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MASSAGING OVER THE GREATER OCCIPITAL NERVE REDUCES THE INTENSITY OF MIGRAINE ATTACKS

Evidence for inhibitory trigemino-cervical convergence mechanisms

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ABSTRACT - Activation of the trigemino-cervical system constitutes one of the first steps in the genesis of migraine. The objective of this study was to confirm the presence of trigemino-cervical convergence mechanisms and to establish whether such mechanisms may also be of inhibitory origin. We describe a case of a 39-years-old woman suffering from episodic migraine who showed a significant improvement in her frontal headache during migraine attacks if the greater occipital nerve territory was massaged after the appearance of static mechanical allodynia (cortical sensitization). We review trigemino-cervical convergence and diffuse nociceptive inhibitory control (DNIC) mechanisms and suggest that the convergence mechanisms are not only excitatory but also inhibitory.

KEY WORDS: DNIC, inhibitory control of pain, migraine.

Massagem sobre o nervo occipital maior reduz a intensidade dos ataques de migrânea: evidência de mecanismos de convergência inibitórios trigemino-cervical

RESUMO - Ativação do sistema trigemino-cervical constitui um dos primeiros passos na gênese da crise de migrânea. O objetivo do estudo foi descrever um caso clínico que sugere a existência de mecanismos de convergência trigemino-cervical (CTC) e que esses possam ser do tipo inibitórios. Nós descrevemos o caso de mulher de 39 anos com migrânea episódica que mostrou significante melhora em sua cefaléia frontal durante suas crises quando realizava massagem sobre o território do nervo occipital maior ipsilateral a dor. A melhora clínica só ocorria quando a paciente apresentava alodinia mecânica estática (sensibilização cortical). Neste estudo nós revisamos os conceitos de CTC e de mecanismos de controle inibitório nociceptivo difuso (MCIN), sugerindo que este último é um elemento comprobatório da presença de CTC do tipo inibitório durante as crises de migrânea.

PALAVRAS-CHAVE: controle de dor, MCIN, enxaqueca.

Migraine is a recurring neurologic disorder with a high prevalence and is characterized by headache and autonomic and somatosensory symptoms. Appropriate treatment for this disorder reduces the impact of the disease on the sufferer, thereby increasing the quality of life. Three levels of therapy are used: prophylactic, pre-emptive and abortive. For abortive (acute) treatment, pharmacological strategies and/or alternative measures are used. Among the alternative techniques, those that stand out are manipulation of the suboccipital region (greater occipital nerve) using acupuncture or electrical stimulation. Stimulation of the greater occipital nerve in the treatment of headaches has been recommended for a number of years[1]. Recent studies have shown that the use of electronic devices implanted subcutaneously at the base of the skull near where the greater occipital nerve emerges is effective in headache control[2]. By surgically or percutaneously implanting a single electrode or dual electrodes in the subcutaneous tissue, a mild feeling

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of paresthesia can be produced in this region, with subsequent blockage of the pain sensation. This procedure is recommended in the control of pain syndromes such as migraine, chronic daily headache, cervicogenic headache and neuropathic pain caused by deafferentation[3]. Stimulation of the greater occipital nerve (GON) is known to control headaches that originate in the trigeminal nerve territory. A possible explanation for this can be found in the trigemino-cervical convergence (TCC) mechanisms. Electrophysiological studies have shown that there is an overlap between the trigeminal and cervical nociceptive systems. The duration and intensity of the stimulus required to induce convergence mechanisms, the neurons involved in this process, and diagnostic and therapeutic techniques that prove the presence of these mechanisms have been described in various studies (Tables 1 and 2). One of the possible mechanisms by which stimulation of the greater occipital nerve produces pain control is through the ability of this stimulus to produce diffuse nociceptive inhibitory control (DNIC). DNIC has been described as one of the most important mechanisms for the control of acute pain. It promotes nociceptive inhibition of neurons located inside the trigeminal dorsal horn (trigeminal nucleus caudalis) following an intense pain stimulus in this region. This pain stimulus promotes local nociceptive inhibition, a phenomenon that is known as counter irritation[4].

