

Preventing and treatment of post-dural Puncture Headache

Szymon Gawrych¹, Aleksandra Białkowska¹, Blanka Budziejko¹, Oliwia Cywińska¹,
Dariusz Dziarkowski¹, Daria Kurtyka¹, Gracjan Różański¹, Anna Maria Dobosiewicz¹,
Nataliia Badiuk²

¹Scientific Circle of Exercise Physiology at Department of Hygiene, Epidemiology and Ergonomics. Division of Ergonomics and Exercise Physiology, Nicolaus Copernicus Univeristy in Toruń, Collegium Medicum in Bydgoszcz, Poland

²State Enterprise Ukrainian Research Institute for Medicine of Transport, Ministry of Health of Ukraine, Odesa, Ukraine

Corresponding author: Anna Maria Dobosiewicz, annamdo@gmail.com

Abstract

Post-dural Puncture Head (PDPH) is a common undesired side effect of lumbar puncture (LP). It is connected with the leakage of Cerebrospinal Fluid (CSF) at the puncture site outside of spinal cord – in to the dura mater. The intracranial pressure sensitive structures in the brain react with the lowered intracranial pressure triggering pain and other PDPH-related symptoms. Conservative PDPH-preventing therapy includes prolonged bed rest and increased fluids intake – those guidelines were invented as long ago as LP itself and even though modern day research show no connection between following those guidelines and PDPH occurrence yet it is still performed in medical practice. Research shows that crucial for the likelihood of PDPH occurrence is the type of used needle gauge whether it is traumatic or atraumatic and the needle size (its' diameter). As for the treatment of prolonged PDPH the most beneficial from the pharmacotherapy is the usage of caffeine (used in treatment of

different-based headaches as well) combined with other pain-easing medicines. As for the more invasive method of treatment epidural patch is being used. It works as a patch, made of patients' blood that covers the hole in the dura mater preventing more CSF from leaking outside. It is the most efficient way of treating PDPH.

Key words: Post-dural puncture headache, cerebrospinal fluid, epidural patch, lumbar puncture

Introduction

Lumbar puncture is an invasive medical procedure conducted in order to provide spinal (epidural) anesthetics, pain easing medicaments or in diagnostic causes. Knowing the anatomy of the lumbar area of the spine is crucial to perform puncture correctly. Many soft tissues structures needs to be pierced before needle might get to its destination – subarachnoid space. It goes through: skin, fat tissue, supraspinous ligaments, interspinous ligaments, ligamentum flavum, epidural space, dura and arachnoid. Bony anatomic structures like L4 vertebra spinous process or top of the iliac crest are indicators of correct in-puncture spot [1].

Particular position of the patient is also required for correct performance of lumbar puncture (LP). The most common position to run this test is with patient lying on either side of the body (depending if the performer of the procedure is left or right-handed) on the table with their lower limbs flexed strongly in knee and hip joints. Patients can also hold their lower limbs with the upper limbs to maximize the lower limbs flexion and by that – increase the distance between lumbar spine vertebrae and make duras more accessible for the procedure performer. Studies show that patients' head flexion doesn't increase the distance between lumbar spine vertebrae therefore heads' neutral position, elevated by patients' arm or pillow, is just enough. Patients' comfort is crucial for the procedure in order to prevent them from moving or flexing lumbar area muscles mid-procedure and resulting its' failure or multiple attempts. Overweight and obese patients are harder to puncture not only because of more fat tissue in lumbar area but also their Tuffler's Line (line running between the top of iliac crests and through the L4 spinous process and indicating optimal spot for LP) can appear higher on the body than in normal-weighted patients which might be misleading [2, 3].

As for the diagnostic purposes LP is being performed in order to confirm or decline presence of diseases like i.e. subarachnoid hemorrhage (SAH), meningitis, Sclerosis Multiplex (MS) and other demyelinating diseases, Guillian-Bare Syndrome, carcinomatous meningitis and also it indicates if patient is suffering for fungal, viral, mycobacterial and bacterial infection. Highlighting requires the fact that nowadays number of LP performance

indicators has decreased remarkably thanks to development and improvement of neuroimaging techniques like computed tomography (CT) or magnetic resonance imaging (MRI). Those neuroimaging techniques are completely non-invasive and they are not connected with a likelihood of occurrence of undesired side effects like thus might follow the LP. Yet LP is still irreplaceable as the tool of providing the anesthetics straight to the spinal cord. No matter what is the point of conducting LP whether it is for diagnostic causes or as a way of providing anesthetics it can always lead to PDPH and other side effects [4, 5].

Cerebrospinal Fluid

Cerebrospinal Fluid (CSF) is being constantly produced in the lateral cerebral ventricles by the intraventricular choroid plexus (CP) from the blood plasma [6, 7].

