

## **CHRONIC TRAUMATIC ENCEPHALOPATHY**

Author: Andrew Gardner B.Psy (Hns), D.Psy (ClinNeuro)

Chronic traumatic encephalopathy (CTE) is the modern term used to refer to the cumulative long term neurological consequences of repetitive concussive and subconcussive blows to the head (1). CTE is a neurodegenerative tauopathy that has been speculated to exist among some former athletes involved in collision sports (like boxing and American football), as well as being observed in some military veterans who were exposed to combat 'blast-injury' (2). The condition is often referred to by a number of names in the medical and non-medical literature including dementia pugilistica and "punch drunk" syndrome.

A recent publication defined CTE as "*chronic cognitive and neuropsychiatric symptoms of chronic neurodegeneration following a single episode of severe traumatic brain injury or (more commonly) repeated episodes of mild traumatic brain injury*" (3). However, historically this 'disease process' was defined somewhat differently.

Dr Harrison Martland first described the 'punch drunk' state in 1928. He presented the clinical details of one of the five subjects he had examined in his publication.

A 38-year-old man who fought professionally for seven years, having commenced his career at the age of 16-years. He had sustained two knockouts (one for a duration of one hour). Examination (20 years after the onset of the patient's symptoms) revealed the boxer had tremor, ataxia and pyramidal tract dysfunction, but possessed normal intelligence when assessed 20 years after the onset of symptoms. Martland's diagnosis was "paralysis agitans [Parkinson's disease]" in this case (4).

The most accurate estimate of the prevalence of this condition was reported by Roberts (5). His random sample of retired boxers however, included a proportion who fought in the late 1800's, in an era where bare-knuckle championships were still conducted, frequent fights occurred even when concussed and limited medical supervision or weight matching of boxers occurred. Using fairly crude diagnostic techniques, it was reported that clinically demonstrable lesions of the nervous system were present in 17% (37 boxers). Roberts discussed the details of eleven of the identified thirty-seven cases. In analysis of Robert's accounts, many of the cases diagnosed as possessing CTE are quite dubious. To some extent such lack of certainty reflects the relatively crude investigation technology available in the 1960's (for example, pneumoencephalograms). It is unlikely that these estimates accurately reflect current prevalence levels.

In the boxing samples cognitive deterioration was typically detected 10-20 years post-retirement (6), with deficits in attention the frequent early feature (7). Interestingly in all cases where details were provided, the physical signs

but not cognitive features progressed following retirement from the ring. There are two distinct clinical syndromes that have been demonstrated in this data set; the first (which occurs in approximately 70% of cases) includes dysarthria, pyramidal problems and cognitive deficits. As the disease manifests clinically, these cognitive abnormalities include difficulties in memory, information processing speed, insight and orientation. The second syndrome includes dysarthria and pyramidal problems, but with intact cognitive abilities (approximately 30% of cases) (5,8,9). Movement disorders were reported to be present in approximately two in every five reported cases (2).

The neuropathological profile have been described by Corsellis, Bruton and Freeman-Browne (10) and typically result in a cavum septum pellucidum with septal fenestration (13/15 cases), cerebellar scarring involving purkinje cell loss and thinning of the granular layer, degeneration of the substantia nigra and locus coeruleus and diffuse neurofibrillary tangles involving the medial temporal region, uncus, amygdala, hippocampus, parahippocampal gyrus, fusiform gyrus along with the more lateral temporal, insular and frontal cortices. The extent of neuropathology appears to be positively correlated with level of exposure.

More recently, CTE has been described in athletes of other collision sports, such as American footballers and wrestlers (1,11). Notably, disparity across the clinical features and outcomes, and also potentially the neuropathology, has been reported that differ from that described by Roberts (5) and Corsellis (10) in their boxing subjects.