We describe a migraine sufferer who showed a significant, transitory improvement in her pain following mechanical stimulation of the greater occipital nerve ipsilateral to the migraine. The findings described in this case report reinforce the existence of trigemino-cervical convergence mechanisms and the influence of DNIC on this process. In this study, we review trigemino-cervical convergence and DNIC mechanisms.

CASE

A 39-year-old woman physical education teacher, who has suffered from episodic migraine without aura for seven years, with an average of one crisis per month; crises triggered by intense physical exertion or menstrual periods. The headaches start with a stabbing pain that lasts 3 seconds, followed by a heavy sensation in the frontal region associated with nausea. The discomfort in this region (2 points on the Visual Analog Pain Scale) (VAS=2) evolves slowly until it becomes intolerable after 120 minutes (VAS=10). At this stage, it is a unilateral throbbing headache, which worsens with the slightest physical effort. At the end of four hours, the patient reports a sensation of pain above the upper right molar (where she had root canal treatment 10 years ago), which worsens with minor pressure (closing the jaws tightly) (Fig 1). The autonomic symptoms accelerate within 120 minutes, and the patient experiences incapacitating vomiting. The patient reported that she massages the right greater occipital nerve territory to reduce the pain. Five seconds after starting to massage the area, the pain decreases from VAS 10 to VAS 6, and the pain sensation above the right molar disappears. Ten seconds after stopping the massage ipsilateral to the pain, the pain symptoms reappear (VAS 6 to 10), as does the allodynia above the right molar. The patient did not report tenderness sensation around the GON region during migraine attacks. In few attacks nausea and vomiting occurs. Headache history starts twelve years ago. Pharmacological treatment, which consists of a mixture of diluted dipyrone and metroclopramide administered intravenously, induces sleep, with pain and autonomic symptoms (nausea and vomiting) disappearing completely approximately five hours later. The patient chose not to undergo prophylactic treatment. Skull tomography and magnetic resonance imaging of the brain and cervical spine (column) are normal.

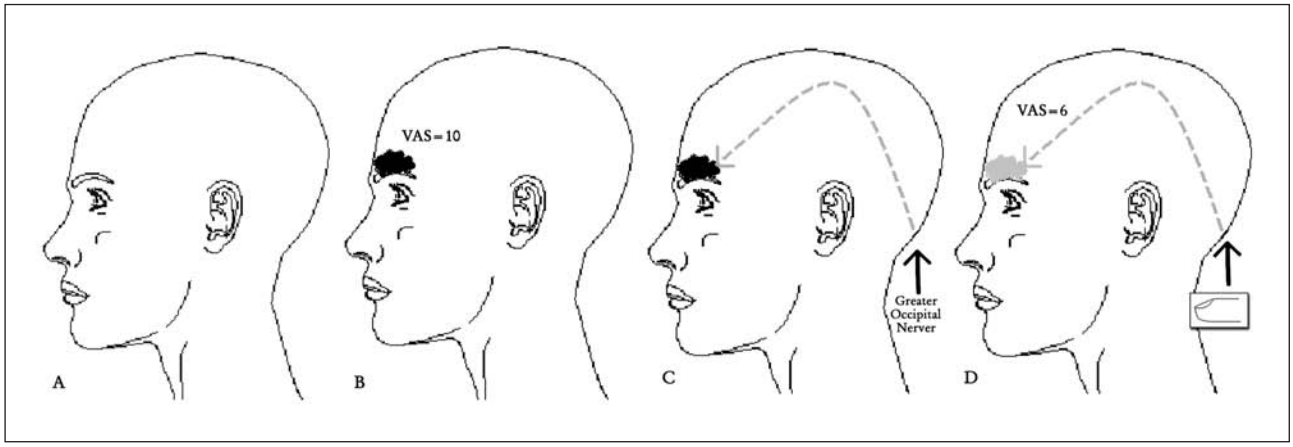

Fig 1. Distribution and evolution of the symptoms during migraine attacks. (A) Normal situation; (B) Topography and intensity of the initial symptoms; (C) Local of the massage during the migraine attacks; (D) Behavior of the pain during migraine attacks after the massage of the greater occipital nerve.

