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► **To cite this version:**

Emmanuel Cognat, Berengère Koehl, Matthieu Lillamand, Stéphane Goutagny, Anissa Belbachir, et al.. Preventing Post-Lumbar Puncture Headache. *Annals of Emergency Medicine*, 2021, 78 (3), pp.443-450. 10.1016/j.annemergmed.2021.02.019 . hal-03905447

HAL Id: hal-03905447

<https://cnrs.hal.science/hal-03905447>

Submitted on 22 Aug 2023

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Preventing Post-Lumbar Puncture Headache

Emmanuel COGNAT M.D., Ph.D.^{1,2}, Berengère KOEHL M.D., Ph.D.³, Matthieu LILAMAND M.D., Ph.D.^{1,2,4}, Stéphane GOUTAGNY M.D., Ph.D.⁵, Anissa BELBACHIR M.D.⁶, Louise DE CHARENTENAY, M.D.⁶, Tamazoust GUIDDIR, M.D.⁷, Paul ZETLAOUI M.D.⁸, Caroline ROOS M.D.⁹, Claire PAQUET M.D., Ph.D.^{1,2}

¹ Université de Paris, UMRS 1144, INSERM, F-75010, Paris, France

² Centre de Neurologie Cognitive, APHP Nord, Site Lariboisière Fernand-Widal, APHP Nord, F-75010 Paris, France

³ Sickle Cell Disease Center, Hematology Unit, APHP Nord, Site Robert Debré, F-75019 Paris, France

⁴ Département de Gériatrie, APHP Nord, Sites Bichat et Bretonneau, F-75018 Paris, France

⁵ Service de Neurochirurgie, APHP Nord, Site Beaujon, F-92110 Clichy, France

⁶ Service d'anesthésie réanimation, UF Douleur, APHP Centre, Site Cochin, F-75014 Paris, France

⁷ Service de Pédiatrie, AP-HP Sud, Site Bicêtre, F-94270 Le Kremlin-Bicêtre, France

⁸ Service d'Anesthésie-Réanimation, AP-HP Sud, Site Bicêtre, F-94270 Le Kremlin-Bicêtre, France

⁹ Centre d'Urgence des Céphalées, APHP Nord, Site Lariboisière Fernand-Widal, F-75010 Paris, France

Title character count: 65

Abstract word count: 227

Total word count: 3554

Number of reference: 55

Number of tables: 1

Corresponding author:

Dr Emmanuel Cognat

Centre de Neurologie Cognitive

Hôpital Fernand-Widal, GHU APHP Nord

200 rue du Faubourg Saint-Denis

75010 PARIS

Mail: Emmanuel.cognat@aphp.fr

Phone: +33140054313

Running title: FAQ review on PLPH Prevention

Keywords: diagnostic lumbar puncture, atraumatic non-cutting needle, prevention, harmonization, bed rest

Conflicts of interest: none to declare

Data availability statement: Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ABSTRACT

Post-lumbar puncture headache (PLPH) is the main adverse event from lumbar puncture (LP) and occurs in 3.5-to-33% of patients, causing functional and socio-professional disability. We searched the PLPH literature and, based on this review and personal expertise, identified and addressed 19 frequently asked questions regarding PLPH risk factors and prevention. Among non-modifiable factors, aging is associated with lower incidence of PLPH, while female sex, lower body mass index and history of headache might be associated with an increased risk. The use of atraumatic, non-cutting needles is the most effective intervention for PLPH prevention. These needles are not more difficult to use. Other commonly recommended measures appear unhelpful (fluid supplementation, caffeine) or may worsen PLPH (bedrest).

INTRODUCTION

Lumbar puncture (LP) collects cerebrospinal fluid (CSF) from the subarachnoid space through a puncture between two lumbar vertebrae. Although adverse events and failures occur, most can be avoided with proper practice ¹.

Post-lumbar puncture headaches (PLPH)—headaches that appear in the standing position with complete relief upon recumbence—are caused by intracranial hypotension due to persistent leakage of CSF through a tear in the meninges. It is the most common complication of LP, observed in 3.5-to-33% of patients. Rarely, it may cause severe complications, but has been demonstrated to be responsible for significant functional and socio-professional disability.

Despite international guidelines¹⁻³, LP practice varies from setting to setting based upon local traditions and experience. The objective of this review is to propose evidence-based answers to frequently asked questions regarding PLPH in order to improve knowledge on LP, decrease the occurrence of adverse events and homogenize practices.