Then, it flows through foramina of Monro to the third ventricle. After that it flows further, through aqueduct of Sylvius into the fourth ventricle. Most of the CSF stays in the brain and its surroundings with only little amount of it flowing down – to the spinal cord. Brain of an adult human weighs approximately 1500 grams but surrounded by CSF it only weighs 50 grams. CSF allows the brain to float into it and it creates better conditions for the brain to grow, compared to situation if CSF wasn't there. There are four crucial functions of the CSF associated with: transmission, protection metabolism and homeostasis maintaining. With its' protective nature CSF works as a cushion absorbing and minimalizing external traumas that may harm brain or spinal cord. The brain doesn't have lymphatic system of its' own so the wastes of most of the metabolic processes that take place in the brain is being transferred to the CSF. As the CSF washes different structures of the brain it collects significant amount of cerebral metabolic by-products. CSF also carry variety of substances from one brain structure to another i.e. hormones produced in hypothalamus are transported via CSF to its' in-brain effectors. CSF takes crucial part in creation of homeostasis. By its' constant secretion in lateral brain ventricles and as the effect – constant amount CSF allows keeping the intracranial pressure (ICP) on the same level. Stable level of ICP is essential for normal functioning and its' variations are associated with PDPH [6]. The amount of the CSF produced in lateral ventricles is approximately 500-600 ml per 24 hours yet the volume of CSF present in the whole human in certain time is approximately 150 ml. CSF is being completely replaced from 3 to 4 times throughout 24 hours after being produced and going through brain and spinal cord structures it is being absorbed back to the venous blood at the arachnoid villi level [7].

Post-dural Puncture Headache – pathophysiology and symptoms

Post-dural Puncture Headache (PDPH) is a common side effect of lumbar puncture. There are two widely spread possible theories explaining PDPH occurrence. First theorize that pain itself is caused by pressure-sensitive structures in the brain. Leakage of cerebrospinal fluid (CSF) to the epidural space in the area of puncture results in lowering the intracranial pressure and trigger pain through those areas. Second one is related to brain blood vessels. After loss of certain amount of CSF at the puncture site and the sudden decreasing of intracranial pressure blood vessels are trying to maintain the standard pressure by constant vasodilatation which may lead to vascular-based headaches [8, 9].

PDPH is strictly associated with patients' posture – pain level increases when standing up whilst it is easing when lying down. When standing up due to lowering the intracranial pressure brain is being sagged downwards. There are few PDPH occurrence risk factors connected to the patients themselves: young age, former cases of PDPH, reports of prolonged and reoccurring headaches, low Body Mass Index (BMI), female sex, ongoing pregnancy, vaginal delivery and also being a non-smoker [9].

The pain will usually develop in 72 hours after the puncture, less often in 48 hours after and rarely between 5th and 14th day after the puncture. The PDPH usual duration is up to 7 days after the puncture yet there are cases showing that PDPH may last up to 6 months after the puncture or even years after [10].

Besides pain itself there other significant symptoms associated with PDPH: nausea, vomiting, vertigo (sensation in which patients see and feel that the objects around them are moving when they are really not), tinnitus (constant and annoying sound of ringing in one or both ears), pain in upper and lower limbs, neck stiffness, photophobia, dizziness and scalp paraesthesia. And for the less often occurring: diplopia (when patients see objects in double) and cortical blindness are being mentioned. Lumbar puncture with its' side effects (PDPH included) may lead to serious medical conditions like: onset of grand mal seizures, cerebral herniation, intracranial subdural haematomas or even death [10, 11].

Preventing PDPH occurrence

Since the first performances of LP and first PDPH records the set of rules preventing PDPH occurrence was set. It included prolonged bed rest and increased fluids intake to compensate CSF loss and stimulate its' production. Modern day researches show no connection between those two rules mentioned earlier and PDPH yet the conservative methods are still in use [1, 4, 10, 12].

Needle orientation

Researches show that the needle positioning is one of the many factors preventing PDPH occurrence. The most efficient needle position is of a bevel (while using standard type needle) facing perpendicularly the structures of dura and its' surroundings what causes lesser likelihood of post-dural CSF leakage [10].

Needle size

Size of the used needle is crucial for preventing the PDPH occurrence. With bigger diameter of the needle the hole it leaves in the dura will also be bigger and it will allow more CSF to leak as the result. Needle sizes are categorized by its' gauges (G) and preceded by a number. For the example needles marked as 16G, 17G or 18G are those of the smaller gauges while 28G, 29G or 32G are those of greater gauges. Yet the smaller gauge is less likely to trigger the PDPH it is more likely that with the smaller gauge LP might end up as a failure and it need another attempt (providing spinal anesthesia). Using smaller gauge also requires LP performer better operating skills than of those using bigger gauge. Choosing of the optimal needle gauge should be resultant of physician skills, PDPH occurrence likelihood and procedure failure likelihood. Yet the smallest needle that is used for LP related procedures is 22G [10, 11].

