetic procedure in headache conditions, is safe and relatively simple to perform. Adverse effects are few and infrequent. The procedure can result in rapid relief of pain, and effects may last for several weeks [95]. Dural stretch induced by low CSF volume is thought to trigger the trigeminal nucleus caudalis (TNC), causing increased activity in the trigeminal and greater occipital nerves. GONB acts by interrupting the transmission of pain via the occipital nerves to the TNC. Niraj et al. performed a prospective audit and reported 66% effectiveness in treating PDPH with GONB, thereby avoiding EBP [96]. Furthermore, Urits et al. recently described the successful management of PDPH using a combination of blocks - however they conclude that larger prospective studies are needed in these patient populations to evaluate the viability of nerve blocks as an alternative or adjunct to EBP [97].

6.2.4. Fibrin glue

Fibrin glue has been used successfully as an alternative treatment to autologous EBP when there has been repeated failure of EBP or when there are special concerns with the patient. It is postulated to help seal the dural defect, thus preventing further CSF leak. Wong K et al. report a case of successful treatment of PDPH using epidural fibrin glue patch after multiple trials of EBPs in a patient with PDPH after ADP during a spinal cord stimulator trial [98]. Additionally, Atallah J et al. reported successful treatment of PDPH in a patient with previously diagnosed human immunodeficiency virus and hepatitis C, where an autologous EBP would have placed them at a theoretical risk of meningeal seeding of the virus during the procedure [99]. Such reports of success with alternative treatments to EBP allow patients alternative PDPH management when conventional treatments fail.

6.2.5. Neuraxial administration

A variety of other approaches have been proposed as beneficial in the treatment of PDPH. A randomised double-blind trial studied the use of 3 mg epidural morphine versus saline, two doses 24 h apart, after ADP and subsequent catheter placement in the epidural space. The morphine group had a statistically lower incidence of headache, the need for therapeutic EBP and the onset of PDPH symptoms. Although there was no increase in respiratory depression, there was however an increased incidence of other side effects e.g. vomiting, pruritus in the morphine group [100].

A number of other mediums have also been utilised for neuraxial administration. Colloid solutions e.g. hydroxyethylstarch and Dextran [101,102] have been injected into the epidural space – the theory being that he increased viscosity of colloid solutions results in slower migration from the epidural space which results in a longer period of increased epidural pressure and a decreased gradient for CSF flow. This in turn allows more time for the defect to seal. This approach may possibly be considered when EBP with autologous blood is undesirable for medical or religious reasons, but there is not enough valid prospective evidence to support their routine use. Isotonic saline into the epidural space after dural puncture has been advocated as a safe and effective approach to prevent PDPH and related complications [103]. However, a systematic review and meta-analysis of epidural saline failed to demonstrate the prophylactic effects of epidural saline on the incidence of PDPH or the need for an EBP [104]. Additionally, isotonic saline has also been used intrathecally. The immediate injection of 10 mL normal saline after a wet tap significantly reduced the incidence of PDPH and the need for EBP. When an intrathecal catheter had been placed following a wet tap, injection of 10 mL of normal saline before its removal effectively prevented PDPH [105]. Likewise, there continues to be a lack of supplementary evidence to support this approach.

7. Conclusion

Postdural puncture headache remains a significant cause of morbidity for obstetric patients and trepidation for practitioners. Although the condition usually resolves spontaneously, management techniques are still being used despite poor evidence of efficacy (e.g. hydration, bed rest). Although therapeutic EBP is the treatment of choice for moderate and severe headache, it is not without risks and other causes should be carefully considered if neurology deteriorates, the headache characteristics alter or a repeat EBP does not improve matters. Even though a number of strategies have been proposed to prevent and treat PDPH, evidence remains ambiguous.

Most published studies are hampered by small sample size, retrospective design and a lack of control arm. Furthermore, the conflicting protocols, data, and heterogeneity of studies mean that precise recommendations are difficult to find. The advent of other treatments although promising, need further investigation to be considered integral to routine PDPH management guidelines.