METHODS

We searched the literature to identify all articles published between January of 2000 and January of 2020 on Medline and Cochrane database using the Medical Subject Heading (MeSH) terms *lumbar puncture, post-lumbar puncture headache, post-dural puncture headache, atraumatic needle, complications, prevention, collection, posture and fluids*. We only included studies published in English and focused on diagnostic LP. Studies and reviews on rachianesthesia (spinal anesthesia) and therapeutic LP were discarded, except when no data was available on the topic in terms of diagnostic LP. Large studies and meta-analysis were considered if they included more than 50% diagnostic LP. Papers were screened based on titles and abstracts, and final selection was made after reading the full text of preselected articles. We also examined papers cited in the selected articles and included additional references based on their originality and/or relevance regarding the scope of this review. Data extraction was performed by three authors according to their field of expertise (EC, BK, LD) using a standardized extraction form.

Based on review data and personal expertise, we identified 19 frequently asked questions regarding PLPH risk factors and prevention. For each question, level of evidence was rated based on the Oxford Center for Evidence-Based Medicine level of evidence 2011 table⁴.

RESULTS

Questions, answers and evidence ratings are summarized in table 1.

ARE SOME PATIENTS AT INCREASED RISK OF PLPH?

Are women more prone to PLPH?

DEBATABLE

One study by Engedal et al identified female sex as a risk factor for PLPH.⁵ In this study, which involved 501 patients, the relative risk (RR) of PLPH in women compared to men was 2.58 [1.39-4.82] (p=0.003). Numerous other studies, however, including multicentric, high-quality and prospective studies, failed to replicate those observations.^{6,7} This discrepancy may be due to confounding factors that might not have been corrected for in the study by Engedal et al⁵, such as weight, age or comorbidities (see below).

Do thinner patients have a higher risk of PLPH?

DEBATABLE

The same prospective, sequential design study by Engedal et al. found a significant increase in the risk of PLPH in patients with a body mass index (BMI) of less than 20 kg/m².⁵ These results were corroborated by two retrospective studies that found that patients that developed PLPH had significantly lower BMI (23.4 versus 24.5, p=0.022)⁸ and that BMI < 25 kg/m² was significantly associated with an increased risk of PLPH (OR 3.26 [1.53-6.96], p=0.001).⁹ This could be linked to the well-known positive relationship between BMI and CSF opening pressure^{10,11} that may exert a protective effect against CSF hypotension in patients with higher BMI. This converging data between BMI/body weight and PLPH occurrence, however, has not been confirmed by more recent studies,^{12,13} and further investigation is needed.

Does PLPH occur in newborns and children?

YES

Although its clinical diagnosis may be difficult in infants, the prevalence of PLPH in children seems in line with the prevalence observed in adults (between 12% and 15%),¹⁴⁻¹⁶ with similar clinical presentation: frontal and/or occipital bilateral headache beginning within 24 hours after LP, which decreases when lying down and worsens while standing, possibly accompanied by nausea, neck pain, visual, vestibular or cochlear symptoms.¹⁴

It should be note, the literature regarding the use of atraumatic needles is much less abundant in children than in adults. Thus, most studies included in this review have used classic cutting needles. Taking this into account, it has been suggested that, with children, the orientation of the bevel parallel to the spine axis, the reinsertion of the stylet before needle removal and the withdrawal of a low volume of CSF are associated with a lower risk of PLPH.¹⁴ Needle gauge and bed rest do not seem to impact the incidence of PLPH in children.^{17,18}

Does aging protect against PLPH?

YES

Older age is believed to play a protective role against PLPH. In an extensive study of over 10,000 LPs, the incidence of PLPH was below 5% in individuals over 60 years old, versus up to 15% in younger individuals.¹⁹ Recently, Salzer and colleagues reported a lower risk of PLPH in older patients that displayed the clearest needle effect²⁰. Various mechanisms have been proposed to explain this reduction of PLPH during the later years of life. Moreover, the prevalence of PLPH is even lower in patients with cognitive impairment and/or cerebral atrophy, probably due to the enlargement of CSF spaces. Indeed, Blennow and colleagues reported a strikingly low prevalence of PLPH of 2-to-2.6%, in two studies conducted on patients with cognitive disturbance.^{21,22} Furthermore, symptoms were mild in all cases but one, and usually resolved within two days. It is worth noting that the authors acknowledged that some of the participants with severe cognitive impairment might have been unable to report headaches after LP, which could have been responsible for the underestimation of the actual prevalence of PLPH in this study.

