

## Movement Disorders in Brain Injury

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### Overview

- Epidemiology
- Pathophysiology
- Phenomenology and etiology
- Workup
- Prognosis and treatment

### Movement Disorders

- Extraparamidal symptoms associated with dysfunction of the basal ganglia or thalamus and their circuitry.
- *Hyperkinetic* disorders:
  - Tremor
  - Dystonia
  - Ballism and chorea
  - Paroxysmal dyskinesias
  - Tics and tourettism
- *Hypokinetic* disorders:
  - Parkinsonism

### Cause-Effect Relationship

- The role of trauma in the development of MDs has medical, psychological, and legal implications.
- To establish the cause-effect relationship between trauma and MD, the severity of the injury, time course, and anatomical relationship must be taken into consideration.
- Trauma may also trigger or accelerate the progression of pre-existing MDs.

## Cause-Effect Relationship

- The concept that trauma to the CNS can induce MDs is widely accepted, whereas the occurrence of MDs after peripheral injury remains a matter of controversy.

## Epidemiology

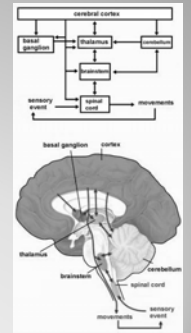
- Severe head injury (GCS  $\leq 8$ )
- Posttraumatic MDs are most frequently associated with severe head injury. Studies report a range of 13-66%.
- Krauss et al: 221 surviving pts with severe head trauma. Posttraumatic MDs were found in 50 (22.6%) pts, transient in 10.4% of total pts and persistent at a mean F/U of 3.9 yrs in 12.2%.

## Epidemiology

- Mild to moderate head injury (GCS 9-15)
- Severe MDs after mild to moderate head trauma are very rare.
- Krauss et al: 158 pts with mild to moderate head trauma. Posttraumatic MDs were found in 16 (10.1%) pts, transient in 7.6% of total pts and persistent in 2.6%.
  - Pts with a GCS score of 15 developed posttraumatic MD significantly less frequently than those with GCS 9-14.

## Pathophysiology

- Primary damage:
  - Focal contusions, particularly to the **basal ganglia** and their pathways.
  - Lesions of **cortical regions** may alter BG function indirectly.
  - Diffuse axonal injury with preferential lesions of the superior **cerebellar** peduncles.
  - Ischemia or hemorrhage caused by injury of penetrating arteries associated with rotational forces of the trauma.



## Pathophysiology

- Secondary damage:
  - Hypoxia, hypotension, and increased intracranial pressure may contribute to the extent of the lesion.
  - Release of toxic cytokines and other neurotoxins; oxidative stress associated with the deposition of hemosiderin and iron, facilitating the production of free radicals; and other metabolic effects.

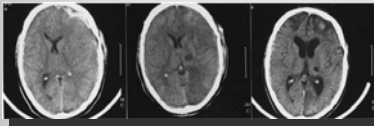


Fig: left thalamic lesion and evidence of DAI

## Pathophysiology

- The balance btwn subsequent neurodegeneration and restorative neuroplasticity may determine whether a lesion results in permanent damage or the pt recovers.
  - Orthograde and retrograde degeneration of the pathways.
- However, the restorative process itself also could be responsible for the development of posttraumatic MDs and responsible for their delayed onset:
  - Aberrant sprouting, ephaptic transmission, and alterations of neurotransmitter sensitivity.
- Individual susceptibility, genetic predisposition.

- All types of MDs have been described after head injury. Different MDs may occur concurrently.
- Kinetic tremors and dystonia are the most common.

## Phenomenology & Etiology

## Tremor

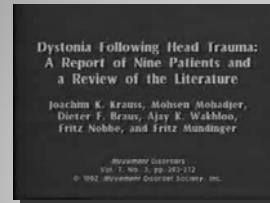


- Rubral tremor: postural and kinetic > rest tremor, coarse (2.5-4 Hz), high-amplitude. May be interrupted by irregular jerking movements, resembling myoclonus or ballism.
- Predominantly affects the upper extremities.
- Latency from 2 wks to 1 yr.

## Tremor

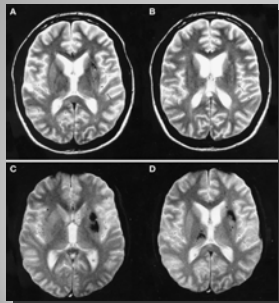
- Majority of pts have a hx of deceleration trauma, associated with diffuse axonal injury. MVA.
  - Diffuse axonal injury: corpus callosal atrophy, ventriculomegaly, subcortical lesions, and brainstem lesions.
- Parkinsonian tremor – substantia nigra or striatonigral pathways. Intention tremor – cerebellum, thalamus (dentatothalamic pathways).

