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Cervical muscles in the pathogenesis of migraine headache

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Abstract The pathogenesis of migraine headache is poorly understood but the trigeminovascular system seems to play an important role in it. The trigeminal nucleus caudalis is sensitised by noxious sensory stimuli, often from convergent afferents originating from a variety of tissues. In this paper, we review evidence to support the view that the cervical muscles play a role in the pathogenesis of the migraine headache as well by facilitating the mechanism of central sensitisation.

Key words Cervical muscles • Migraine • Central sensitisation • Convergence

Introduction

Migraine is a common disorder with a lifetime prevalence of 16%, worldwide, and a last-year prevalence of 10% [1, 2]. Although the pathogenesis of the migraine headache remains poorly understood, current theories suggest that a primary, genetically determined, central nervous system dysfunction is involved in the initiation of migraine headache, with subsequent activation of the trigeminovascular system [3, 4]. We review clinical and experimental evidence showing how nociceptive input from the cervical muscles may contribute to the activation of the trigeminovascular system as part of the pathogenesis of the migraine headache.

Pathogenesis of the migraine headache

Clinical and experimental considerations suggest that the pathogenesis of the migraine headache is intimately linked to the trigeminal innervation of the cranial blood vessels [5]. Dilation of these blood vessels and the consequent stimulation of the surrounding trigeminal sensory nerve fibres represent key mechanisms in the generation of the pain of the migraine headache [6]. Orthodromic conduction along the trigeminovascular nerve fibres transmits the nociceptive information centrally, via the trigeminal nucleus caudalis onto third-order neurones in the thalamus and from there on to cortical structures where the pain is perceived [7].

Central neuronal sensitisation

Sensitisation of central neurones is supposedly induced by input from the intracranial dura mater, travelling along the trigeminovascular pain pathway [8]. It results in:

- (i) Reduction of the threshold to cell depolarisation;
- (ii) Cellular activity that continues after cessation of the peripheral nociceptive input; and
- (iii) Spread of cellular activity to neighbouring cells [9–11].

Noxious stimulation of muscle afferents increases the excitability of spinal cord neurones [12]. Persistent noxious stimulation leads to cellular and molecular changes, which result in neuronal hyperexcitability to the extent that pain is elicited by low-threshold, normally non-noxious stimuli [13–18]. Cells in the trigeminal nucleus caudalis that are normally nociceptive-specific begin to respond to low-threshold, primary afferent mechanoreceptors, after an increase in central excitability produced by the activation of peripheral chemoreceptors [19]. Repeated stimulation of a dorsal root produces, in some neurones, a prolonged heterosynaptic facilitation with an augmentation of the response to the conditioning root (homosynaptic potentiation) as well as to adjacent test roots (heterosynaptic potentiation) [20].

Cervical muscles: clinical findings in migraine patients

Many migraine patients suffer from neck pain during and between attacks, stiffness and tenderness of the cervical muscles, and limitation of range of motion in the neck [21–26]. In addition, migraine patients are characterised by high electromyographic activity of the cervical muscles intra- and interictally [21, 27–29], and trigger-point injections may effectively treat them [23, 30, 31]. Although physical therapy and manipulation of the neck can precipitate migraine headaches [24], there is no known cause-effect relationship between cervical muscle tenderness and triggers, such as dietary factors, alcoholic beverages, and hormonal changes.

Nociceptive trigeminocervical convergence

The trigeminocervical nucleus is the area in the upper cervical spinal cord where sensory nerve fibres in the descending tract of the trigeminal nerve converge with sensory fibres from the upper cervical nerve roots [32]. In this nucleus, a considerable population of neurones demonstrates convergent input from the intracranial dura mater as well as from the cervical muscles. This convergence of trigeminal and upper-cervical nociceptive pathways suggests the existence of a functional continuum between the trigeminal and upper-cervical segments involved in cranial nociception and, thus, headache [33, 34]. Consequently, afferent nociceptive input from tight and sore or painful neck muscles innervated by the upper cervical nerve roots may contribute to the activation of the trigeminovascular, neuroinflammatory cascade [35].

The clinical phenomenon of pain in the front and back of the head and in the upper neck may be a consequence of overlapping processing of nociceptive information at the level of the second-order neurones in the trigeminocervical nucleus [34].

Conclusions

Current theories suggest that a primary, genetically determined, central nervous system dysfunction is involved in the initiation of the migraine headache, with subsequent activation of the trigeminovascular system and sensitisation of neurones in the central nervous system. Clinical findings suggest a relationship between migraine headache on the one hand and neck pain, or neck-muscle stiffness or tenderness, on the other hand. In addition, there is convergence of trigeminovascular and cervical-muscle nociceptive afferents in the area of the upper cervical cord, referred to as trigeminocervical nucleus. The evidence provides a compelling argument that central sensitisation may be enhanced, at least in some migraine patients, by sensory input originating from the cervical muscles.