Do patients with chronic headache develop PLPH more frequently?

DEBATABLE

Reports regarding the association between PLPH and a history of chronic headaches are conflicting. Indeed, a reduced incidence of PLPH has been reported in migraine-sufferers compared to controls (28% and 44.9%, respectively) in a prospective study using classic traumatic needles.⁷ In contrast, Kim et al., in a pilot study published in 2012, observed that 27.3% of patients that developed PLPH reported a history of chronic headaches, compared to only 2.1% of patients without PLPH.²³ These data were confirmed by a prospective, multicentric study that enrolled 3,686 participants in 23 memory centers⁷. In this study, Duits et al. found an OR of 1.76 [1.16-2.59] in patients reporting a history of mild headaches and an OR of 2.65 [1.88-3.74] in patients with a history of moderate-to-severe headaches. A different study—which had a similar design but a smaller population (689 participants), and did not stratify the analysis based on headache severity—failed to identify a significant increase in the risk of PLPH in patients with a history of headaches (OR 1.47 [0.81-2.67]).⁶ Interestingly, the study by Kim et al. also suggested that a history of PLPH was associated with an increased risk of PLPH occurrence.²³

Do underlying diseases and medications increase the risk of PLPH occurrence?

No

Diagnostic lumbar punctures are performed in patients presenting various neurological and non-neurological disorders. PLPH occurrence has been assessed in some of them. Among patients with cognitive complaints included in the Alzheimer's Disease Neuroimaging Initiative (ADNI), Vidoni et al. reported no significant difference in PLPH incidence between patients without dementia and patients with mild cognitive impairment (MCI), or in the subgroup of patients whose CSF biomarkers were indicative of Alzheimer's disease.²⁴ Duits et al. reported a similar absence of difference in the risk of PLPH between non-demented and MCI patients. However, they identified dementia as a protective factor toward PLPH development (OR 0.66 [0.55-0.8]) after correction for age.⁷ Another prospective study focused on cerebral inflammatory diseases and found no difference in the occurrence rate of PLPH among patients with clinically isolated syndrome or multiple sclerosis as compared to patients with other diagnoses.¹² Similarly, a study performed on HIV patients and controls identified no association between HIV serological status and PLPH incidence.⁹ Similarly, the rates of PLPH reported in a non-comparative study performed in amyotrophic lateral sclerosis, while high (15-28 %) remained in the usual ranges for LP performed with cutting needles.²⁵

Regarding the association between patient's medications and PLPH, only aspirin has been evaluated in a single monocentric, retrospective cohort study of 274 patients that had undergone LP over a two-year period. This study reported a decrease in the relative risk of PLPH in patients taking aspirin in univariate analysis (RR 0.17 [0.04-0.73]) that no longer existed in multivariate analysis.¹³

WHICH NEEDLE SHOULD I CHOOSE AND HOW SHOULD I HANDLE IT TO MINIMIZE THE RISK OF PLPH?

Are atraumatic needles really effective for PLPH prevention?

YES

Historically, LP has been performed with a sharp cutting-point ("Quincke") needle. Non-cutting—atraumatic—needles with a rounded point (i.e. pencil-point "Whiteacre" needles and bullet-point "Sprotte" needles) were developed during the 1980's in order to limit dura mater fiber lesions and, ultimately, CSF leaking. Indeed, studies performed *in vitro* on post-mortem dura maters have shown that wounds caused by the two types of needles differ: punctures with cutting needles result in U shaped lesions, while atraumatic needles produce more rounded holes. Microscopic examination confirmed that the latter needles caused more disruption and compression of the dura fibers, while the former caused a clean-cut opening of the dural membrane.^{26,27} Consequently, cutting-point needles resulted in a 5-fold increase of fluid leakage compared to non-cutting needles of the same diameter.²⁸