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Conflict of interest

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References

[1] R. Grant, B. Condon, I. Hart, G.M. Teasdale, Changes in intracranial CSF volume after lumbar puncture and their relationship to post-LP headache, J. Neurol. Neurosurg. Psychiatry 54 (5) (1991) 440–442.
[2] R. Bakshi, L.L. Mechtler, S. Kamran, E. Gosy, V.E. Bates, P.R. Kinkel, W.R. Kinkel, MRI findings in lumbar puncture headache syndrome: abnormal dural-meningeal and dural venous sinus enhancement, Clin. Imag. 23 (2) (1999) 73–76.
[3] D.N. Levine, O. Rapalino, The pathophysiology of lumbar puncture headache, J. Neurol. Sci. 192 (1–2) (2001) 1–8.
[4] P.T. Choi, S.E. Galinski, L. Takeuchi, S. Lucas, C. Tamayo, A.R. Jadad, PDPH is a common complication of neuraxial blockade in parturients: a meta-analysis of obstetrical studies, Can. J. Anaesth. 50 (5) (2003) 460–469.
[5] J.S. Sprigge, S.J. Harper, Accidental dural puncture and post dural puncture headache in obstetric anaesthesia: presentation and management: a 23-year survey in a district general hospital, Anaesthesia 63 (1) (2008) 36–43.
[6] J.A. Amorim, M.V. Gomes de Barros, M.M. Valenca, Post-dural (post-lumbar) puncture headache: risk factors and clinical features, Cephalalgia 32 (12) (2012) 916–923.
[7] C.L. Wu, A.J. Rowlingson, S.R. Cohen, R.K. Michaels, G.E. Courpas, E.M. Joe, S.S. Liu, Gender and post-dural puncture headache, Anesthesiology 105 (3) (2006) 613–618.
[8] H. Lybecker, J.T. Moller, O. May, H.K. Nielsen, Incidence and prediction of postdural puncture headache. A prospective study of 1021 spinal anesthesias, Anesth. Analg. 70 (4) (1990) 389–394.
[9] A. Khlebtovsky, S. Weitzen, I. Steiner, A. Kuritzky, R. Djaldetti, S. Yust-Katz, Risk factors for post lumbar puncture headache, Clin. Neurol. Neurosurg. 131 (2015) 78–81.
[10] P. Angle, D. Thompson, S. Halpern, D.B. Wilson, Second stage pushing correlates with headache after unintentional dural puncture in parturients, Can. J. Anaesth. 46 (9) (1999) 861–866.
[11] F. Peralta, N. Higgins, E. Lange, C.A. Wong, R.J. McCarthy, The relationship of body mass index with the incidence of postdural puncture headache in parturients, Anesth. Analg. 121 (2) (2015) 451–456.
[12] M. Miu, M.J. Paech, E. Nathan, The relationship between body mass index and

