Analysis of EMG writer`s cramp pathophysiology

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Abstract
Time and again, around five percent check in an accident or injury to the intrinsic hands or arms the moment preceding the onset of signs and symptoms (or features) of dystonia writer`s cramp. Dystnoic Writer's cramp frequently affects persons who write a great deal or perform other repetitive hand movements such as typing. However, less than fifty percent (< 50 %) of the patients with writer's cramp give a history of intensive writing before dystonia onset and did not find a correlation between the estimate of writing hours and the age of onset. It is noted that prolonged rest from writing did not result in remission and in some patients, dystonia developed on writing at a fast pace in an uncomfortable position. Hence, the most likely scenario is that, like most diseases, writer's cramp is a product of a genetic background and an environmental insult. That is, writer's cramp develops with excessive writing only in those persons who are genetically predisposed. Rare associations have been reported, including C6 ruptured disk, lithium use, basal ganglia or cortical tumors, arteriovenous malformations (AVMs), and stroke, but their role in causing dystonia is still unknown. This study reveals the pathophysiology of the EMG dystonic writer`s cramp and analysis.

Keywords: EMG, SICI, MEPs

Introduction

Dystonia can be classified as focal (single region), segmental (2 or more regions), multifocal (2 or more nonadjacent regions) or generalized (leg or legs, trunk and one other region) or hemi dystonia (ipsilateral arm and leg), based on the region involved.[1-14] Writer's cramp is a task specific focal dystonia. Approximately 5% of patients have a positive family history of a similar condition. Patients with D.Y.T.1 gene-mutation may initially present with writer's cramp before developing generalized dystonia and may have a history of writer's cramp among their family members. In EMG dystonic writer`s cramp, most cases are idiopathic.

Cohen and Hallet observed abnormal EMG pattern in 19 patients with hand dystonia. They exhibited excessive co-contraction of agonists and antagonist muscles with prolongation of EMG bursts. In healthy individuals while the EMG bursts lasted for 100 milli-seconds, they lasted for 200-300 ms in patients with dystonia. There was occasional failure of willed activity to occur and there was lack of selectivity in attempts to perform independent finger movements.[30]

Atypical electrophysiological activation

The finding of abnormal co-contraction of agonists and antagonists is the underlying feature of all dystonia and suggests abnormal motor control and muscle selection by the basal ganglia.[30]

The exact pathophysiology of dystonia is still unclear. There are three proposed mechanisms –loss of inhibition, abnormal plasticity and abnormal sensory activation, which individually or together has been noted in dystonia.

Failure of inhibition

A principal finding in focal dystonia is that of loss of inhibition.The abnormally long bursts of EMG activity, co-contraction of antagonist muscles, and overflow of activity into muscles not intended for the task may be explained by the loss of inhibition. Various studies have demonstrated loss of inhibition at spinal, brainstem and cortical level.

Spinal/or vertebral and brainstem reflexes

A study by Nakashima et al recorded reciprocal inhibition between forearm muscles in 16 patients with writer's cramp, other occupational cramps, hemidystonia and hemi paresis due to stroke and 10 healthy controls. In this study, early disynaptic phase of reciprocal inhibition was normal but there was a reduction in later presynaptic inhibition in writer's cramp patients. Panizza et al studied H reflex recovery curve and reciprocal inhibition in different dystonias and found a decrease in the amount of reciprocal inhibition among patients with writer's cramp.[15-20, 30]

Similarly in other focal dystonia like blepharospasm, abnormalities of blink reflex recovery have been demonstrated. Loss of reciprocal inhibition can be partly responsible for presence of co-contraction of antagonist muscles that characterizes voluntary movement in dystonia.

Motor cortical functioning

Loss of inhibition has also been be demonstrated for motor cortical function via studies on short intracortical inhibition, long intracortical inhibition, and the silent period.

Brief and short-intra cortical-inhibition

Using transcranial magnetic stimulation, short intracortical inhibition (SICI) is obtained with paired pulse methods and reflects interneuron influences in the cortex. In such studies, an initial conditioning stimulus is given, enough to activate

cortical neurons, but small enough that no descending influence on the spinal cord can be detected. A second test stimulus, at suprathreshold level, follows at short interval. Intracortical influences initiated by the conditioning stimulus modulate the amplitude of the motor evoked potential (MEP) produced by the test stimulus. At short intervals, less than 5ms, there is inhibition that is largely a GABAergic effect, mediated via GABA-A receptors called short intracortical inhibition or SICI. At intervals between 8 and 30ms, there is facilitation, called intracortical facilitation, (ICF).

In studies on patients with focal hand dystonia, there was a loss of SICI which was seen in both hemispheres.