Many studies have been conducted to compare cutting and non-cutting needles regarding the risk of PLPH. Most of them reported a highly significant increase in PLPH when LP is performed using cutting needles. This has been confirmed by two large meta-analyses (17,067 and 20,241 LPs); the first found an increase in PLPH risk of 2.14 [1.72-2.67] when using cutting as compared to atraumatic needles, while the second identified a relative risk of PLPH of 0.4 [0.34-0.47] with atraumatic needles compared to cutting needles.^{29,30} Importantly, while these meta-analyses included LPs performed for any purpose (diagnosis, anesthesia, treatment), studies that focused on diagnostic LP only found similar reductions in the risk of PLPH with the use of non-cutting needles. For instance Salzer et al. recently reported in a prospective controlled trial on diagnostic LP that the use of atraumatic needles reduced the

occurrence of PLPH with an odds ratio of up to 0.58 (0.4-0.82) when standard 22 Gauge cutting needles were compared to 25 Gauge atraumatic needles²⁰.

Does needle diameter affect PLPH risk?

DEBATABLE

A wide range of needle diameters—from 19-20 to 25-27 Gauge—are used in daily clinical practice depending on both local habits and the purpose of the LP. Consequently, data regarding the impact of needle diameter on the risk of PLPH are much more heterogeneous than those regarding needle type. Indeed, while two studies concluded to a reduced risk of PLPH when using smaller caliber needles,^{12,24} a large meta-analysis failed to identify a relationship between needle diameter and the occurrence of PLPH.²⁹ The latter meta-analysis separately analyzed the impact of needle gauge on the risk of PLPH in LPs performed with cutting and atraumatic needles, and failed to demonstrate any effect in both setups, emphasizing, however the high heterogeneity and poor global quality of the studies. Importantly, in their monocentric, prospective, randomized control trial, Salzer et al. recently reported a significant decrease in the risk of PLPH when using a 25 Gauge as compared to a 22 Gauge atraumatic needle (OR 0.65 [0.45-0.93])²⁰.

Should the needle be handled in a specific way to minimize PLPH occurrence?

DEBATABLE

It has been hypothesized that strands of arachnoid might be trapped in the lateral eye of atraumatic needles, causing the worsening of dura mater injury during needle removal and, eventually, increased CSF leaking. This issue might be prevented by the reinsertion of the stylet into the canula prior to needle removal. A prospective, randomized trial that enrolled 600 patients undergoing diagnostic LP showed a highly significant difference favoring stylet reinsertion (5% PLPH compared to 16.3% when stylet was not reinserted, $p < 0.005$).³¹ A recent prospective randomized trial did not corroborated these results however, leaving this question unsolved.²⁰

When using cutting needles, a meta-analysis of five randomized studies demonstrated that the orientation of the bevel parallel to the axis of the spine significantly lowers PLPH incidence (OR 0.29 [0.17-0.5]).³²

Is it more difficult to perform LP with atraumatic needles?

No

Some clinicians who are used to traditional cutting-point needles are reluctant to move to atraumatic needles because the need of an introducer would supposedly increase LP's technical difficulty. Several studies have explored this issue. All showed that use of atraumatic LP neither affects the rates of success and success on first attempt, nor the duration of the procedure.^{20,33,34} Interestingly, Engedal et al. performed a study with a sequential design in which they compared indicators of LP success and ease in a neurology department during two time periods. During the first one (249 LPs), only cutting-point needles were used, while they were replaced by atraumatic needles during the second period (252 LPs). Interestingly, the study revealed a significant reduction in both the number of LPs needing more than one attempt (30% versus 44%, $p=0.001$) and in the failure rate of the first operator (17% versus 29%, $p=0.005$) during the atraumatic needle period as compared to the first period.⁵ It must be taken into account, however, that experience regarding practice of LP acquired by residents during the first period of the study, might have positively impacted the rate of success in the second period. Altogether, these results suggest however that provided that operators receive proper training, atraumatic needles should be considered as easy to use as traumatic ones.

SHOULD I PERFORM LP IN A SPECIFIC WAY TO PREVENT PLPH?

Does position during LP matter?

DEBATABLE

In clinical practice, LP is usually performed either in the seated or lateral decubitus position. Indeed, both of these positions—especially the seated one—allow for good hip flexion that results in a widening of interspinous space, a key determinant of LP success.^{35,36} While data regarding purely diagnostic LP are scarce, some evidence pleads for a protective effect of lateral decubitus position toward PLPH. Four studies showed such a reduction of PLPH for patients in which LP had been performed in lateral decubitus, including the one performed by Duits et al. that reported an OR of 0.6 [0.3-0.9].^{7,8,37,38} These results are in line with those of a meta-analysis of seven studies (including mainly rachianesthesia but also diagnostic LP), which found a RR of PLPH of 0.61 [0.44-0.86] in patients in lateral decubitus during LP as compared to those performed in the seated position.³⁹

Is there a preferred intervertebral space?