## Dystonia



- May be present at rest, but usually is exacerbated or elicited by voluntary action (action dystonia).
- Typical presentation = hemidystonia.
- Rare manifestations include cervical dystonia, segmental axial dystonia, and spasmodic dysphonia.
- Mean latency of 20 months.

## Dystonia



- The majority of pts with hemidystonia have lesions of the contralateral *striatum* (= caudate + putamen).
  - Dystonia can also be seen w/ lesions of the thalamus and pontomesencephalic (brainstem) region.
- More common in men.
- *Fig:* Right hemidystonia. Lesions of left putamen.

## Dystonia

- Differential diagnosis:
  - Nondystonic torticollis – for example, from atlantoaxial subluxation or fixation, 4th nerve palsy, hemianopsia causing head posturing.
  - Primary (idiopathic torsion) dystonia
  - Psychogenic dystonia

## Ballism and Chorea



- Ballism and chorea may be part of a continuum.
  - Ballism is proximal and chorea is distal.
- Typical presentation = hemiballism.
- Latency of wks to months.

## Ballism and Chorea

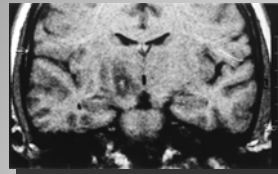


Fig: right STN lesion

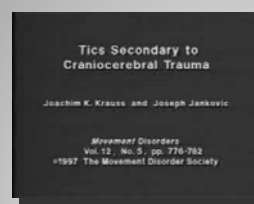
- Hemiballism is most frequently related to lesions of the contralateral subthalamic nucleus.
- Chorea can rarely be caused by epidural or subdural hematomas.

## Paroxysmal Dyskinesias



- The pathophysiology remains unclear. It may represent a type of subcortical epilepsy. It is also thought to be associated with dysfunction of sensory processing at the level of the basal ganglia or the thalamus.
- In some cases, putaminal lesions were found.

## Tics and Tourettism



- Rapid, jerk-like movements or involuntarily produced sounds and words.
- Differentiated from other MDs by presence of premonitory feelings or sensations, variability, temporary suppressibility, and distractability.
- *Tourettism* – adult-onset disorders with motor tics as well as vocalizations secondary to a known cause.

## Parkinsonism



- *Single* head injury
- Parkinsonism is a rare complication of a single head injury except for penetrating injury to the brainstem (substantia nigra) or the injury is severe enough to result in a coma or vegetative state.
- There have been several reports of parkinsonism secondary to SDH.
- Dominated by akinetic-rigid symptoms: bradykinesia, rigidity.
- Latency of wks.

## Parkinsonism

- *Repeated* head injuries
- Pugilistic parkinsonism (PP) from cumulative effects of concussions secondary to rotational acceleration traumas by direct blows to the head.
  - Most associated with boxers: The frequency of PP has been estimated to range from 20-50% of professional boxers. The severity of PP correlates with the length of the boxing career and the number of bouts. Presents with a delay of several yrs after the end of an active boxing career.
- In contrast to posttraumatic parkinsonism secondary to a single severe head injury, rest tremor is a relatively frequent feature of PP.

## Parkinsonism

- *Repeated* head injuries
- Post-mortem examinations in boxing injuries have shown petechial hemorrhages in the cortex and brainstem with neurofibrillary tangles and degeneration of the substantia nigra. Lewy bodies, the histologic hallmark for Parkinson's disease, are not seen.
- Genetic predisposition: The apolipoprotein E4 allele may play a role in the development of PP.

## Trauma & Parkinson's Disease

- Several studies have found a higher frequency of head injury in pts with PD.
  - Twin study: A case-control study of 93 twin pairs from the National Academy of Sciences/National Research Council WWII Veteran Twins Cohort demonstrated an association btwn a prior head injury with amnesia or LOC and an increased risk for PD. Risk increased further with a subsequent head injury and with head injuries requiring hospitalization.
- The history of trauma usually dates back 20-30 yrs before the onset of PD.
- With regard to head injury and other possible *environmental* factors, PD might be the consequence of clinically silent exposure in early and middle life, with sxs manifesting only when dopaminergic neurons decline with advancing age.
  - Key pathogenic pathways in PD: mitochondrial dysfunction, oxidative stress, protein clearance problems, and inflammation.

## Pyramidal Features

- The coexistence of spastic HP or quadriparesis is observed frequently in pts with posttraumatic MDs.
- MDs may be masked by weakness or spasticity from corticospinal tract involvement.

## Workup

- H&P
- Head imaging – CT head, MRI brain. Structural lesions are found in most pts with posttraumatic MDs.
- Functional studies such as SPECT, PET, and fMRI are currently used for research purposes.

