Neck muscle afferents influence oromotor and cardiorespiratory brainstem neural circuits

Brain Structure & Function March 2014

IJ Edwards, VK Lall, JF Paton, Y Yanagawa, G Szabo, SA Deuchars, J Deuchars
From the School of Biomedical Sciences, University of Leeds, UK

KEY POINTS FROM THIS ARTICLE:

1) “The intermedius nucleus of the medulla (InM) is a neurochemically diverse perihypoglossal nucleus.” **[It is in the caudal medulla, just above the atlas]**

2) These authors investigated “whether upper cervical sensory afferents, particularly those arising from muscle spindle afferents [mechanoreceptors/proprioceptors], do indeed influence cardiorespiratory activity.”

3) “Sensory information arising from the upper neck is important in the reflex control of posture and eye position.”

4) Sensory information from the upper neck is “linked to the autonomic control of the cardiovascular and respiratory systems.”

5) Whiplash disorders and cervical dystonia often present with abnormalities to the oromotor, respiratory and cardiovascular systems.

6) In animal experiments:

- Electrically stimulating neck afferents of the C2 nerve alters the pattern of central respiratory drive and increased perfusion pressure.

- Tracing these C2 sensory afferents show projections to the intermedius nucleus of the medulla (InM), and the evidence indicates that they are proprioceptive.

- “Anterograde tracing from the InM identified projections to brain regions involved in respiratory, cardiovascular, postural and oro-facial behaviors—the neighboring hypoglossal nucleus, facial and motor trigeminal nuclei, parabrachial nuclei, rostral and caudal ventrolateral medulla and nucleus ambiguus.”

- Electrical stimulation of afferent fiber tracts lateral to the cuneate nucleus monosynaptically excited InM neurones.

- Direct stimulation of the InM mimicked the response of second cervical nerve stimulation

8) “Disruption of these neuronal pathways could, therefore, explain the dysphagic and cardiorespiratory abnormalities which may accompany cervical dystonia and whiplash associated disorders.”

9) There exists a monosynaptic projection from the InM into the nucleus of the solitary tract (NTS), “indicating a possible role in autonomic and/or respiratory control.”

10) There is direct primary afferent input to the InM from upper cervical levels.

11) “Studies are suggestive of a possible role for the InM in mediating autonomic/respiratory responses to sensory afferent signals arising from the upper neck.”

15) These findings reveal cardiorespiratory responses to neck muscle afferent stimulation.

16) The primary investigations in this study involved rats, antibody phenotype tracings, immunohistochemistry staining, confocal microscopic assessment, electron microscopy, nerve stimulation, and much more. The exact protocols are extremely sophisticated and complex.

17) The experiments showed:

- Cardiovascular and respiratory responses to C2 nerve stimulation.
- “C2 muscle afferents terminate within the intermedius nucleus of the medulla (InM).”
- There is also a direct pathway from the cuneate nucleus to the InM.
- “Neurones in the InM send efferent projections to known CNS areas associated with cardiovascular and oromotor functions.”
- The “efferent projections from the InM were bilateral with an ipsilateral predominance.”

- The InM neurons fired to (and significantly bilaterally):
    - •• Cranial Nerve XII
    - •• Cranial Nerve VII
    - •• the ventrolateral medulla, coursing through the intermediate reticular formation with terminals observed within the nucleus ambiguous
    - •• the nucleus tractus solitarius (NTS)
    - •• the caudal portion of the spinal vestibular nucleus
    - •• they showed medullary catecholamine immunoreactivity
    - •• the ventral horn motoneurones in the cervical spinal cord at levels C4–6, predominantly around the phrenic motoneurones
    - •• the pontine parabrachial nucleus
    - •• medullary sympathetic relays
    - •• “Efferent projections from the InM were observed within cardiovascular, respiratory and oromotor regions of the brainstem.”
    - •• “This study shows that stimulation of neck muscle afferents can influence behaviour of the cardiovascular and respiratory systems. This is due to unique neuronal pathways which exhibit specialized functions, the first stage of this signaling arising from neck muscles.”

18) “Neurophysiological and neuroanatomical experiments indicate that the [upper cervical] sensory input exerts its influence via the InM, which appears to act as an integratory center.”

19) “Neck muscle afferent input to the intermedius nucleus of the medulla (InM).”

20) “Neuroanatomical studies looking at the central targets of cervical sensory afferents have revealed a direct sensory projection to the InM from upper cervical but not lower cervical levels.”

21) “The input to the InM is thought to be of a muscle origin [muscle proprioceptors/spindles] as when tracers are applied to the lesser occipital nerve, a pure skin nerve branch of C2, no terminal labeling is observed within the InM.”

22) “The majority of the traffic to the InM through the C2 nerve is likely to be of a muscle origin.” “Many of the primary afferent inputs to the InM arise from the musculature of the neck.”

23) “The muscles supplying the upper cervical segments are particularly rich in muscle spindles.”

27) The InM may be acting as an upper cervical muscle sensory relay station.

