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REVIEW

Expanding Medical Acupuncture to Promote Balance: The Role of Cerebellar Functioning

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ABSTRACT

Conventional neurology teaches that the cerebellum is a regulator of balance; smoothness; and synergy of coordinated movement, speech, and oculomotor activity. Recent discoveries have expanded the understanding of the role of the cerebellum in affective behavior, executive functioning, and movement. Medical acupuncture treatments that can access the cerebellum and influence treatment choices are reviewed in this article. As practitioners consider medical acupuncture patients, it is valuable to be mindful of the inordinate role that the cerebellum can play in disturbances of affective behavior, executive function, and all aspects of movement.

Keywords: balance, cerebellum, affect, executive function, medical acupuncture

INTRODUCTION

Neurology teaches that the cerebellum is involved in stance, gait, balance, eye-movement coordination, speech articulation, and regulation of coordinated motor activities.[1,2] These functions can be assessed clinically by tandem gait challenge, conjugate-ocular motion observation, speech analysis, and limb-coordination tests.[2,3] The pathologic signs of cerebellar dysfunction are ataxia, nystagmus, dysarthria, intention tremor, dysmetria, and impaired rapid alternating motions (dysdiadochokinesia.)[2]

In 2018, functional magnetic resonance imaging (fMRI) studies, from Washington University in St. Louis, were reported to show cerebellar activation associated with nonmotor functions in 80% of cases.[4] This 80% represented activity of the affective and executive networks. Furthermore, while the cerebellum occupies 10% of the intracranial volume, studies have shown that it contains 101 billion neurons while the cerebral neocortex contains 21–26 billion neurons.[5,6]

The 2018 report of cerebellar activation during primarily nonmotor activities was surprising.[4] Speculation suggests several converging factors leading to the previously hidden life of the cerebellum and to its new and emerging role. The neurology library does not reveal an appreciation of the cerebellum beyond the vestibulocerebellar and motor domain until recently.[7] Newer considerations of the behavioral aspect of affect, extensive neuropsychologic testing, and interdisciplinary evaluations have led to a deeper understanding of the cerebellar self.[8] New technologies, such as fMRI, showed cerebral flood flow changes during activities in a live subject. The cerebellum has been more-difficult to scan due to its anatomical location but with newer 7.0 Tesla magnets and appropriate protocols, imaging can be achieved. Magnetic resonance imaging–diffusion tensor imaging (MRI-DTI) enables visualization of connectivity through the showing the tracts themselves. These convergences enabled new structural and functional discoveries.

A contemporary view of the cerebellum sees it as a neuronal, computational device.[7] The redundant, stereotypical neuronal circuitry enables definition of inputs and outputs for this neural ''machine.'' Inputs come from the large population of granule cells that provide spatial and temporal information through the dense parallel fiber system of the molecular layer. The density of the parallel fiber system correlates with its capacity to function as an adaptive filter.[8] In sharks, this system is geared to recognizing the shifting current changes felt by the shark's external hair cells. Its primitive cerebellum is used like noise-cancelling headphones to subtract the shark's own movements from all other external

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movements including the external prey's movements. This then identifies all nonself-generated signals to be external and possibly prey. In this way, the cerebellum helps to create an image of self versus nonself.[8] The extreme cell numbers in the cerebellum are meant to provide a rich information stream. Knowledge of the proprioceptive and other consequences of one's actions is necessary to have if one has reached one's target. Climbing fibers provide the error signals regarding the predicted outcome and the actual outcome.[6]

Both afferent streams, from granule cells and climbing fibers, influence the solitary efferent cells, the Purkinje cells. These large cells are gamma aminobutyric acid–ergic and inhibitory, operating as an internal, negative-feedback, braking mechanism as they project to the deep dentate nuclei of the cerebellum. The dentate nuclei project to the contralateral red nuclei. From the red nucleus, ascending fibers synapse in the thalamus, which then project to the motor and premotor cortices, descending rubrospinal fibers influence spinal, segmental gamma-servomotor mechanisms, and recurrent rubrocerebellar climbing-fiber tracts help synchronize and enable meeting of intention with actualization. It has been suggested that the premotor cortex, lateral cerebellum, and the recurrent climbing fiber error-message loop might participate in motor learning and mental–motor rehearsal.[7]