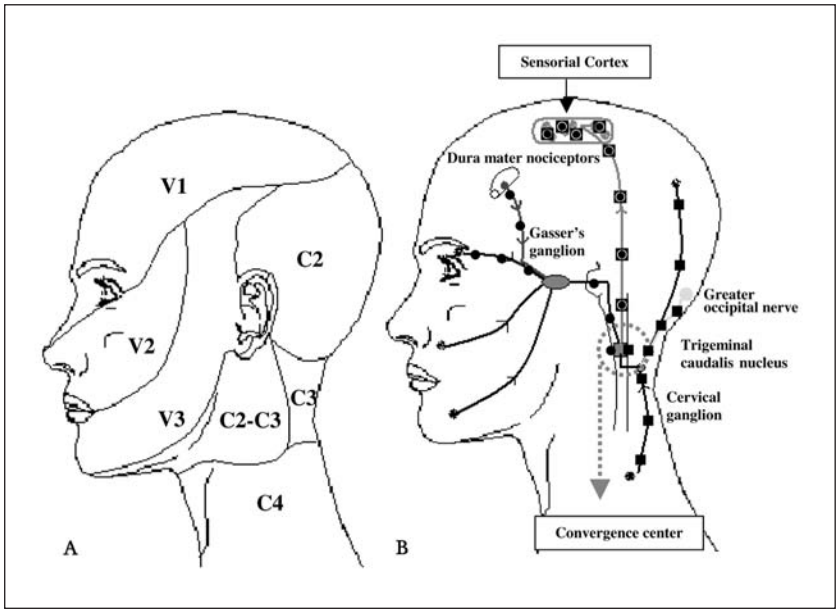

Fig 2. Convergence mechanisms between cervical and trigeminal nociceptive system. (A) Nociceptive distribution of the trigeminal and cervical system; (B) Ilustrative convergence mechanisms during the migraine attacks. ● Trigeminal input´s; ● cervical input´s; ● trigeminal and cervical convergente input´s.

Table 1. Electrophysiological and immunohistochemical laboratory studies to prove the existence of trigemino-cervical convergence. For convergence mechanisms to take place clinically, there must be a nerve that induces and a nerve that is induced, and both must have clinical manifestations.

Methods	Stimuli/species	Primary neuron #1 inductor neuron	Primary neuron #2 induced neuron	Features
trigemino-cervical reflex[15]	electrical/ human	supraorbital (V1 trigeminal branch)	sternocleidomastoid (C1-C4)	– sternocleidomastoid contraction
trigemino-cervical sensitization[16]	chemical-electrical/rats	GON (C1-C2)	meningeal neurons V1-trigeminal	• trigeminal sensitization
trigemino-cervical sensitization[17]	extraction incision tooth/rats	alveolar nerve (V2 trigeminal branch)	V1-trigeminal branches	• activation in bilateral neurons of the TNC and spinal cord
trigemino-cervical sensitization[18]	mustard oil/rats	supratentorial dura mater (V1) trigeminal branch	greater occipital nerve	• enlargement of the (T-C) cutaneous mechano-receptive fields • increased excitability to electrical stimulation of the GON
trigemino-cervical sensitization[16]	electrical and mustard oil/ rats	GON (C1-C2)	dura mater (V1) trigeminal branch	• enhanced afferent dural input • increased excitability of dural responses
trigemino-cervical sensitization[19]	electrical/cats	SSS (V1 trigeminal) GON (C1-C2)	TNC and upper cervical spinal cord (C1-C2)	• input from the superior sagittal sinus and the occipital nerve
c-fos[20]	electrical/ mechanical macaque, cats and rats	SSS (V1 trigeminal)	upper cervical spinal cord (C1-C2)	• fos expression in the TNC and dorsal horn of the C1 and C2
metabolic and vascular activity[21]	electrical/rats	SSS (V1 trigeminal)	upper cervical spinal cord (C1-C2)	• blood flow and metabolic activity increase in the TNC and LCN
metabolic activity (2-deoxyglucose autoradiography)[22]	electrical/cats	GON (C1-C2)	TNC	• increased metabolic activity in dorsal horn of the C1-C2 and TNC

LCN, lateral cervical nucleus; GON, greater occipital nerve; TNC, trigeminal nucleus caudalis; SSS, superior sagittal sinus.