post-dural puncture headache in obstetric patients, Int. J. Obstet. Anesth. 23 (4) (2014) 371–375.
[13] J.A. Amorim, M.M. Valenca, Postdural puncture headache is a risk factor for new postdural puncture headache, Cephalalgia 28 (1) (2008) 5–8.
[14] H.S. Dodge, N.N. Ekhator, L. Jefferson-Wilson, M. Fischer, I. Jansen, P.S. Horn, W.E. Hurford, T.D. Geracioti, Cigarette smokers have reduced risk for post-dural puncture headache, Pain Physician 16 (1) (2013) E25–E30.
[15] M.C. Vallejo, G.L. Mandell, D.P. Sabo, S. Ramanathan, Postdural puncture headache: a randomized comparison of five spinal needles in obstetric patients, Anesth. Analg. 91 (4) (2000) 916–920.
[16] A. Pal, A. Acharya, N.D. Pal, S. Dawn, J. Biswas, Do pencil-point spinal needles decrease the incidence of postdural puncture headache in reality? A comparative study between pencil-point 25G Whitacre and cutting-beveled 25G Quincke spinal needles in 320 obstetric patients, Anesth. Essays Res. 5 (2) (2011) 162–166.
[17] S. Nath, A. Koziarz, J.H. Badhiwala, W. Alhazzani, R. Jaeschke, S. Sharma, L. Banfield, A. Shoamanesh, S. Singh, F. Nassiri, W. Oczkowski, E. Belley-Cote, R. Truant, K. Reddy, M.O. Meade, F. Farrokhyar, M.M. Bala, F. Alshamsi, M. Krag, I. Etxeandia-Ikobaltzeta, R. Kunz, O. Nishida, C. Matouk, M. Selim, A. Rhodes, G. Hawryluk, S.A. Almenawer, Atraumatic versus conventional lumbar puncture needles: a systematic review and meta-analysis, Lancet 391 (10126) (2018) 1197–1204.
[18] H. Xu, Y. Liu, W. Song, S. Kan, F. Liu, D. Zhang, G. Ning, S. Feng, Comparison of cutting and pencil-point spinal needle in spinal anesthesia regarding post-dural puncture headache: a meta-analysis, Medicine (Baltim.) 96 (14) (2017) e6527.
[19] A. Zorrilla-Vaca, V. Mathur, C.L. Wu, M.C. Grant, The impact of spinal needle selection on postdural puncture headache: a meta-analysis and metaregression of randomized studies, Reg. Anesth. Pain Med. 43 (5) (2018) 502–508.
[20] J.M. Richman, E.M. Joe, S.R. Cohen, A.J. Rowlingson, R.K. Michaels, M.A. Jeffries, C.L. Wu, Bevel direction and postdural puncture headache: a meta-analysis, Neurol. 12 (4) (2006) 224–228.
[21] M. Strupp, T. Brandt, A. Muller, Incidence of post-lumbar puncture syndrome reduced by reinserting the stylet: a randomized prospective study of 600 patients, J. Neurol. 245 (9) (1998) 589–592.
[22] G. Haller, J. Cornet, M.O. Boldi, C. Myers, G. Savoldelli, C. Kern, Risk factors for post-dural puncture headache following injury of the dural membrane: a root-cause analysis and nested case-control study, Int. J. Obstet. Anesth. 36 (2018) 17–27.
[23] N. Michaan, M. Lotan, M. Galiner, S. Amzalag, A. Many, Risk factors for accidental dural puncture during epidural anesthesia for laboring women, the journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians 29 (17) (2016) 2845–2847.
[24] S. Aida, K. Taga, T. Yamakura, H. Endoh, K. Shimoji, Headache after attempted epidural block: the role of intrathecal air, Anesthesiology 88 (1) (1998) 76–81.
[25] S. Segal, K.W. Arendt, A retrospective effectiveness study of loss of resistance to air or saline for identification of the epidural space, Anesth. Analg. 110 (2) (2010) 558–563.
[26] M. Miro, E. Guasch, F. Gilsanz, Comparison of epidural analgesia with combined spinal-epidural analgesia for labor: a retrospective study of 6497 cases, Int. J. Obstet. Anesth. 17 (1) (2008) 15–19.
[27] T. Grau, R.W. Leipold, R. Conradi, E. Martin, J. Motsch, Efficacy of ultrasound imaging in obstetric epidural anesthesia, J. Clin. Anesth. 14 (3) (2002) 169–175.
