

# Study describes 68 CTE cases in veterans, high school, college and pro athletes

December 3 2012

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A study done by investigators at the Boston University Center for the Study of Traumatic Encephalopathy (CSTE) and the Veterans Affairs Boston Healthcare System, in collaboration with the Sports Legacy Institute (SLI), describes 68 cases of chronic traumatic encephalopathy (CTE) among deceased athletes and military veterans whose brain and spinal cords were donated to the VA CSTE Brain Bank. Of the 68 cases, 34 were former professional football players, nine had played only college football, and six had played only high school football. The results, which will be published in the December issue of the scientific journal, *Brain*, represent the largest case series of CTE published to date, doubling the number of published CTE cases internationally.

Ann McKee, MD, professor at Boston University School of Medicine (BUSM), director of the Neuropathology Service for VA New England Healthcare System and co-director of the CSTE, led this clinicopathological study, which is the first to characterize the pathology of the disease into four stages of severity.

CTE is a [degenerative brain disease](#) associated with repeated [brain trauma](#), including concussions and multiple subconcussive exposures such as those in [contact sports](#) and military combat, and appears to be slowly progressive in most individuals. In early stages, CTE is characterized by the presence of abnormal deposits of a protein called tau in the form of neurofibrillary tangles, glial tangles and neuropil threads throughout the brain. These tau lesions eventually lead to [brain cell death](#). Currently, CTE can only be diagnosed postmortem.

In the study, the 68 cases of CTE were found in males between the age of 17 and 98. The cases represented 64 athletes, 18 of whom were also military veterans, as well as three additional veterans who did not have a sports background and one individual who engaged in self-injurious head-banging behavior. The development of CTE in an individual in whom self-injurious head banging was the sole environmental exposure, which has been previously published by other groups, suggests that repetitive brain trauma alone is sufficient to trigger CTE in some cases.

There were 50 football players who had evidence of CTE, including 33 who played in the National Football League (NFL), one in the Canadian Football League (CFL), one semi-professional player, nine college and six high school football players. In addition, CTE was found in four National Hockey League (NHL) players, one amateur hockey player, seven professional boxers, one amateur boxer, and one professional wrestler. Veterans with CTE included marines, soldiers and sailors from World War II, the Vietnam and Gulf Wars, as well as the Wars in Iraq and Afghanistan.

The report provides specific pathological criteria for the diagnosis of CTE and divides CTE into four stages of disease (Stages I-IV). The families of all deceased brain donors were interviewed extensively about their loved one's history and medical records were reviewed when available. Eighty-nine percent of individuals pathologically diagnosed with CTE showed clinical symptoms involving cognitive, behavioral, or mood impairments. Headaches and issues related to attention and concentration were common in Stage I. In Stage II, the symptoms expanded to include depression, explosivity and short-term memory impairment. In Stage III, reported symptoms included cognitive impairment and problems with executive functions, specifically planning, organization, multitasking and judgment. Full-blown dementia (i.e., memory and cognitive impairments severe enough to impact daily living) was characteristic of Stage IV. Although CTE appeared to be

slowly progressive in most individuals, CTE may not progress, or may not progress at the same rate in all persons.

Furthermore, one-third of the CTE cases were diagnosed with additional neurodegenerative disease, including: motor neuron disease (12 percent), Lewy body disease (16 percent), Alzheimer's disease (11 percent) and frontotemporal lobar degeneration (six percent). Of the individuals with CTE and motor neuron disease (CTE-MND), most presented with symptoms of motor weakness, atrophy and fasciculations, or muscle twitches, years before the onset of cognitive and behavioral symptoms.

"This study extends our knowledge concerning the spectrum of the clinical and pathological abnormalities associated with CTE," said McKee, who also is director of the Brain Banks for BU's Alzheimer's Disease Center and the CSTE, which are based at the Bedford VA Medical Center. "Although further studies are needed to investigate critical aspects of trauma-induced neurodegeneration, including the incidence and prevalence of CTE; whether the symptoms of CTE are distinctive from other conditions; how genetics influence susceptibility or resistance to CTE; and whether other environmental exposures also play an additive role in the development of CTE."

There are several studies underway at the Boston VA and at CSTE to develop methods of diagnosing CTE during life. Robert Stern, professor of neurology and neurosurgery at BU and co-author of the report, stated, "The ability to diagnose CTE while someone is alive is an important next step to allow us to address some of these important issues, as well as develop and test treatment and prevention strategies for the disease."

"While it remains unknown what level of exposure to brain trauma is required to trigger CTE, there is no available evidence that occasional, isolated or well-managed concussions give rise to CTE," said Robert Cantu, MD, a coauthor of the paper and co-director of CSTE as well as

co-founder of SLI.

The BU CSTE has permission to release the following names of those who were diagnosed with CTE in this study: NFL Hall of Fame tight end John Mackey, who died in 2011 from complications of dementia and was found to have both CTE and frontotemporal lobar degeneration; NFL Hall of Fame running back Ollie Matson, who died in 2011 from complications of dementia and was diagnosed with Stage IV CTE; former NFL and CFL running back Cookie Gilchrist, who died in 2011 at age 75 from throat cancer and was diagnosed with Stage IV CTE; Ron Perryman, a former Boston College linebacker who died from respiratory failure associated with Amyotrophic Lateral Sclerosis in 2011 at the age of 42 and was diagnosed with CTE-MND; and Eric Pelly, a former [high school football](#) and rugby player diagnosed with multiple concussions who died at age 18 from complications resulting from a previous concussion and had Stage I CTE. In addition, the BU CSTE has permission to release the brain images from an anonymous Marine Veteran of the wars in Iraq and Afghanistan, who suffered multiple concussions in combat and in sports who died in his 20s with Stage I CTE. (\* See contact information.)

The VA CSTE Brain Bank, led by the recruiting efforts of Chris Nowinski, now contains more than 135 brains, of which approximately 80 percent have shown evidence of CTE. More than 600 living athletes have committed to donate their brain to the BU CSTE after death and are being followed longitudinally as part of the LEGEND study.

Nowinski, a co-director of the CSTE and a coauthor of the paper, said, "We appreciate the generosity and support of the athletes and their families involved in our research. This pathological research is a critical step as we continue to make advances toward our ultimate goal of an effective treatment for CTE."

Provided by Boston University Medical Center

Citation: Study describes 68 CTE cases in veterans, high school, college and pro athletes (2012, December 3) retrieved 10 April 2024 from <https://medicalxpress.com/news/2012-12-cte-cases-veterans-high-school.html>

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