Table 2. Therapeutic, clinical and experimental evidence from laboratory and clinical studies that prove the existence of the trigemino-cervical convergence process.

Methods	Stimuli/species	Neuron #1 inductor neuron	Neuron #2 induced neuron	Features	Drug used and effect
c-fos[23]	mustard and mineral oil/rats	occipital muscle (C1-C2)	V1-trigeminal branches	• altered c-fos expression (TC) complex	• MK 801 • inhibited fos expression
c-fos[24]	electrical/cats	SSS (V1) trigeminal branch	Upper cervical spinal cord (C1-C2)	• altered c-fos expression TNC and spinal cord (C1-C2)	• MK801 • large reduction in Fos expression
behavior study[25]	chemical/ humans	GON (C1-C2)	V1 (trigeminal branch)	• pain over the V1 territory	• H_2O • induced pain
pressure algometry[26]	visual/humans	(V1) ophthalmic trigeminal branch	GON (C1-C2)	• Reduced pain threshold over the GON	• no drugs
cervicogenic headache[27]	dysfunctions in cervical structures/ humans	cervical (C1-C3)	V1 (trigeminal branches)	• pain starts in occipital and suboccipital regions with frontal irradiation	• GON blocked • recovery from the pain symptoms
cluster and episodic and chronic migraine[28,29]	electrical stimulation/ humans	GON and suboccipital regions	V1 (territory)	• headache, such as cluster and episodic and chronic migraine	• GON stimulation • headaches improved

C1-C2, cervical branch; TC, trigeminal nucleus caudalis; V1, first-division of trigeminal nerve; GON, greater occipital nerve.

The patient has a family history (mother and sister) of migraine without aura.

The patient provided written informed consent, as required by appropriate local (and national) committees on the protection of research subjects.

DISCUSSION

We describe the case report of a patient suffering from migraine without aura preceded by primary stabbing headache who, during the evolution of the clinical picture, presented with signs and symptoms suggestive of cortical hypersensitization characterized by static mechanical allodynia. Diffuse nociceptive inhibition was triggered by massaging over the greater occipital nerve. The features of this case characterize inhibitory trigemino-cervical convergence mechanisms.

Stimuli on the trigeminal nociceptors producing clinical trigeminal and cervical responses, and vice versa, characterize trigemino-cervical convergence mechanisms (Fig 2). These mechanisms can be inhibitory or excitatory: inhibitory mechanisms are related to diffuse nociceptive inhibitory control, and excitatory mechanisms are observed in cases of migraine or cervicogenic headache or other myofascial syndromes (Table 1 and 2). Our daily observations in clinical practice suggest that the relationship between the intensity of the stimulus and the type of inhibitory or excitatory clinical response in trigemino-cervical convergence mechanisms is not fully understood, and indeed there is much controversy regarding this in the literature. The underlying disease and nociceptive tonus the patient presents while the convergence mechanisms are in action may influence the direction in which this response is targeted. For example, migraineurs can benefit from the pain relief afforded by electrical stimulation of the GON. In contrast, stimulation of the GON during asymptomatic periods can induce migraine attacks. As previously mentioned, these data suggest that trigemino-cervical convergence in migraine can be involved in inhibiting, inducing or potentializing pain (Tables 1 and 2). Recently Afridi et al have suggested that tenderness around the region of the GON was significantly associated with a positive response to the anesthetic injection. This suggests that tenderness may be useful in selecting out patients who are more likely to respond[5]. Diffuse noxious inhibitory control may be defined as the inhibition of nociceptive neurons in the spinal and trigeminal dorsal horns produced by a noxious stimulus applied to any body region remote from the neuron's excitatory receptive field[6].