YES

Lumbar puncture may be performed safely through a wide range of intervertebral spaces (L3-L4 to L5-S1)¹. Unfortunately, data to address this question that are truly relevant to clinical practice are lacking. One retrospective study of 724 LPs using both traumatic and atraumatic needles reported the frequency of PLPH depending on the punctured interval assessed by fluoroscopy, using bloodpatch as a surrogate marker. Interestingly, it showed a direct relation between the punctured level and the incidence of PLPH, the lower levels being associated with a higher incidence (ranging from 5.2% in L1-L2 to 16.2% in L4-L5).⁴⁰

Are difficult LPs more at risk of causing PLPH?

NO

It may be hypothesized that difficult LP (multiple attempts, hemorrhagic CSF, etc.) that could cause increased damage to dura mater are at higher risk of developing PLPH. Data focusing on this issue are scarce, but a few studies counter this suggestion. Indeed, Hammond et al. who analyzed the factors associated with PLPH in 266 consecutive patients that had undergone LP over one year in a clinical setting, did not find any association between the number of attempts, the presence of more than five red blood cells per microliter in CSF and PLPH occurrence.⁴¹ Another indicator of difficult LP may be needle deformation. Similarly, measurement of needle deformation did not detect any association between needle bending and PLPH, even for angles higher than 5°. Of note, however, is that PLPH was very frequent (6/7 cases) when the needle tip was deformed in a specific “hook” shape.⁴²

Should I limit CSF volume to lower the risk of PLPH?

NO

While about 500 ml of CSF are produced every day, the central nervous system contains only approximately 125 ml of CSF at one time⁴³. Thus, clinicians are often reluctant to withdraw more than 10-to-15 ml of fluid per sample. Five studies tried to correlate withdrawn CSF and PLPH,^{12,25,40,41,44} but only one of them²⁵ identified such a relationship. Moreover, in a very detailed observational study on 338 LPs performed in older patients, Monserrate et al. identified an inverse association between sample volume and occurrence of PLPH. Indeed, while immediate postprocedural headaches increased with sample volume, the risk of PLPH significantly diminished (RR=3.07 [1.11-8.49] when comparing sampling volume lower and higher than 17 ml).⁴⁴ Interestingly, in this study, 33 patients had more than 30ml of CSF

collected. Only three of them (9.1%) developed PLPH (compared to 40.9% in the less than 17 ml group and 16.6% in the 17-30 ml group).

Is it dangerous to aspirate CSF with respect to PLPH risk?

No

According to Poiseuille's law, flow rate through a needle is highly dependent of the needle's diameter (radius⁴ relationship). Consequently, increasing needle gauge may increase collection time by gravity drip as recently demonstrated in the study by Salzer et al.²⁰ Thus, alternative collection techniques have been proposed, such as negative-pressure and active suction, which dramatically reduce collection time.⁴⁵ None of five prospective and retrospective cohort studies identified a significant difference in the respective risk of PLPH after sampling using one method or the other.^{9,12,24,44,45} For instance, Vidoni et al. analyzed the effect of different needles and sampling methods on the incidence of PLPH after the first lumbar puncture in patients included in the Alzheimer's Disease Neuroimaging Initiative (ADNI) database.²⁴ In their study, 20 of 300 patients (6.7%) developed PLPH after CSF withdrawal using syringe suction as compared to the 8 of 214 patients (3.7%) whose sampling had been performed by gravity drip (p=0.31).

IS THERE SOMETHING TO DO AFTER LP TO REDUCE PLPH OCCURRENCE?

Should patients rest after LP?

No

It is widely accepted that prolonged decubitus after LP is a key measure in reducing the incidence of PLPH⁴⁶. None of the numerous studies that tried to substantiate this practice, however, demonstrated any protective effect of decubitus (whatever the type and duration of decubitus) on PLPH.^{7,47-52} Conversely, a 2016 Cochrane review that included 2996 patients from 24 studies showed that decubitus after LP was associated with a low, but significant, increase in the relative risk of PLPH (1.24 [1.05-1.48]) compared to immediate mobilization.⁴⁶

Is fluid supplementation useful in preventing PLPH?