[28] M. Davoudi, M. Tarbiat, M.R. Ebadian, P. Hajian, Effect of position during spinal anesthesia on postdural puncture headache after cesarean section: a prospective, single-blind randomized clinical trial, Anesthesiol. Pain Med. 6 (4) (2016) e35486.
[29] J. Olesen, International classification of headache disorders, Lancet Neurol. 17 (5) (2018) 396–397.
[30] V. Loures, G. Savoldelli, K. Kern, G. Haller, Atypical headache following dural puncture in obstetrics, Int. J. Obstet. Anesth. 23 (3) (2014) 246–252.
[31] D.K. Turnbull, D.B. Shepherd, Post-dural puncture headache: pathogenesis, prevention and treatment, Br. J. Anaesth. 91 (5) (2003) 718–729.
[32] A. Jabbari, E. Alijanpour, M. Mir, N. Bani Hashem, S.M. Rabiea, M.A. Rupani, Post spinal puncture headache, an old problem and new concepts: review of articles about predisposing factors, Caspian J Intern Med 4 (1) (2013) 595–602.
[33] S. Singh, Immediate onset of postdural puncture headache after spinal anesthesia, J. Anaesthesiol. Clin. Pharmacol. 33 (1) (2017) 134–135.
[34] B.V. Reamy, Post-epidural headache: how late can it occur? J. Am. Board Fam. Med. 22 (2) (2009) 202–205.
[35] C.L. Stella, C.D. Jodicke, H.Y. How, U.F. Harkness, B.M. Sibai, Postpartum headache: is your work-up complete? Am. J. Obstet. Gynecol. 196 (4) (2007) 318 e1–7.
[36] A. Sabharwal, G.M. Stocks, Postpartum headache: diagnosis and management, Cont. Educ. Anaesth. Crit. Care Pain 11 (5) (2011) 181–185.
[37] H. Lybecker, M. Djernes, J.F. Schmidt, Postdural puncture headache (PDPH): onset, duration, severity, and associated symptoms. An analysis of 75 consecutive patients with PDPH, Acta Anaesthesiol. Scand. 39 (5) (1995) 605–612.
[38] S.H. Mosavy, M. Shafei, Prevention of headache consequent upon dural puncture in obstetric patient, Anaesthesia 30 (6) (1975) 807–809.
[39] I. Arevalo-Rodriguez, A. Ciapponi, M. Roque i Figuls, L. Munoz, X. Bonfill Cosp, Posture and fluids for preventing post-dural puncture headache, Cochrane Database Syst. Rev. 3 (2016) CD009199.
[40] W. Lin, J. Geiderman, Myth: fluids, bed rest, and caffeine are effective in preventing and treating patients with post-lumbar puncture headache, West. J. Med. 176 (1) (2002) 69–70.
[41] R.B. Halker, B.M. Demaerschalk, K.E. Wellik, D.M. Wingerchuk, D.I. Rubin, B.A. Crum, D.W. Dodick, Caffeine for the prevention and treatment of post-dural puncture headache: debunking the myth, Neurol. 13 (5) (2007) 323–327.
[42] M. Masoudifar, O. Aghadavoudi, S. Adib, Effect of venous dexamethasone, oral caffeine and acetaminophen on relative frequency and intensity of postdural puncture headache after spinal anesthesia, Adv. Biomed. Res. 5 (2016) 66.
[43] X. Basurto Ona, D. Osorio, X. Bonfill Cosp, Drug therapy for treating post-dural puncture headache, Cochrane Database Syst. Rev. 7 (2015) CD007887.
[44] M. Paech, Unexpected postpartum seizures associated with post-dural puncture headache treated with caffeine, Int. J. Obstet. Anesth. 5 (1) (1996) 43–46.
[45] A. Mahoori, E. Hassani, H. Noroozinia, N. Javaheri, S. Hatami, Theophylline versus acetaminophen in the treatment of post-dural puncture headache (PDPH), Middle East, J Anaesthesiol 22 (3) (2013) 289–292.
[46] C. Wu, Y. Lian, D. Guan, L. Wang, Y. Miao, N. Xie, Y. Chen, Y. Zheng, A multicenter clinical study on treating post-dural puncture headache with an intravenous injection of aminophylline, Pain Physician 19 (5) (2016) E761–E765.