The anatomical and neurophysiological basis of DNIC has been studied in detail in experimental and

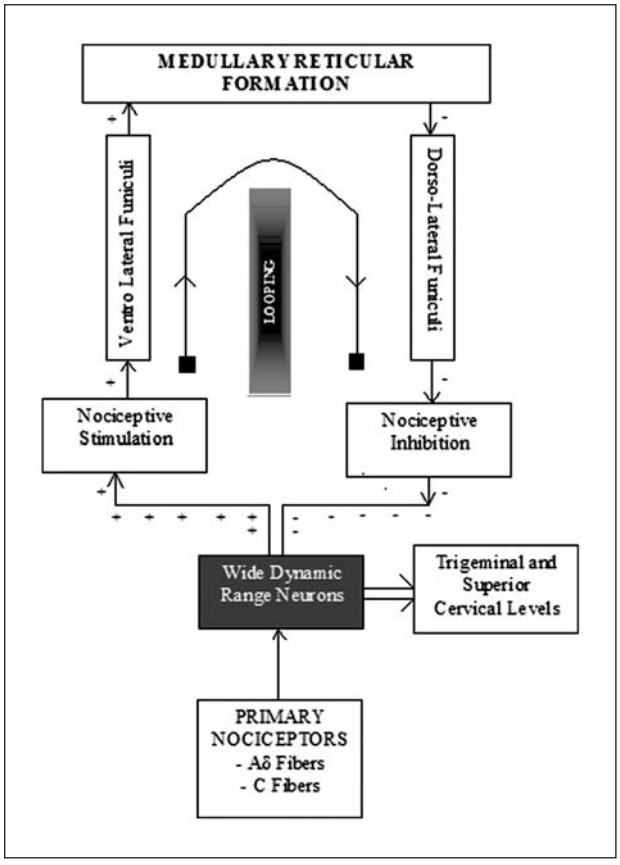

Fig 3. Diffuse noxious inhibitory controls (DNIC). Inhibitory bulbospinal pathways: (+) Stimulation, (–) Inhibition.

clinical models[7,8]. The effect of DNIC has been proved in studies of the trigeminal nociceptive system (i.e. blink reflex and trigeminal-mediated reflex)[9]. DNIC is mediated by a loop established by the spino-bulbospinal circuit, producing a post-synaptic inhibitory system[6] that acts directly on the wide-dynamic-range neurons[10] (Fig 3). The inhibitory control produced by DNIC acts specifically on spinal and trigeminal wide-dynamic-range (WDR) neurons. DNIC can be activated by stimuli that are not painful, as in the case described (in which the greater occipital nerve was massaged); however, the extent of its inhibitory effect depends on the intensity of the initial stimulus. This could explain why DNIC is more effective at inhibiting secondary (inflammatory) pain than primary (neurogenic) pain[11]. Recent studies have shown that pain modulatory systems subserving DNIC are impaired in both migraine and chronic tension-type headache[12], as well as in other pain situations such as fibromyalgia[13].

The patient in this study also presented with pain in the right molar region, which was aggravated when her teeth were subjected to mild compression (mechanical static allodynia). These findings, together with the presence of primary stabbing headache, characterize cortical sensitization.

Self-administered pain-relieving maneuvers in migraine such as massage over different regions of the skin produce scarce results in a good or excellent pain control. Moreover, the efficacy of maneuvers is often momentary, wearing off when the manoueuvre stopped. In spite of this, 46% of the subjects used the maneuvers constantly, at each attack. However, that study the massage over the GON is limited to few patients to make some conclusions[14].

In conclusion, showed a case suggestive of inhibitory trigemino-cervical convergence mechanisms during a migraine without aura attacks. The initial stimulus originated in the greater occipital nerve following light massage. The inhibitory mechanisms (DNIC) only come into operation after cortical sensitization (the presence of stabbing headache and static mechanical allodynia) and are only able to reduce the intensity of the pain. The duration of this improvement is directly proportional to the duration and intensity of the stimulus over the greater occipital nerve.

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