In the 'modern samples' CTE is described as including symptoms such as gait disorders, speech slowing, and extrapyramidal signs may be present however neuropsychiatric and behavioural symptoms tend to predominate throughout the course of the condition (5,12,13). The most common symptoms reported are depression, paranoia, agitation, social withdrawal and aggression. Neuropathology appears more closely related and shares a number of common features with the original description; i.e. fenestrated septum pellucidum, cerebral atrophy, neurofibrillary tangle inclusion, beta amyloid deposition, reduced pigmentation of the substantia nigra and locus coeruleus and enlarged ventricles.

Concussive injury and/or subconcussive blows have been speculated as 'necessary but not sufficient' for later life symptoms and post-mortem diagnosis of CTE (14). Identification of other risk factors, which may or may not include genetic susceptibility, drug and alcohol use, steroid abuse or chronic pain, require further investigation. The prevalence of this putative condition remains unknown and also requires investigation.

Whether appropriate management of acute head injury is effective in reducing the incidence of late-life neurodegenerative disease requires further investigation. The most important next step in the process of further delineating this nomenclature and potentially answering some of the unresolved issues associated with CTE, is for the conduct of a large scale

prospective, longitudinal clinicopathological study in samples with increases exposure to concussion and subconcussive blows who may be at greater risk for developing later life problems that are associated with this condition.

## References

1. McKee, A. C., R. C. Cantu, et al. (2009). "Chronic Traumatic Encephalopathy in Athletes: Progressive Tauopathy After Repetitive Head Injury." Journal of Neuropathology and Experimental Neurology **68**(7): 709-735.
2. ScienceDaily (2012) "Brain Injury to Soldiers Can Arise from Exposure to a Single Explosion." Published online 16 May 2012. Accessed online 15 June 2012 DOI: <http://www.sciencedaily.com/releases/2012/05/120516152440.htm>
3. Omalu, B. I., J. Bailes, et al. (2010). "Chronic Traumatic Encephalopathy, Suicides and Parasuicides in Professional American Athletes: The Role of the Forensic Pathologist." American Journal of Forensic Medicine and Pathology **31**(1): 1-3.
4. Martland, H. S. (1928). "Punch Drunk." JAMA: Journal of the American Medical Association **91**(15): 1103-1107.
5. Roberts, A.H. (1969). Brain damage in boxers: A study of the prevalence of traumatic encephalopathy among ex-professional boxers, London: Pitman Medical & Scientific Publishing Co.
6. McCrory, P. (2011). "Sports Concussion and the Risk of Chronic Neurological Impairment." Clinical Journal of Sport Medicine **21**(1): 6-12.
7. McCrory P, Zazryn T, Cameron P. The Evidence for Chronic Traumatic Encephalopathy in Boxing. Sports Medicine. 2007;**37**(6):467-76.
8. Roberts GW, Allsop D, Bruton C. The occult aftermath of boxing. Journal of Neurology, Neurosurgery and Psychiatry. 1990;**53**:373-8.
9. Johnson J. Organic psychosyndromes due to boxing. British Journal of Psychiatry. 1969;**115**:45-53.
10. Corsellis JA, Bruton CJ, Freeman-Browne D. The aftermath of boxing. Psychological Medicine. 1973;**3**(1):270-303.
11. Omalu BI, Bailes J, Hamilton RL, Kamboh MI, Hammers J, Case M, et al. Emerging Histomorphologic Phenotypes of Chronic Traumatic Encephalopathy in American Athletes. Neurosurgery. 2011;**69**(1):173-83.
12. Jordan B. Neurologic aspects of boxing. Archives of Neurology. 1987;**44**:453-9.
13. La Cava G. Boxer's encephalopathy. Journal of Sports Medicine & Physical Fitness. 1963;**168**:87-92.
14. Stern, R.A., Riley, D.O., Daneshvar, D.H., Nowinski, C.J., Cantu, R.C., & McKee, A.C. Long-term Consequences of Repetitive Brain Trauma: Chronic Traumatic Encephalopathy. PM & R. 2011; **3**:S460-S467.