[47] C. Wu, D. Guan, M. Ren, Z. Ma, C. Wan, Y. Cui, P. Zhong, W. Zhao, C. Li, F. Yan, J. Xie, F. Xue, Y. Lian, H. Liu, C. Wang, X. Ji, N. Xie, Aminophylline for treatment of postdural puncture headache: a randomized clinical trial, Neurology 90 (17) (2018) e1523–e1529.
[48] H. Carp, P.J. Singh, R. Vadhera, A. Jayaram, Effects of the serotonin-receptor agonist sumatriptan on postdural puncture headache: report of six cases, Anesth. Analg. 79 (1) (1994) 180–182.
[49] N.R. Connelly, R.K. Parker, A. Rahimi, C.S. Gibson, Sumatriptan in patients with postdural puncture headache, Headache 40 (4) (2000) 316–319.
[50] G. Bussone, V. Tullo, F. d'Onofrio, V. Petretta, M. Curone, F. Frediani, C. Tonini, S. Omboni, Frovatriptan for the prevention of postdural puncture headache, Cephalalgia 27 (7) (2007) 809–813.
[51] S.M. Hakim, Cosyntropin for prophylaxis against postdural puncture headache after accidental dural puncture, Anesthesiology 113 (2) (2010) 413–420.
[52] M.W. Rucklidge, S.M. Yentis, M.J. Paech, Synacthen Depot for the treatment of postdural puncture headache, Anaesthesia 59 (2) (2004) 138–141.
[53] R.R. Gaiser, Postdural puncture headache: a headache for the patient and a headache for the anesthesiologist, Curr. Opin. Anaesthesiol. 26 (3) (2013) 296–303.
[54] C.D. Oliver, S.A. White, Unexplained fitting in three parturients suffering from postdural puncture headache, Br. J. Anaesth. 89 (5) (2002) 782–785.
[55] S.R. Hanling, J.E. Lagrew 2nd, D.H. Colmenar, A.S. Quiko, C.A. Drastol, Intravenous Cosyntropin versus Epidural Blood Patch for Treatment of Postdural Puncture Headache, Pain Med, 2016.
[56] A. Mahoori, H. Noroozinia, E. Hasani, H. Saghaleini, Comparing the effect of pregabalin, gabapentin, and acetaminophen on post-dural puncture headache, Saudi J. Anaesth. 8 (3) (2014) 374–377.
[57] B. Zencirci, Postdural puncture headache and pregabalin, J. Pain Res. 3 (2010) 11–14.
[58] F. Yousefshahi, Dexamethasone increases the frequency of post-dural puncture headache (PDPH): an evidence based reality, Anesthesiol. Pain Med. 7 (1) (2017) e42426.
[59] M.R. Alam, M.A. Rahman, R. Ershad, Role of very short-term intravenous hydrocortisone in reducing postdural puncture headache, J. Anaesthesiol. Clin. Pharmacol. 28 (2) (2012) 190–193.
[60] C.C. Shih, S.H. Tsai, W.I. Liao, J.C. Wang, C.W. Hsu, Successful treatment of epidural anesthesia-induced severe pneumocephalus by hyperbaric oxygen therapy, Am. J. Emerg. Med. 33 (8) (2015) 1116 e1–3.
[61] S.L. Kracoff, V. Kotlovker, Post dural puncture Headache°™Review and suggested new treatment, Open J. Anesthesiol. 09 (2016) 15. Vol.06No.
[62] P.E. Hansen, J.H. Hansen, Desmopressin (DDAVP) in lumbar puncture, Br. Med. J. 280 (6223) (1980) 1146.
[63] Z. Fattahi, S.M. Hadavi, M.A. Sahmeddini, Effect of ondansetron on post-dural puncture headache (PDPH) in parturients undergoing cesarean section: a double-blind randomized placebo-controlled study, J. Anesth. 29 (5) (2015) 702–707.
[64] M.M. Rizvi, R.B. Singh, R.K. Tripathi, S. Immaculate, New approach to treat an old problem: mannitol for post dural puncture headache!, Indian J. Anaesth. 59 (4) (2015) 260–261.
[65] F. van Kooten, R. Oedit, S.L. Bakker, D.W. Dippel, Epidural blood patch in post dural puncture headache: a randomised, observer-blind, controlled clinical trial, J. Neurol. Neurosurg. Psychiatry 79 (5) (2008) 553–558.
[66] M.J. Paech, D.A. Doherty, T. Christmas, C.A. Wong, G. Epidural, Blood Patch Trial, the volume of blood for epidural blood patch in obstetrics: a randomized, blinded clinical trial, Anesth. Analg. 113 (1) (2011) 126–133.
[67] S. Banks, M. Paech, L. Gurrin, An audit of epidural blood patch after accidental