No

Oral and/or parenteral fluid supplementation is one of the most traditional methods used to prevent PLPH. The rationale is so logical and simple (the addition of external fluid to replace leaked internal fluid) that its effectiveness has barely been scientifically evaluated. Indeed, only one controlled study, published in 1988 by Dieterich and Brandt, analyzed the effect of oral fluid supplementation (3 versus 1.5 liters per day) in 100 patients undergoing LP.⁵³ In this study, authors found no difference in the rate of PLPH between the two groups. A Cochrane meta-analysis recently reviewed this study and concluded that there was low quality evidence of an absence of benefit of fluid supplementation on the incidence of PLPH.⁴⁶ Actually, this review concluded that there was an absence of benefit of fluid supplementation in the prevention of any headache occurring after LP.

Is caffeine efficient for PLPH prevention?

No

Patients are frequently advised to drink coffee or cola after LP, as caffeine is supposed to be an efficient preventive agent for PLPH⁵⁴. Evidence is lacking, however, as shown by Halker et al. in their 2007 review.⁵⁴ Indeed, they identified only five studies with small sample sizes, methodological flaws and inconsistent designs that reported conflicting results. To the best of our knowledge, no additional trial has been conducted since the publication of this paper.

Are there other pharmacological agents of interest for PLPH prevention?

DEBATABLE

Frovatriptan has been proposed as an option for PLPH prevention in patients undergoing LP in an uncontrolled study that has not been replicated so far.⁵⁵ Some evidence supports the effectiveness of morphine, cosyntrophine and aminophylline in the prevention of PLPH caused by regional anesthesia (mainly in obstetric patients).⁵⁶ As previously emphasized, those observations might not be extrapolated to patients undergoing diagnostic LP due to the major differences between this procedure and rachianesthesia.

CONCLUSION

Among non-modifiable factors, aging is associated with lower incidence of PLPH, while female sex, lower body mass index and history of headache might be associated with an increased risk. The use of atraumatic, non-cutting needles is the most effective intervention for PLPH prevention. These needles are not more difficult to use. Other commonly recommended measures appear unhelpful (fluid supplementation, caffeine) or may worsen PLPH (bedrest).

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TABLE 1

Question	Answer	Rating
<i>Are some patients at increased risk of PLPH?</i>		
Are women more prone to PLPH?	Debatable	4
Do thinner patients have a higher risk of PLPH?	Debatable	3
Does PLPH occur in newborns and children?	Yes	3
Does aging protect against PLPH?	Yes	3
Do patients with chronic headaches develop PLPH more frequently?	Debatable	2
Do underlying diseases and medications increase the risk of PLPH occurrence?	No	2
<i>Which needle should I choose and how should I handle it to minimize the risk of PLPH?</i>		
Are atraumatic needles really effective for PLPH prevention?	Yes	1
Does needle diameter affect PLPH risk?	Debatable	2
Should the needle be handled in a specific way to minimize PLPH incidence?	Debatable	2
Is it more difficult to perform LP with atraumatic needles?	No	1
<i>Should I perform LP in a specific way to prevent PLPH?</i>		
Does position during LP matter?	Yes	2
Is there a preferred intervertebral space?	Yes	4
Are difficult LPs more at risk of causing PLPH?	No	3
Should I limit CSF volume to lower the risk of PLPH?	No	3
Is it dangerous to aspirate CSF with respect to PLPH risk?	No	3
<i>Is there something to do after LP to reduce PLPH occurrence?</i>		
Should patients rest after LP?	No	1

Is fluid supplementation useful to prevent PLPH?	No	2
Is caffeine efficient for PLPH prevention?	No	5
Are there other pharmacological agents of interest for PLPH prevention?	Debatable	4

Summary of frequently asked questions included in the review with answer and evidence rating. Level of evidence was rated based on the Oxford Center for Evidence-Based Medicine level of evidence 2011 table⁴ as follows:

Level 1: Systematic review of randomized trials

Level 2: Randomized trial or observational study with dramatic effect

Level 3: Non-randomized controlled cohort/follow-up study

Level 4: Case-series, case-control studies, or historically controlled studies

Level 5: Mechanism-based reasoning

(Level of evidence has been adapted (graded down) on the basis of study quality, imprecision, indirectness, because of inconsistency between studies, or because the absolute effect size was very small.)