Extensive intra-cortical inhibition

Intracortical inhibition can also be assessed with paired suprathreshold TMS pulses at intervals from 50 to 200 mSec. This is called long intracortical inhibition, or LICI. LICI and SICI differ in that on increasing test pulse strength, LICI decreases but SICI tends to increase, and LICI is mediated via GABA-B receptors. Chen, Wassermann, Caños, and Hallett (1997) investigated long intracortical inhibition in patients with writer's cramp and found a deficiency only in the symptomatic hand and only with background contraction. This abnormality is particularly interesting as it is restricted to the symptomatic setting, and therefore might be a correlate of the development of the task specific dystonia.

Silent period

The silent period (SP) is a pause in ongoing voluntary EMG activity produced by TMS. While the first part of the SP is due in part to spinal cord refractoriness, the latter part is entirely due to cortical inhibition.[47] this type of inhibition is likely mediated by GABA-B receptors and is shortened in focal dystonia.[48]

Border or edge/ surround-inhibition

The concept of "surround inhibition" is a well-known phenomenon in sensory physiology and probably applies to the motor system also.

During a specific movement it is likely that the specific movement is generated, and, simultaneously, other possible movements are suppressed thus is 'surround inhibition'. In dystonia, a failure of surround inhibition may be responsible for the overflow movements.

Evidence from studies supports the principle of surround inhibition in motor activity. Sohn, Jung, Kaelin-Lang, and Hallett (2003) have shown that with movement of one finger there is widespread inhibition of muscles in the contra-lateral limb. Significant suppression of MEP amplitudes was observed when TMS was applied between 35 and 70ms after EMG onset. Sohn et al. have also noted that there is some inhibition of muscles in the ipsilateral limb when those muscles are not involved in any way in the movement. In a study when TMS was delivered to the left motor cortex 3 to 1000ms after EMG onset in the flexor digitorum superficialis muscle, MEPs from abductor digiti minimi were slightly suppressed during the movement of the index finger in normal individuals with increased F-wave amplitude and persistence, indicating that cortical excitability is reduced. But in patients with focal hand dystonia MEPs were enhanced in both flexor digitorum superficialis and abductor digiti minimi muscles, indicating a failure of surround inhibition.

Using another experimental-investigational paradigm, Stinear, andByblow have also demonstrated a loss of surround inhibition in the hand in patients with focal dystonia.

Aberrant-plasticity

The possibility of increased plasticity in dystonia had been suspected for some time given that repetitive activity over long periods seems to be a trigger for its development. An animal model supported this idea. Monkeys were trained to hold a vibrating manipulandum for long periods. After some time, they became unable to do so, and this motor control abnormality was interpreted as a possible dystonia. The sensory cortex of these animals was studied, and sensory receptive fields were found to be large and it was concluded that the synchronous sensory input caused the receptive field enlargement, which then led to abnormal motor function.

Similar mechanism has been proposed in humans with dystonia and studies have demonstrated an abnormal plasticity of the motor cortex in patients with focal hand dystonia.

Combined and matching associatory stimulus

In paired associative stimulation (PAS), a median nerve shock is paired with a TMS pulse to the sensorimotor cortex. The TMS pulse is timed to be immediately after the arrival of the sensory volley. This intervention increases the amplitude of the MEP produced by TMS to the motor cortex. It has been demonstrated that the process of PAS produces motor learning similar to long-term potentiation (LTP). In patients with dystonia, PAS produces a larger increase in the MEP than what is seen in normal participants.[56]

Another aspect of the abnormal plasticity has recently been identified. Not only is the plasticity increased, but there is a failure of its homeostatic property. The homeostatic property is that plasticity ordinarily increases and decreases within bounds. If, for example, the excitability of the motor cortex is high, then it cannot be driven higher, only lower. The recent finding, using several types of brain stimulation, is that plasticity in dystonia may not be properly bounded and may increase abnormally.

Increased plasticity may be an important link in demonstrating how environmental influences can trigger dystonia.

Irregular sensory function

Stimulated by the findings of sensory dysfunction in the primate model, investigators began examining sensory function in patients with focal hand dystonia and found it to be abnormal. Although there is no apparent sensory loss on a clinical level, detailed testing of spatial and temporal discrimination revealed subtle impairments. The abnormality was present on both hands of patients with unilateral hand

dystonia and on hands of patients with cervical dystonia and blepharospasm. The identification of abnormality of sensation beyond the symptomatic body parts indicated that the sensory abnormality was more likely to be a pre-existing physiological state rather than a learned act.

Sensory dysfunction has also been demonstrated with somatosensory evoked potential (SEP) testing which evaluates the integrity of the sensory pathway from the sensory ganglion to the cortex. The dipoles of the N20 from stimulation of individual fingers showed disordered representation in the primary sensory cortex and these abnormalities were present on both hands of patients with focal hand dystonia.