dural puncture with a Tuohy needle in obstetric patients, Int. J. Obstet. Anesth. 10 (3) (2001) 172–176.
[68] E.A. Loeser, G.E. Hill, G.M. Bennett, J.H. Sederberg, Time vs. success rate for epidural blood patch, Anesthesiology 49 (2) (1978) 147–148.
[69] M. Kokki, S. Sjovall, M. Keinanen, H. Kokki, The influence of timing on the effectiveness of epidural blood patches in parturients, Int. J. Obstet. Anesth. 22 (4) (2013) 303–309.
[70] V. Safa-Tisseront, F. Thormann, P. Malassine, M. Henry, B. Riou, P. Coriat, J. Seebacher, Effectiveness of epidural blood patch in the management of post-dural puncture headache, Anesthesiology 95 (2) (2001) 334–339.
[71] M.H. Stein, S. Cohen, M.A. Mohiuddin, V. Dombrovskiy, I. Lowenwirt, Prophylactic vs therapeutic blood patch for obstetric patients with accidental dural puncture–a randomised controlled trial, Anaesthesia 69 (4) (2014) 320–326.
[72] A.N. Agerson, B.M. Scavone, Prophylactic epidural blood patch after unintentional dural puncture for the prevention of postdural puncture headache in parturients, Anesth. Analg. 115 (1) (2012) 133–136.
[73] C.L. Bradbury, S.I. Singh, S.R. Badder, L.J. Wakely, P.M. Jones, Prevention of post-dural puncture headache in parturients: a systematic review and meta-analysis, Acta Anaesthesiol. Scand. 57 (4) (2013) 417–430.
[74] S. Armstrong, R. Fernando, P. Tamilselvan, A. Stewart, M. Columb, The effect of serial in vitro haemodilution with maternal cerebrospinal fluid and crystalloid on thromboelastographic (TEG((R))) blood coagulation parameters, and the implications for epidural blood patching, Anaesthesia 70 (2) (2015) 135–141.
[75] B.M. Scavone, Timing of epidural blood patch: clearing up the confusion, Anaesthesia 70 (2) (2015) 119–121.
[76] S.C. Beards, A. Jackson, A.G. Griffiths, E.L. Horsman, Magnetic resonance imaging of extradural blood patches: appearances from 30 min to 18 h, Br. J. Anaesth. 71 (2) (1993) 182–188.
[77] H. Djurhuus, M. Rasmussen, E.H. Jensen, Epidural blood patch illustrated by CT-epidurography, Acta Anaesthesiol. Scand. 39 (5) (1995) 613–617.
[78] M. Szeinfeld, I.H. Ihmeidan, M.M. Moser, R. Machado, K.J. Klose, A.N. Serafini, Epidural blood patch: evaluation of the volume and spread of blood injected into the epidural space, Anesthesiology 64 (6) (1986) 820–822.
[79] S.B. Vakharia, P.S. Thomas, A.E. Rosenbaum, J.J. Wasenko, D.G. Fellows, Magnetic resonance imaging of cerebrospinal fluid leak and tamponade effect of blood patch in postdural puncture headache, Anesth. Analg. 84 (3) (1997) 585–590.
[80] J.L. Booth, P.H. Pan, J.A. Thomas, L.C. Harris, R. D'Angelo, A retrospective review of an epidural blood patch database: the incidence of epidural blood patch associated with obstetric neuraxial anesthetic techniques and the effect of blood volume on efficacy, Int. J. Obstet. Anesth. 29 (2017) 10–17.
[81] J. Oh, W. Camann, Severe, acute meningeal irritative reaction after epidural blood patch, Anesth. Analg. 87 (5) (1998) 1139–1140.
[82] S. Snidvongs, S. Shah, Horner's syndrome following an epidural blood patch, JRSM Short Rep 3 (10) (2012) 68.
[83] H. Yeon, Y.O. Shin, O.Y. Lee, E. Kwon, E.H. Jeong, Temporary homonymous hemianopsia after epidural blood patch, Obstet Gynecol Sci 56 (2) (2013) 130–133.
[84] W.M. Woodward, D.M. Levy, A.M. Dixon, Exacerbation of post-dural puncture headache after epidural blood patch, Can. J. Anaesth. 41 (7) (1994) 628–631.
[85] C. Carlsward, B. Darvish, J. Tunelli, L. Irestedt, Chronic adhesive arachnoiditis after repeat epidural blood patch, Int. J. Obstet. Anesth. 24 (3) (2015) 280–283.
[86] S. Ayad, Y. Demian, S.N. Narouze, J.E. Tetzlaff, Subarachnoid catheter placement after wet tap for analgesia in labor: influence on the risk of headache in obstetric patients, Reg. Anesth. Pain Med. 28 (6) (2003) 512–515.
