Case Report

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Combined Invasive Peripheral Nerve Stimulation in the Management of Chronic Post-Intracranial Disorder Headache. A Case Report

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Abstract: The introduction of ventricular shunts dramatically changed the outcome and quality of life of hydrocephalic patients. However, shunt surgery continues to be associated with numerous adverse events. Headache is one of the most common complications after shunt operation. It is often of prolonged duration, the symptoms resemble migraine, and pain does not respond to medication. We propose invasive peripheral nerve stimulation as a potential solution in the treatment of patients suffering from chronic headache associated with shunted hydrocephalus. A young woman with daily holocephalic headache with diffuse pain exacerbated by lying down. Imaging revealed panventricular enlargement and possible aqueduct stenosis. When a ventriculoperitoneal shunt was placed, clinical symptoms resolved. Nevertheless, she gradually exacerbated after a second valve replacement due to wound infection. Imaging revealed decompressed ventricles and appropriate shunt placement. The diagnosis of chronic post-intracranial disorder headache was set. Therefore, occipital nerve stimulation was applied and considering that the patient had not a total response, bilateral parietal stimulation was added. Three months after the combined PNS she experienced total remission of headache. Combined PNS eases refractory headaches much more than occipital nerve stimulation alone and could be considered as a solution for shunted hydrocephalus associated headache.

Keywords: Combined Peripheral Nerve Stimulation; occipital nerve stimulation; secondary headache disorders; chronic post-intracranial disorder headache and case report

1. Introduction

The introduction of ventricular shunts dramatically changed the outcome and quality of life of hydrocephalic patients. Despite the continued development of various valve types, shunt surgery continues to be associated with numerous adverse events. Headache, epilepsy, and abdominal pain are the most common complications after shunt operation. They are considered mild to moderate adverse events of which neurosurgeons need to be aware [1]. Headaches in patients with shunts do not necessarily mean shunt failure or malfunction, CSF overdrainage or even intracranial bleeding. In these cases, complaint or chronic headache is often over a prolonged duration, the symptoms resemble migraine, and pain does not respond to medication. Some authors suggested that the concept of shunt migraine should not be overlooked. It was identified that patients with treated idiopathic intracranial hypertension (IIH) had headaches that can be classifiable by current IHS criteria compatible with episodic and chronic tension- type headache, migraine with and without aura, analgesic overuse headache, idiopathic stabbing headache, and benign exertional headache [2–4].

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Peripheral Nerve Stimulation (PNS) of the Occipital Nerves (ONS), is a procedure that is primary applied to treat pain associated with refractory chronic migraine and chronic cluster headaches. ONS has been shown to affect blood flow in brain structures, interfering with the pathophysiology mechanisms of migraine [5].

To our knowledge, patients with chronic headache associated with shunted hydrocephalus responding to invasive PNS have not been previously reported. We describe the significant response of combined invasive PNS to a 33-year-old woman suffering from chronic post-shunt headache.

2. Case Presentation

A 33-year-old Caucasian woman with holocephalic headache presented to the outpatient clinic with a 3 weeks' history of deteriorating headaches. She described diffuse daily pain exacerbated by lying down, and relieved by sitting up or standing. She had associated gait impairment and visual symptoms.

Her neurological exam was unrevealing except for bilateral papilledema. There was no headache history or medication overuse, and no family history of neurologic disorders. The findings of the general medical examination were normal.

Non-enhanced brain magnetic resonance imaging (MRI) revealed ventricular dilatation and possible aqueduct stenosis (figure 1).

The patient consented to participate in the intracranial pressure Telemetry monitoring protocol, which was held between September 2016 and December 2019. The ethics committee of our hospital approved the study and informed consent was obtained. Thus, she underwent ICP monitoring implantation (via a right frontal ICP bolt insertion – Neurovent® P-tel Raumedic®) for a longer period of 2 months. The trace was analyzed and revealed intracranial hypertension (>30mmHg).

A ventriculoperitoneal shunt (VPS) (Medtronic Strata®) was placed in the occipital region, which resulted in resolution of her symptoms. Follow-up with head CT scan also revealed resolution of the hydrocephalus.

After VPS placement, intracranial pressure values were initially measured close to the upper normal limit (<20mmHg) with appropriate manipulations in the regulation of the valve mechanism.

One month after the shunt was placed, the patient presented with a cranial wound infection. She was not affected, and there were no changes on her previous neurological examination. CSF cultures were negative. The valve cultures grew Staphylococcus aureus sensitive to levofloxacin. She underwent a shunt replacement with a frontal ventricular approach on the contralateral side and she completed a four-week course (figure 2).