PET studies have shown that the sensory cortex is more activated than normal with writing and the activity correlated with the severity of dystonia.Voxel-based morphometry studies in patients with focal hand dystonia have shown an increase in gray matter in the primary sensory cortex.Recent studies have further shown patients with sensory abnormalities and decrease in gray matter in the sensorimotor cortex further indicating that the primary sensory deficit may be the causative factor for dystonia. Thus there are abnormalities documented in the sensory and motor control in patients with writer's cramp.

Prognostic features

Occasional patients may report a history of trauma or strain to the affected limb.[12-35] Most patients initially complain of feelings of tension in the fingers or forearms that interfere with the fluency of writing; a minority may also experience pain. Then the pen is held forcefully with abnormal excessive contraction (dystonia) of the hand and/or forearm muscles, causing different patterns of deviation from the normal or premorbid pen grip and hand posture, Writing may begin normally with dystonic posturing occurring after a few alphabets or words; In some patient develops dystonia of hand even before commencement of writing, as soon as they reach up to pick the pen. A common pattern of writer's cramp involves excessive flexion of the thumb and index finger, with pronation of the hand and ulnar deviation of the wrist. Other patients may have abnormal activation of wrist flexors, with supination of the hand and flexion of the wrist. Individual patients may experience involuntary lifting off of the index or thumb from the pen or isolated extension of other fingers as well. When dystonic cramps affect up to three fingers only, Cohen and Hallett have suggested the term of 'localized' (Vs non-localized) writer's cramp. The forearm muscles most often involved in writer's cramp are the flexor carpi ulnaris and radialis, flexor digitorum superficialis, flexor pollicis longus, and extensor digitorum communis muscles.[12-30] Up to 50% of patients with writer's cramp may also show upper limb tremor. Although sensations of strain and aching in dystonic forearm muscles are common in writer's cramp, pain – unlike in cervical dystonia is rarely a prominent feature, presumably due to the task-specific and intermittent nature of the disorder where the build-up of pain would normally stop individuals from performing the task.

In patients with simple writer's cramp, no other abnormal signs are evident except for postural tremor of the outstretched hand in 50% of cases. In progressive and dystonic writer's cramp, dystonic posturing of the outstretched arms is also present. Subtle loss of associated arm swing of the affected arm when walking occurs in 20-30% of patients. Many patients also demonstrate mirror dystonia, which is defined as abnormal posturing and involuntary movements of the resting dominant hand while writing with the non-dominant i.e., left-hand. Various studies have demonstrated incidence ranging from 44%[67] to 70% in patients with writer's cramp has been documented and may be useful on characterizing the muscles involved.

The intensity of dystonic movements is influenced by various conditions with voluntary motor activity-walking, talking etc, stress and fatigue exacerbating it. As is common with other focal dystonia sensory tricks (geste antagonistique) such as holding the arm against the table, rest and sleep decrease dystonia.

Diagnostics

The diagnosis of writer's cramp is based on clinical history and the appearance of dystonia on writing. There are no tests to confirm the diagnosis of writer's cramp. Further testing with nerve conduction studies and electromyography may be done to evaluate for underlying neuropathy and to identify which muscles are involved and to what extent.

Differential diagnosis

The hand may be involved in various other disorders and a clear history and detailed neurological examination will help in differentiating it from various other disorders.

1. Pain in the hand: Carpal tunnel syndrome secondary to median nerve compression and musculoskeletal problems like arthritis, tendon injuries and muscle cramps can all cause pain in the hand but does not cause dystonia,
2. Primary writing tremor is usually misdiagnosed as writer's cramp. It is a large amplitude tremor occurring during writing only. However, it is not associated with dystonia or pain and in contrast to essential tremor, action and postural tremors are not seen.
3. Generalized dystonia especially idiopathic generalized dystonia may manifest initially as writer's cramp. Search for other co-existing dystonia apart from hand dystonia helps in diagnosis.
4. Writing abnormalities may be the initial features to be noted in patients with secondary dystonia like Wilson's disease and Parkinson's disease. Presence of other features like micrographia, bradykinesia and postural instability in Parkinson's disease, KF ring in the cornea, dystonic smile, behavioral disturbances and rubral tremor consisting of tremor occurring during posture, action and intention in Wilson's disease helps in distinguishing these syndromes.

5. Repetitive strain injury refers to the various symptoms occurring during prolonged use of keyboard resulting in pain in the hand, write and shoulder and is becoming more common nowadays. However, they are more musculoskeletal disorders and does not manifest as dystonia.[2-8]

Conclusion

Dystonia in writer's cramp is assessed while the patient performs the following tasks and is rated as per the writer's cramp rating scale (WRCS), Writing of a test paragraph dictated to them, writing of 2 lines of letter 'e', drawing of 2 spirals, and drawing of 2 straight lines.

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Conflict of Interest

None.

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