Needle tip type

Needle types can be categorized as a standard type needle (traumatic) and atraumatic (pencil-point). Standard type needles have beveled tip, which was designed to pierce through the tissues, and an opening allowing it to inject drugs or collect CSF. Pencil-point needles are blunted at its tip with the port on a side for either injection or collection of CSF and as contrary to standard type needles which tear the dura structures atraumatic needles splay the dural fibers allowing them to return to its primary position once LP is finished. Studies show that the usage of pencil-point needles is related with a significantly lower likelihood of PDPH compared to traumatic needles. Back in 2005 American Academy of Neurology suggested using atraumatic needles as prevention of PDPH occurrence, yet this practice haven't adapted correctly among neurologist and it is rarely used. Authors speculate it might be connected to the different feel atraumatic needle gives piercing through the tissues compared to standard, bevel needle and physicians might not be familiar with it so that's why they keep on using standard, yet archaic kind of needle. According to the recent study only 2% out of interviewed neurologist and physicians answered they use atraumatic needles in their practice [1, 13, 14, 15].

Treating PDPH

As mentioned before, the conservative methods of preventing PDPH occurrence are prolonged bed rest and increased fluids uptake and the research show there is no actual connection whether those precautions are provided or not. If the headache occurs and it meets criteria of PDPH (time of occurrence after the puncture, pain localization, body position as the easing or intensifying factor, other symptoms following the PDPH etc.) and it doesn't ease within 5-7 days after the puncture we should consider introducing a proper treatment. The two most widely spread treatment methods are: pharmacotherapy and epidural patch [8-10, 16, 17].

Pharmacotherapy

The substance which is widely used for headaches, not only PDPH, treatment is caffeine. Caffeine is commonly used as medicine in migraine or tension-type headache (TTH) occurrence. Besides having headache-easing properties of its' own it is also boosting the effectiveness of other medical anti-headache substances provided like acetaminophen, acetylsalicylic acid, and ibuprofen. Caffeine can be provided either intravenous or as an oral therapy. Thanks to its' rather gentle side effects (nervousness, dizziness, nausea, abdominal ache/discomfort) it can be used in most of the patients. The recommended dose is between 100 mg and 130 mg of caffeine either provided intravenous or orally. As for the other, less spread substances researchers were trying using: subcutaneous sumatriptan, oral gabapentin, oral theophylline, intravenous hydrocortisone and intramuscular adrenocorticotrophic hormone (ACTH). As the result they found out that the caffeine significantly reduces the pain of PDPH patients compared to placebo. All the mentioned before substances showed better Visual Analogue Scale (VAS) scores compared to placebo besides sumatriptan and ACTH. Different research shows that oral usage of theophylline (750 mg per 24 hours) is supreme to oral usage of acetaminophen (1500 mg per 24 hours). It is highly recommended to provide further research on other Methylxanthines in order to find new, and maybe more efficient and effective PDPH easing medicaments [16, 17, 18].

Epidural patch

Epidural patch is an ad hoc way of PDPH treating. The patch, made of autologous patients' blood is being applied at the puncture site. It works as a plaster and is being injected in to the epidural space – securing the post puncture hole and preventing more CSF from leaking. It is usually performed after the 7-10th day after PDPH occurrence if the symptoms don't ease off by themselves. The successfulness of using epidural patch as a treatment method reaches up to 90% of cases. The research conducted in Finland where usage of

epidural patch efficiency was tested on elderly patients (no matter why LP was performed i.e. anesthetic providing, diagnostic causes etc.) showed that epidural patch eased or completely eliminated PDPH symptoms in 85% of patients. Only in 15% of patients (n=4) improvement was either slight or non [19]. With epidural patch being the best way of treating PDPH there are some patients on whom this kind of treatment can't be used. With those patients the best option of treatment would be pharmacology or non-blood-containing epidural injections. One of the substances used when traditional, blood-based epidural patch fails is the fibrin glue. It is being injected the same way blood-containing patch is – to the epidural space where it seals the post-puncture hole. Acupuncture is also being presented as an alternate way of PDPH treatment yet this subject requires more research [20, 21].

Summary

Even with the development of modern day medicine PDPH is still widely noted side effect of LP. The physicians don't realize that the PDPH occurrence is by far based on their choices – needle tip type, needle diameter and their skill – proper pierce angle and knowledge of anatomy rather than on providing outdated, conservative prevention methods like prolonged bed-rest and increased fluid intake. It is crucial to rise physicians and doctors consciousness on newest accessible LP equipment and improve their skills in LP performance. Patients suffering PDPH should monitor themselves because PDPH symptoms usually ease off in time yet if they don't more ad hoc treatment (pharmacology or epidural patch) should be considered to introduce.