Taking real-time inputs, comparing them with predicted results, and making corrections through feed-forward mechanisms based on prediction, the basic, reiterated cerebellar computational circuit allows the cerebellum to learn and perform these functions. This type of circuitry enables the cerebellum to update and store internalized dynamic models that relate the global movement and action demands of the individual to the actual physical states of the body. The role of the cerebellum as quality controller manifests in its ability to learn, to learn timing, contextual timing, and precision to enhance the predictive performance of the cerebellum. It is particularly important when learning tasks and skill sets requiring repetitive practice.[6]

In 1998, Schmahmann and Sherman identified a unique clinical syndrome in 20 patients suffering with mixed cerebellar pathologies. These patients had hypoplasias, infarctions, traumata, and tumors. Their multidisciplinary evaluations revealed a constellation of affective behavior and executive-function abnormalities. They described the cerebellar cognitive-affect syndrome (CCAS).[9] His patients had disturbed modulation of affective behavior, executive function, and personality. They had impaired memory, language, cognition, and visuospatial organization, with features of distractibility, impulsivity, hyperactivity, disinhibition, and anxiety. They manifested ritualistic behaviors, illogical thinking, lack of empathy, irritability, aggressiveness, depressive behavior, with sensitivity to sensory overload, and poor maintenance of boundaries. They tended to cluster into four general groups: patients with (1) impaired executive function; (2) those with impaired visuospatial function; (3) those who had personality changes; and (4) and those with language impairments. In an attempt to create a new term they labeled this condition *dysmetria of thought*.[10]

Relatively recent research has expanded understanding of the cerebellum and its functions. In 2018, Marek et al., at Washington University did fMRI studies of the cerebellum showing that 80% of its activity is associated with nonmotor activities.[4] Resting-state and task-related fMRI activity was mostly associated with thinking, planning, feeling, and communicating. The cerebellum showed its greatest connectivity with the default-mode network and the executive network of the central nervous system.[4] In 2016, Klein et al. at the National Institutes of Health mapped the cerebellum functionally using fMRI.[11] Cognition localized to the most lateral cerebellum, and sensorimotor pathways to the intermediate cerebellum, while affect-serving structures localized to the most midline cerebellar structures. Executive functions and personality were shown to be dependent on bilateral activity, while visuospatial tasks engaged the left cerebellar hemisphere, and language primarily engaged the right cerebellar hemisphere.[11]

In 2016, Meabon and a team at the University of Washington demonstrated that blast exposure caused lasting cerebellar dysfunction in an animal model and in human combat veterans.[12] The more blast exposure sustained, the more dysfunction the more Purkinje cell loss occurred. ^{18}FDG [18-fludeoxyglucose] positron emission tomography (PET) showed decreased cerebellar uptake after blast exposure, MRI-DIT showed increased disruption of cerebellar tracts after blast exposure. Phosphorylated-*tau* protein, indicative of cytoskeletal disruption, accumulates in Purkinje cells in association with blast exposure, as does the gliosis is seen in deep subcortical nuclei of the cerebellum and at the blood–brain barrier.[12]

In 2019, at the Canadian Institute of Health Research, Rabellino and her colleagues demonstrated variations of altered cerebellar connectivity in patients diagnosed with posttraumatic stress disorder (PTSD), depending on the presence or absence of dissociative clinical features.[13] In 2018, Holmes and a group at Yale, portrayed the cerebellar and prefrontal alterations in PTSD, using structural and functional evaluations, morphometry, and fMRI.[14] The study showed that, in subjects experiencing chronic stress, the cerebellum has a commensurate impairment of connectivity and a reduction in volume.[14]

The following sections comprise a brief summary of known cerebellar patterns of function and dysfunction as they relate to motor, affective, and executive functions.