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References

1. Rasmussen BK, Jensen R, Schroll M, Olesen J (1991) Epidemiology of headache in a general population - a prevalence study. *J Clin Epidemiol* 44:1147–1157
2. Schwartz BS, Stewart WF, Lipton RB (1997) Lost workdays and decreased work effectiveness associated with headache in the workplace. *J Occup Environ Med* 39:320–327
3. Russell MB (1997) Genetic epidemiology of migraine and cluster headache. *Cephalalgia* 17:683–701

4. Edvinsson L (2001) Aspects on the pathophysiology of migraine and cluster headache. *Pharmacol Toxicol* 89:65-73
5. Goadsby PJ, Edvinsson L (1993) The trigeminovascular system and migraine: studies characterizing cerebrovascular and neuropeptide changes seen in humans and cats. *Ann Neurol* 33:48-56
6. Davis KD, Dostrovsky JO (1986) Activation of trigeminal brain-stem nociceptive neurons by dural artery stimulation. *Pain* 25:395-401
7. Sanchez del Rio M, Reuter U, Moskowitz MA (2000) Central and peripheral mechanisms of migraine. *Funct Neurol* 15[Suppl 3]:157-162
8. Malick A, Burstein R (2000) Peripheral and central sensitization during migraine. *Funct Neurol* 15[Suppl 3]:28-35
9. Woolf CJ, Salter MW (2000) Neuronal plasticity: increasing the gain in pain. *Science* 288:1765-1768
- 10.Coderre TJ, Katz J (1997) Peripheral and central hyperexcitability: differential signs and symptoms in persistent pain. *Behav Brain Sci* 20:404-419
11. Dubner R (2000) Neural basis of persistent pain: sensory specialization, sensory modulation, and neuronal plasticity. In: Jensen TS, Turner JA, Weisenfeld-Hallin Z (eds) *Progress in pain research and management*. IASP, Seattle, pp 77-91
12. Hu JW, Sessle BJ, Raboisson P, Dallel R, Woda A (1992) Stimulation of craniofacial muscle afferents induces prolonged facilitatory effects in trigeminal nociceptive brain-stem neurones. *Pain* 48:53-60
13. Jensen TS (1996) Mechanisms of neuropathic pain. In: Campbell JN (ed) *Pain 1996, an updated review*. IASP, Seattle, pp 77-86
14. Gracely RH, Lynch SA, Bennett GJ (1992) Painful neuropathy: altered central processing, maintained dynamically by peripheral input. *Pain* 51:175-194
15. Gottrup H, Nielsen J, Arendt-Nielsen L, Jensen TS (1998) The relationship between sensory thresholds and mechanical hyperalgesia in nerve injury. *Pain* 75:321-329
16. Gottrup H, Andersen J, Arendt-Nielsen L, Jensen TS (2000) Psychophysical examination of patients following operation for cancer mammae. *Pain* 87:275-284
17. Koltzenburg M (1998) Painful neuropathies. *Curr Opin Neurol* 67:307-316
18. Yamamura H, Malick A, Chamberlin NL, Burstein R (1999) Cardiovascular and neuronal responses to head stimulation reflect central sensitization and cutaneous allodynia in a rat model of migraine. *J Neurophysiol* 81:479-493
19. Woolf CJ, Shortland P, Sivilotti LG (1994) Sensitization of high mechanotransduction threshold superficial dorsal horn and flexor motor neurones following chemosensitive primary afferent activation. *Pain* 58:141-155
20. Woolf CJ, Thompson SW, King AE (1988-89) Prolonged primary afferent induced alterations in dorsal horn neurones, an intracellular analysis in vivo and in vitro. *J Physiol [Paris]* 83:255-266
21. Bakal DA, Kaganov JA (1977) Muscle contraction and migraine headache: psychophysiological comparison. *Headache* 17:208-215
22. Kidd RF, Nelson R (1993) Musculoskeletal dysfunction of the neck in migraine and tension headache. *Headache* 33:566-569
23. Tfelt-Hansen P, Lous I, Olesen J (1981) Prevalence and significance of muscle tenderness during common migraine attacks. *Headache* 21:49-54
24. Blau JN, MacGregor EA (1994) Migraine and the neck. *Headache* 34:88-90
25. Bakke M, Tfelt-Hansen P, Olesen J, Møller E (1982) Action of some pericranial muscles during provoked attacks of common migraine. *Pain* 14:121-135
26. Anttila P, Metsähonkala L, Mikkelsen M, Aromaa M, Kautiainen H, Salminen J, Viander S, Jäppilä E, Sillanpää M (2002) Muscle tenderness in pericranial and neck-shoulder region in children with headache. *Cephalalgia* 22:340-344
27. Cohen MJ (1978) Psychophysiological studies of headache: is there a similarity between migraine and muscle contraction headache? *Headache* 18:189-196
28. Clifford T, Lauritzen M, Bakke M, Olesen J, Møller E (1982) Electromyography of pericranial muscles during treatment of spontaneous common migraine attacks. *Pain* 14:137-147
29. Pozniak-Patewicz E (1976) "Cephalgic" spasm of head and neck muscles. *Headache* 15:261-266
30. Hay KM (1976) The treatment of pain trigger areas in migraine. *J R Coll Gen Pract* 26:372-376
31. Hay KM (1979) Pain thresholds in migraine. *Practitioner* 222:827-833
32. Biondi DM (2000) Cervicogenic headache: mechanisms, evaluation, and treatment strategies. *J Am Osteopath Assoc* 100[Suppl 9]:S7-S14
33. Bartsch T, Goadsby PJ (2002) Stimulation of the greater occipital nerve induces increased central excitability of dural afferent input. *Brain* 125:1496-1509
34. Goadsby PJ, Knight YE, Hoskin KL (1997) Stimulation of the greater occipital nerve increases metabolic activity in the trigeminal nucleus caudalis and cervical dorsal horn of the cat. *Pain* 73:23-28
35. Biondi DM (2001) Cervicogenic headache: diagnostic evaluation and treatment strategies. *Curr Pain Headache Rep* 5:361-368