References

1. Carolynne M. Doherty, *Diagnostic Lumbar Puncture, Ulster Med J.* 2014 May; 83(2): 93–102.
2. Costerus JM, Brouwer MC, van de Beek D, *Technological advances and changing indications for lumbar puncture in neurological disorders.* Lancet Neurol. 2018 Mar;17(3):268-278
3. Groschel K, Groschel S, *How to do: The diagnostic lumbar puncture,* Dtsch Med Wochenschr. 2015 May;140(10):738-40
4. Chern JJ, Tubbs RS, Gordon AS, Donnithorne KJ, Oakes WJ, *Management of pediatric patients with pseudotumorcerebri* published on Epub ahead of print on 2012 Jan 19
5. Kimberly S Johnson, Daniel J Sexton, *Lumbar puncture: Technique, indications, contraindications, and complications in adults* published on UpToDate 2018 Jul 02

6. David N. Irani, *Cerebrospinal Fluid in Clinical Practice*, p: 5-11,2009 ISBN: 978-1-4160-2908-3 Elsevier
7. Helle H. Damkier, Peter D. Brown, JeppePraetorius, *Cerebrospinal Fluid Secretion by the Choroid Plexus*, American Physiological Society 2013 Oct; 93(4):1847-1892
8. Morewood GH, *A rational approach to the cause, prevention and treatment of postdural puncture headache*. CMAJ. 1993 Oct 15; 149(8):1087-93.
9. Kyung-HwaKwak, *Postdural puncture headache*, Korean J Anesthesiol. 2017 Apr; 70(2): 136–143.
10. D.K. Turnbull, D.B.Shepherd, *Post - dural puncture headache: pathogenesis, prevention and treatment*, British Journal of Anaesthesia, 2003 Nov; 91(5):718-729
11. Arevalo-Rodriguez I, Muñoz L, Godoy-Casasbuenas N, Ciapponi A, Arevalo JJ, Boogaard S, Roqué I Figuls,*Needle gauge and tip designs for preventing post-dural puncture headache (PDPH)*, Cochrane Database Syst Rev. 2017 Apr 7;4:CD010807
12. Arevalo-Rodriguez I, Ciapponi A, Roqué i Figuls M, Muñoz L, BonfillCosp X, *Posture and fluids for preventing post-dural puncture headache*, Cochrane Database Syst Rev. 2016 Mar 7;3:CD009199.
13. van de Beek D, Brouwer MC, *Atraumatic lumbar puncture needles: practice needs to change*, Lancet 2018 Mar 24;391 (10126):1128-1129
14. Arevalo-Rodriguez I, Muñoz L, Godoy-Casasbuenas N, Ciapponi A, Arevalo JJ, Boogaard S, Roqué I Figuls M, *Needle gauge and tip designs for preventing post-dural puncture headache (PDPH)*, Cochrane Database Syst Rev. 2017 Apr 7;4:CD010807
15. SiddharthNath, Jetan H Badhiwala, WaleedAlhazzani, FarshadNassiri, Emilie Belley-Cote, Alex Koziarz, AshkanShoamanesh, Laura Banfield, WieslawOczkowski, Mike Sharma, DemetriosSahlas, Kesava Reddy, ForoughFarrokhyar, Sheila Singh, Sunjay Sharma, Nicole Zytaruk, MagdySelim, Saleh A Almenawer, *Atraumatic versus traumatic lumbar puncture needles: a systematic review and meta-analysis protocol*. BMJ Open, 2017; (7)3: e014478
16. BasurtoOna X, MartínezGarcía L, Solà I, BonfillCosp X, *Drug therapy for treating post-dural puncture headache*, Cochrane Database Syst Rev. 2011 Aug 10;(8):CD007887
17. Lipton RB, Diener HC, Robbins MS, Garas SY, Patel K, *Caffeine in the management of patients with headache*, J Headache Pain. 2017 Oct 24;18(1):107

18. Mahoori A, Hassani E, Noroozinia H, Javaheri N, Hatami S, *Theophylline versus acetaminophen in the treatment of post-dural puncture headache (PDPH)*, Middle East J Anaesthesiol. 2013 Oct;22(3):289-92.
19. Sjövall S, Kokki M, Turunen E, Laisalmi M, Alahuhta S, Kokki H, *Postdural puncture headache and epidural blood patch use in elderly patients*, J Clin Anesth. 2015 Nov;27(7):574-8
20. Katz D, Beilin Y, *Review of the Alternatives to Epidural Blood Patch for Treatment of Postdural Puncture Headache in the Parturient*, Anesth Analg. 2017 Apr;124(4):1219-1228
21. Wong K, Monroe BR, *Successful Treatment of Postdural Puncture Headache Using Epidural Fibrin Glue Patch after Persistent Failure of Epidural Blood Patches*, Pain Pract. 2017 Sep;17(7):956-960