The patient's condition gradually deteriorated after the second valve replacement. She complained of a severe daily headache. The headache was long lasting, holocephalic, pulsating, exploding headache aggravated by routine physical activity, accompanied by photophobia, phonophobia, and nausea, not responding to common pain medication, influencing her daily activities and the quality of sleep. The underlying organicity was excluded because, the headache was not related to pressure, and there were no other features and tests suggestive of valve malfunction or overdrainage. Therefore, our patient met the description of a severe non-aura chronic migraine [6]. The assessment of headache severity and related disability is shown in Table 1.

Table 1. Pre- and post-implantation performance (regarding the severity of headache, disability due to headache, quality of life, insomnia, depression, and anxiety).

	Pre-Implantation	Post-Implantation
VAS	10	0
MIDAS	90	20
SF36	31	63
AIS	17	6
BDI II	38	24
BAI	26	7

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* (VAS: visual analog scale score, MIDAS: Migraine Disability Assessment Scale, SF-36: Short Form (36) Health Survey, AIS: Athens Insomnia Scale, BDI II: Beck Depression Inventory, BAI: Beck Anxiety Inventory).

A non-contrast head CT revealed decompressed ventricles and appropriate VPS placement and intracranial pressure values measured within the normal range (<15mmHg).

In our case a new headache first occurred in close temporal relation to CSF fistula placement and is therefore considered a secondary headache attributed to non-vascular intracranial disorder [6,7]. Additionally, this new headache was daily, occurring for more than three months, and had the features of migraine headache, fulfilling the diagnostic criteria of chronic migraine [6]. Considering the findings of imaging and the intracranial pressure values, other cases of shunt-related headaches (e.g., intracranial hypotension, intermittent proximal obstruction, shunt failure without ventricular enlargement, increased ICP with a working shunt) were excluded [8].

Non-steroid anti-inflammatory drugs (NSAIDs) failed to control the headaches and the response to tramadol was transient. Pharmacological treatment of her headaches with topiramate, flunarazine, propranolol, venlafaxine proved to be ineffective. The headache did not subside or improve markedly after 3 classes of migraine prophylactic medications, each used for at least 3 months and such that was classified as refractory [9]. We did not consider botulinum toxin injection, because the described exploding headache does not respond to this treatment [10,11]. Anti-CGRP monoclonal antibodies were not in our routine clinical practice when we were handling this case [12].

In patients with chronic medically refractory headaches, including migraine, neuromodulation treatment targeting peripheral nerves is an attractive and valuable approach which offers symptom relief [13]. Considering the clinical characteristics and the refractoriness of symptoms, we considered a trial of peripheral nerve stimulation. The patient provided written informed consent prior to the procedure.

3. Implantation techniques and Devices

The implantation of the peripheral nerve stimulator was performed in two stages. We started with a 2-week trial, and we implanted two electrodes (Boston Scientific Corporation (BSC) Spectra™ System) subcutaneously, bilaterally parietally in the region of the greater occipital nerve territory. To assess headache severity, disability due to headache, quality of life, insomnia, depression, and anxiety before and after implantation we used the following rating scales: Visual Analog Scale Score (VAS), Migraine Disability Assessment Scale (MIDAS), Short Form (36) Health Survey (SF-36), Athens Insomnia Scale (AIS), Beck Depression Inventory (BDI II), Beck Anxiety Inventory (BAI) [14–19]. The MIDAS has not been validated for secondary headaches. However, we decided to include the above rating scale in our instruments because the described headache met the diagnostic criteria for chronic migraine.

The trial was considered successful, as the patient stated at least 50% reduction in pain (the VAS score reduced from 10 to 3). Considering that our patient did not have a total response to occipital nerve stimulation (ONS) and based on the clinical approach of covering the remaining painful frontal area as best as possible, we hypothesized that she would benefit when additional supraorbital stimulation was performed.

For the permanent implant, we decided to apply electrical stimulation by placing leads in the subcutaneous area of the scalp, at the point of initiation of daily headache before extending to the whole head. We finally placed three leads with 8 contacts, two leads at the parietal lobe areas symmetrically on both sides and more specifically in the areas of distribution of the greater occipital nerves and one supraorbital lead (figures 3,4).

The device was activated after the surgical site healed, 10 days after implantation. Three months after the implantation of the bilateral combined stimulation system, headache promptly and completely resolved, quality of life was improved, and remained completely medication-free (table 1). No side effects were observed. When we tried to inactivate the stimulation for a few hours, pain reappeared. The stimulator is continuously on during the day. She uses equally the single frontal lead and the double parietal system.