THE CEREBELLUM AND MOTOR FUNCTIONS

Motor functions of the cerebellum include:

- Modulation of vestibular and motor behavior
- Balance of stance and gait
- Nystagmus, the binocular, biphasic eye movements, conjugate, and symmetricality

- Speech with proper rhythm, speed, timing, amplitude, prosody, and clarity
- Ability to reach a target by properly gauging speed, distance, and power of movement needed
- Ability to maintain a fine balance between agonist and antagonist muscles when active
- Ability to switch rapidly among antagonistic muscle groups as needed
- Smooth and graceful movements.

THE CEREBELLUM AND MOTOR DYSFUNCTIONS

Motor dysfunctions of the cerebellum include:

- Disturbed modulation of vestibular and motor behavior
- Ataxia with wide-based stance and gait, arms abducted for stability
- Nystagmus appearing asymmetrically or pendular
- Dysarthia with slurred speech, scanning speech, and loss of prosody, rhythm, and sound.
- Dysmetria demonstrating undershooting or, over shooting of the target; missing the point!
- Intention tremor that increases in amplitude as it approaches its target.
- Dysdiadochokinesia with trouble switching rapidly between agonist and antagonist muscle groups (i.e., pronation/supination of the palm).[15]

THE CEREBELLUM AND AFFECTIVE FUNCTIONS

Affective functions of the cerebellum include:

- Modulation of affective behavior
- Sense of self, sense of boundaries
- Emotional stability, well-regulated affective behavior
- Smooth and graceful affective behaviors.

THE CEREBELLUM AND AFFECTIVE DYSFUNCTIONS

Affective dysfunctions of the cerebellum include:

- Disturbed modulation of affective behavior
- Trouble with boundaries
- Emotional imbalance
- Impaired memory, disturbed personality, aggressiveness, impaired empathy
- Trouble interpreting affective and social cues, and impaired social relations
- Impulsivity, distractibility, hyperactivity, irritability, and ritualistic behaviors
- Anxiety and depression.

THE CEREBELLUM AND EXECUTIVE FUNCTIONS

Executive functions of the cerebellum include:

- Modulation of executive function
- Sense of self, sense of agency
- Able to think and imagine, plan and create, and communicate and execute
- Smooth and graceful executive functions.

THE CEREBELLUM AND EXECUTIVE DYSFUNCTIONS

Executive dysfunctions of the cerebellum include:

- Disturbed modulation of executive functions
- Loss of sense of agency
- Unbalanced thinking
- Poor communication skills
- Thoughts and plans that miss the point
- Impaired memory, disturbed personality, disturbed cognition, impaired visuospatial organization, impulsivity, distractibility, hyperactivity, illogical thinking, poor empathy, and ritualistic behaviors.

ACUPUNCTURE AND THE CEREBELLUM

If acupuncture's goal can be seen as moving the patient toward balance, then persistent imbalance is the state associated with the development of symptoms and later signs of illness. Treatment must pursue balance at all levels available. To that end, adding specific cerebellar treatment must be a consideration. Various functions of the cerebellum can be regulated through the use of various forms of acupuncture. Treatment approaches for the cerebellum and its varied functions have been explored.

Cerebellar access using acupuncture

Points used to attain cerebellar access include:

- GV16—This is the biggest acupoint near the cerebellum. GV16 is particularly rewarding, as it also serves as a Window of the Sky/Window of Heaven point. It is the point where *Du Mai* enters the brain. This point clears Wind and, therefore, is used for all acute brain problems (infarctions, seizures, mania, neck stiffness, refractory headaches and dizziness, sudden speech loss, and more).[16]
- GV16 +/- GB12 and GB20—This point widens the zone of access to the cranial base, posterior fossa, and the cerebellum.
- GV20—The upper *Dantian,* the most Yang acupoint where all Yang Qi meets, this point regulates Yang in

Excess states to cause Yang to descend and, in Deficiency states to raise Yang. This point meets with the BL, GB, TH, and LR channels. Therefore, the point is useful for addressing interior Wind conditions (i.e., dizziness, tinnitus, and headache). It is the Sea of Marrow point, useful for all brain and brain-related problems.[16]

In addition:

- *Du Mai*—The Sea of Marrow, Sea of Yang, enters the brain at GV 16, and exits the brain at GV 20. The *Du Mai* has a Heart branch that enables psychoemotional access through treatment.
- *Sishencong*—This array widens the functional zone of GV 20 with 4 quadrantic needles inserted from 1'' away, aiming transversely at GV 20.