[87] M. Heesen, S. Klohr, R. Rossaint, M. Walters, S. Straube, M. van de Velde, Insertion of an intrathecal catheter following accidental dural puncture: a meta-analysis, Int. J. Obstet. Anesth. 22 (1) (2013) 26–30.
[88] I.F. Russell, A prospective controlled study of continuous spinal analgesia versus repeat epidural analgesia after accidental dural puncture in labour, Int. J. Obstet. Anesth. 21 (1) (2012) 7–16.
[89] K. Chaudhary, K.N. Saxena, B. Taneja, P. Gaba, R. Anand, Intrathecal catheterisation for accidental dural puncture: a successful strategy for reducing post-dural puncture headache, Indian J. Anaesth. 58 (4) (2014) 473–475.
[90] D.K. Jagannathan, A.F. Arriaga, K.G. Elterman, B.S. Kodali, J.N. Robinson, L.C. Tsen, A. Palanisamy, Effect of neuraxial technique after inadvertent dural puncture on obstetric outcomes and anesthetic complications, Int. J. Obstet. Anesth. 25 (2016) 23–29.
[91] I. Velickovic, B. Pujic, C.W. Baysinger, C.L. Baysinger, Continuous spinal anesthesia for obstetric anesthesia and analgesia, Front. Med. 4 (2017) 133.
[92] S. Cohen, C.W. Hunter, A. Sakr, R.H. Hijazi, Meningitis following intrathecal catheter placement after accidental dural puncture, Int. J. Obstet. Anesth. 15 (2) (2006) 172.
[93] S. Kent, G. Mehaffey, Transnasal sphenopalatine ganglion block for the treatment of postdural puncture headache in obstetric patients, J. Clin. Anesth. 34 (2016) 194–196.
[94] S. Cohen, D. Levin, S. Mellender, R. Zhao, P. Patel, W. Grubb, G. Kiss, Topical Sphenopalatine Ganglion Block Compared with Epidural Blood Patch for Postdural Puncture Headache Management in Postpartum Patients: a Retrospective Review, Reg Anesth Pain Med, 2018.
[95] M. Levin, Nerve blocks in the treatment of headache, Neurotherapeutics 7 (2) (2010) 197–203.
[96] G. Niraj, A. Kelkar, V. Girotra, Greater occipital nerve block for postdural puncture headache (PDPH): a prospective audit of a modified guideline for the management of PDPH and review of the literature, J. Clin. Anesth. 26 (7) (2014) 539–544.
[97] I. Urits, O. Viswanath, V. Orhurhu, J. Petro, V. Cai, Sphenopalatine ganglion block in combination with greater and lesser occipital nerve blocks for the management of post dural puncture headache, J. Clin. Anesth. 52 (2018) 69–70.
[98] K. Wong, B.R. Monroe, Successful treatment of postdural puncture headache using epidural fibrin glue patch after persistent failure of epidural blood patches, Pain Pract. 17 (7) (2017) 956–960.
[99] J. Atallah, E. Gage, J. Koning, J. Duggan, V. Ramsey-Williams, S. Scott, D. Gaudin, M. Sarhan, Treatment of post-dural puncture headache using epidural injection of fibrin sealant as an alternative to autologous epidural blood patch (case report), Scand J Pain 5 (3) (2014) 170–172.
[100] R.R. Al-metwalli, Epidural morphine injections for prevention of post dural puncture headache, Anaesthesia 63 (8) (2008) 847–850.
[101] S. Sun, S.Q. Huang, Epidural injection of hydroxyethyl starch in the management of post-dural puncture headache: a case series, Int. J. Clin. Exp. Med. 8 (5) (2015) 8254–8258.
[102] M.E. Reynvoet, P.A. Cosaert, M.F. Desmet, S.M. Plasschaert, Epidural dextran 40 patch for postdural puncture headache, Anaesthesia 52 (9) (1997) 886–888.
[103] I. Kiki, M. Gundogdu, H.A. Alici, R. Yildirim, M. Bilici, A simple, safe and effective approach to prevent postdural puncture headache: epidural saline injection, Eurasian J Med 41 (3) (2009) 175–179.
[104] C.C. Apfel, A. Saxena, O.S. Cakmakkaya, R. Gaiser, E. George, O. Radke, Prevention of postdural puncture headache after accidental dural puncture: a quantitative systematic review, Br. J. Anaesth. 105 (3) (2010) 255–263.
[105] M.M. Charsley, S.E. Abram, The injection of intrathecal normal saline reduces the severity of postdural puncture headache, Reg. Anesth. Pain Med. 26 (4) (2001) 301–305.