28) The InM is a major source of input to the hypoglossal nucleus. “The InM appears to be in a prime position to integrate information from both the periphery and the CNS before influencing airway patency and tongue movements through the hypoglossal nucleus.”

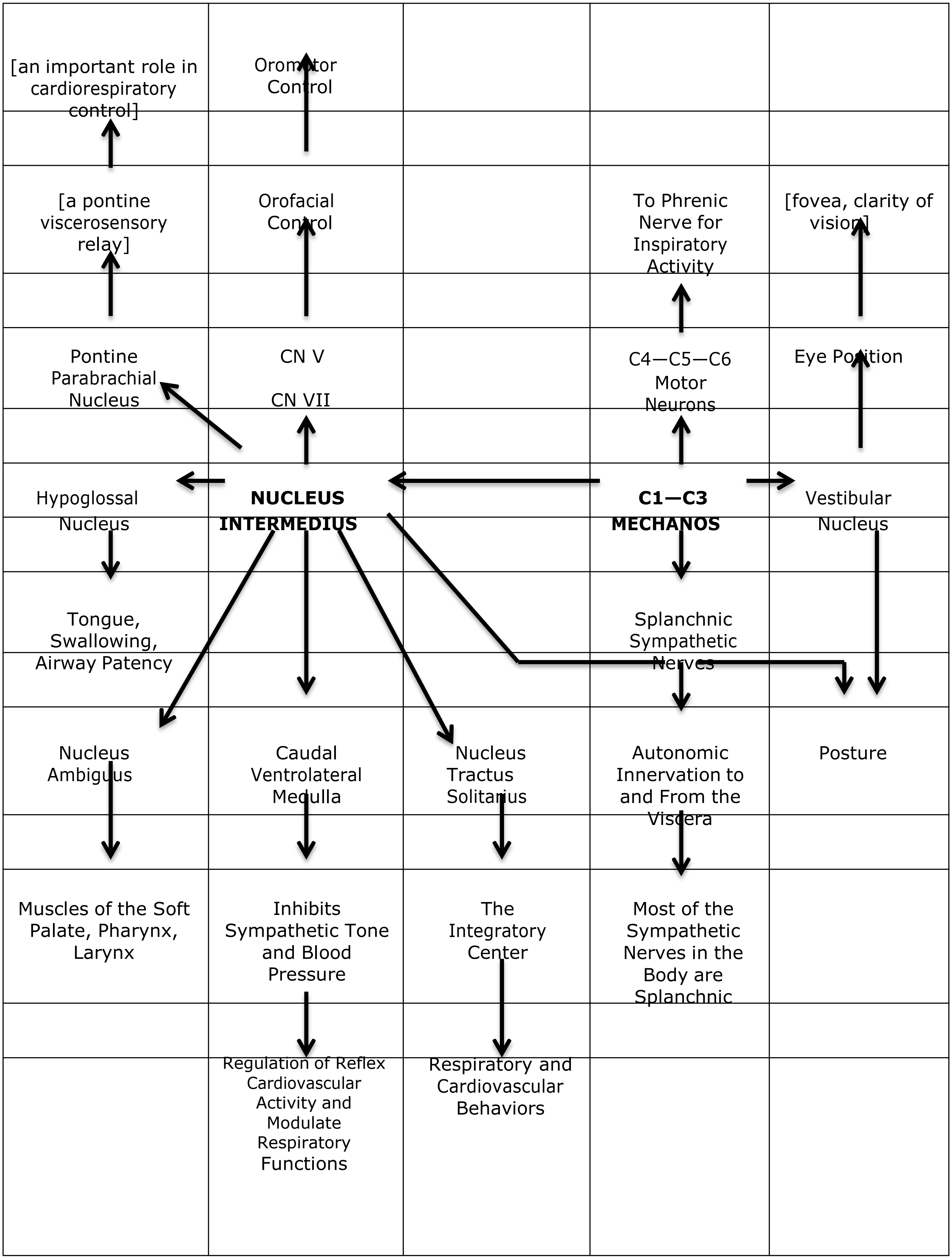
29) A main unique target of the “upper cervical sensory afferents is the InM.”

30) The InM plays an integral part to upper cervical peripheral nerve stimulation.

COMMENTS

I significantly simplified this article. The authors presented detailed, complex, sophisticated primary research showing the biological plausibility of how the proprioceptors of the upper cervical spine influence a wide variety of visceral responses. This supports more than a century of chiropractic anecdotal and clinical observations.

The nucleus intermedius (InM) in turn influences the function of the lower 7 cranial nerves, including their parasympathetic functions, as well as medullary sympathetic relays. The biological plausibility is that the upper cervical spine mechanosensitive afferents have a major influence in the balance between the parasympathetic and sympathetic nervous systems, influencing whole body homeostasis and health. Please note the following schematic:



Dr. Chris Quigley, Boston Spine, Disc and Chiropractic Center
102 Charles Street, Boston Massachusetts 02114
617-720-1992 DrChris@DrQuigley.com