Balancing Techniques

There are two sets of balancing techniques. Global balancing involves use of SP 6, GB 39, MH 6, TH 5, and CV 12. Autonomic balancing involves use of LR 3, SP 6, MH 6, HT 7, LI 4, and ST 36.

Equilibration Techniques

Equilibrium techniques include Five-Phase dynamic management[17] and trigram-driven triangular energetic equilibrations.[17]

Scalp Acupuncture

The balance region overlies the cerebellum and posterior fossa, 3–4 cm from either side of the midline, at the level of the inion, a zone spanning 3–4 cm inferiorly.[18]

Auricular Acupuncture

On the Anterior ear, the cerebellum region is on the Antihelix, region AH 1, anterior to the cervical spine zone. On the Posterior ear, the cerebellum region is on the posterior periphery within region PP 2.[19]

Hand Acupuncture

The dorsal aspect of the distal phalanx, middle finger, the distal aspect of the distal interphalangeal joint, which represents the cerebellar region.[20]

DISCUSSION

The cerebellum is involved in balance, synergy, coordination, and grace. Lacks of grace in movement, in thought, in affect, in behavior, and in psychosocial settings are frequently seen in clinical practice. Are they all significantly cerebellar in nature?

The following sections represent speculative considerations of 3 novel cerebellar syndromes.

Affective Ataxia

This syndrome manifests with difficulty with emotional balance and social interactions, trouble interpreting social cues, and clumsiness in affective expression and receptivity. The patient has trouble with maintaining boundaries.

Cognitive Dysmetria

This problem involves missing the point, not getting the joke, and/or not connecting in conversation or with conversation. The patient's thoughts and plans that are off target in execution. Often, this is due to poor communications and misperceptions.

Dysdiadochokinetic Syndromes

These syndromes involve inability to make rapid cognitive and behavioral changes in real life's time constraints. This can affect thought patterns, affective behaviors, and interpersonal demands. Usually, this is due to the diminished resilience, limited range, flexibility, and reserve of the affected individual.

Understanding and Managing the Syndromes

Certainly, these syndromes need to corroborated in the clinic, with fMRI, and in more-and better-controlled studies. There is little in the neurologic literature and even less in the English-language acupuncture literature on these matters. The current author's own unblinded, nonrandomized, uncontrolled anecdotal observations of general clinic patients treated with cerebellar access points showed meaningful responses to treatment. Often, this was manifested at the affective level with deeper calming, better emotional awareness, and improved social interactions. However, this sample size was small and more-systematic testing is in order.

Medical acupuncture performed in the pursuit of balance, patient well-being, and optimal therapeutic outcome can be influenced by specific attention to the cerebellum as outlined in this article.

CONCLUSIONS

The cerebellum has been underappreciated for its robust function in securing grace. Graceful movement has been well-appreciated previously. Now, it is known that graceful affective behavior and graceful thinking, and the ability to communicate comfortably and successfully, may be associated with the cerebellum. Furthermore, these functions can be threatened by a host of natural and unnatural conditions.

Balance can be fostered by taking advantage of synergic efforts beyond acupuncture. Balanced eating, balanced working/resting, balanced physical activities, including exercises that emphasize balance (i.e., yoga, *T'ai Chi*, equestrianism, gymnastics), balanced mental/emotional life (i.e., meditation, *Qigong*, yoga, *T'ai Chi*, group time). These become a part of the patient's prescription. They are especially important in that they require the active participation of the patient.

Adding cerebellar awareness to the diagnostic process enables cerebellar considerations for inclusion in treatment planning. This article is meant to provide a more-comprehensive and helpful approach to our complex patients.

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