## Prognosis & Treatment

## Prognosis

- Complete, spontaneous recovery is rare except in pts with tremors following mild head injury.
- Although MDs after mild and moderate head injury are frequently transient and non-disabling, kinetic tremors and dystonia may be a source of marked disability in survivors of severe head injury.

## Treatment

- Treatment for posttraumatic MDs are similar to those of nontraumatic MDs; however, the response is variable.
- Multidisciplinary treatment including physical therapy and psychotherapy should be considered.

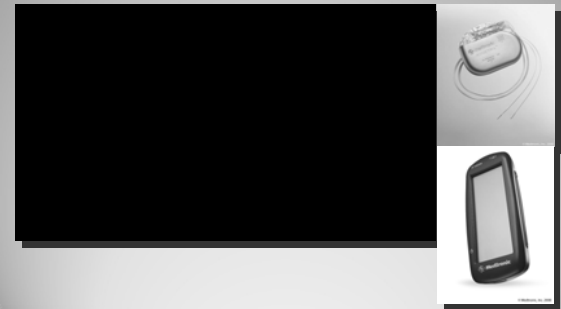
## Tremor

- Mild to moderate head injury – Tremor usually non-disabling and spontaneously resolves. No treatment needed.
- Severe head injury – Tremor usually does not improve spontaneously within 1 year of onset. Notoriously difficult to treat.
- Meds: glutethimide, isoniazid, L-tryptophan, propranolol, primidone, topiramate, benzodiazepines, carbamazepine, carbidopa/levodopa, anticholinergics.

## Tremor

- Botulinum toxin to affected limb: May be helpful in some cases that fail oral therapy.
  - The higher doses that must be administered to both proximal and distal arm muscles limit the use of this treatment.
- Surgery:
  - DBS to thalamus. Less effective than in parkinsonian tremor or essential tremor; variable symptomatic and functional benefit. \*\*Recommendation of waiting at least 1 yr after the onset of posttraumatic tremor before considering surgery.

## Deep Brain Stimulation





## Advantages of DBS Over Ablation

- Reversibility
- Programmability
  - DBS settings can be adjusted for better efficacy.
- Ability to perform bilateral procedures safely.
  - Bilateral surgical lesioning is no longer performed because of the unacceptably high rate of side effects. SEs such as increased dysarthria or gait disturbance are particularly seen in pts with kinetic tremor secondary to diffuse axonal injury.

## DBS and Posttraumatic Tremor



## Dystonia

- Dystonia tends to slowly progress then stabilizes.
- Meds: Anticholinergic drugs, benzos. Medical treatment is usually ineffective.
- Botulinum toxin: Treatment of choice for posttraumatic torticollis and other focal dystonias.
- Surgery:
  - DBS to thalamus or globus pallidus. Pts with secondary dystonia experience more modest improvement as compared with pts with primary dystonia.
  - In the rare cases of dystonia related to SDH, favorable prognosis after drainage of the hematoma.
  - In pts with generalized dystonia, intrathecal baclofen therapy may provide symptomatic relief.

## Ballism and Chorea

- In contrast to vascular hemiballism, posttraumatic hemiballism seems to be more persistent with less tendency for spontaneous improvement.
- Meds: Tetrabenazine
- Surgery:
  - DBS to thalamus or GP. Experience is very limited.
  - Intrathecal baclofen therapy may provide symptomatic relief.
  - In chorea associated with chronic SDH, the prognosis usually is favorable after drainage of hematoma.

## Paroxysmal Dykinesias

- Meds: Anti-convulsants. Often respond favorably.
- Surgery: DBS to thalamus.

## Parkinsonism

- Meds: Levodopa. Medical treatment similar to that for idiopathic Parkinson's disease, but response is less predictable.
- Surgery:
  - DBS to subthalamic nucleus or GP.
  - Favorable outcome after drainage of SDH.

## Rehabilitation

- Physical Therapy – strength, mobility, ROM
  - Fixed contractures often develop in posttraumatic dystonias following severe head injury if treatment and PT are delayed.
- Occupational Therapy - ADLs

## Psychogenic Movement Disorders



Fig: Irregular tremor, dystonic posturing, marked distractibility.

- Suggested by sudden onset; spontaneous remissions; variable frequency, amplitude and pattern; paroxysmal occurrence; distractibility; and a character of movement that is not consistent with a typical MD.
- Consider the possible combination of an organic MD with a psychogenic MD or the exaggeration of a posttraumatic MD on a psychological basis.

## Conclusions

- Trauma may result in many forms of MDs. The cause-effect relationship is sometimes difficult to establish.
- Though uncommon, posttraumatic MDs may be a source of marked disability. Medical and surgical treatment options are available, but response is variable.
- The association between brain injury and Parkinson's disease is the subject of ongoing research.
- The role of trauma in the development of MDs has medical, psychological, and legal implications.