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4. Discussion

The patient described here presented with a new- onset daily headache associated with reclination and gait impairment, suggesting increased intracranial pressure. She was diagnosed with hydrocephalus and was successfully treated with VPS. The pathogenesis of hydrocephalus- related headache is correlated with any pathophysiological process capable of causing alterations in CSF production, circulation, and absorption [20].

After the valve revision due to postoperative infection, our patient complained of the development of a new pulsating headache that resembled the characteristics of a non-aura headache. After implantation of the PNS, she experienced total remission of symptoms. These findings led us to speculate that the latter headache may share similar biological mechanisms with a primary headache such as migraine. The genesis of a secondary headache attributed to post-intracranial disorder may also involve peripheral sensitization to neurogenic inflammation as a consequent of sensitization of trigemino-vascular afferents. Taylor et.al. also propsed this mechanism to explain the genesis of brain tumour headache [21]. These observations provide a new insight into the pathophysiology of secondary headaches, suggesting an overlap with primary headache.

The convergence of cervical, somatic and dural afferents on second-order nociceptors in the trigeminocervical complex (TCC) in animal studies provided the theoretical background for application of ONS [22,23]. This indeed explains how the stimulation of the anatomically distant occiput relieves symptoms in patients with certain intractable headaches and a fronto-temporal pain distribution. Nevertheless, not all the patients experience adequate relief, and this is our case. In these conditions, the stimulation of supraorbital area produces a concordant paraesthesia, covering the painful frontal region with the stimulator-induced paraesthesia. This rationale explains the additional beneficial effect on holocephalic headaches offered by combined PNS [24].

In migraine, neuromodulation approaches regard peripheral nerve stimulation (PNS). They range from non-invasive techniques to surgically implanted devices such as occipital nerve stimulation. Invasive PNS has been mainly performed in most disabled patients. Current clinical trials suggest the application of invasive (subcutaneous) ONS in occipital neuralgia and in several primary chronic headache types, including chronic cluster headache, chronic migraine, hemicrania continua, and short-lasting unilateral neuralgiform headache attacks with cranial autonomic symptoms (SUNA) [25]. Simultaneous stimulation of the occipital (ONS) and supraorbital nerves (SNS) has been reported more successfully [24].

However, only a few reports have demonstrated the efficacy of ONS for secondary headache disorders such as cervicogenic headache, C2-mediated headaches, posttraumatic headache, and postsurgical headaches [26,27]. There is a growing field of stimulation devices used in patients with medically intractable primary headache syndromes.

The main limitation of the current case report is that the results regard only one patient. Nevertheless, the fact that when the stimulation was inactivated, the pain reoccurred strengthens the management of this case.

Neurosurgeons are not always familiar handling chronic, refractory, secondary to shunt placement headaches which are not related to the valve dysfunction. This condition frequently creates exhaustion for the patients themselves, but also for the health system, as they are forced to undergo repeated diagnostic tests and inadequate treatments. These different kinds of headaches (e.g. migraines with or without aura, tension type headache) usually appear several times a month and tend to become chronic and drug resistant. As known chronic pain conditions are strictly linked with central sensitization. PNS modifies synaptic plasticity leading to clinically significant and sustained results [28]. Therefore, we have the conviction that PNS could be considered as a possible solution in this population who have failed to respond to first line interventions.

This report shows a way to deal with these cases and find a path to improve quality of life. Neurostimulation devices should also be used in patients with secondary intractable pain in headache centers to validate the efficacy and safety of the method and be officially suggested as a potential therapy in this patient population.

Our report not only confirms the historical data that combined PNS stimulation facilitates refractory headaches much more than ONS alone, but also suggests common pathophysiological mechanisms between primary and secondary headaches. Finally, further larger, controlled studies are needed to validate and disseminate the use of neurostimulation in secondary headaches.

5. Data Availability

As the corresponding author, I take full responsibility for the data, analyses and interpretation, and the conduct of the research. I have full access to all data; and subsequently the right to publish any and all data separately and independently of any sponsor.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, X.X. and Y.Y.; methodology, X.X.; software, X.X.; validation, X.X., Y.Y. and Z.Z.; formal analysis, X.X.; investigation, X.X.; resources, X.X.; data curation, X.X.; writing—original draft preparation, X.X.; writing—review and editing, X.X.; visualization, X.X.; supervision, X.X.; project administration, X.X.; funding acquisition, Y.Y. All authors have read and agreed to the published version of the manuscript.", please turn to the CRediT taxonomy for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

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