G86 Diffuse Axonal Injury Observed in Structures of the Brain Not Commonly Described

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After attending this presentation, attendees will learn the importance of identifying acute traumatic injuries to the septum pellucidum and fornix when suspected blunt head trauma is entertained. The identification of these injuries in the absence of other fatal head injuries can serve as an important marker for diffuse axonal injury.

This presentation will impact the forensic science community by alerting medical examiners and coroners to other areas in the brain involved by diffuse axonal injury in blunt head trauma cases.

Diffuse Axonal Injury (DAI) is a common traumatic brain injury that causes widespread damage to axonal tracts, as opposed to focal brain injury. It is well documented that DAI results from acceleration-deceleration and rotational forces. Subsequently, DAI most commonly occurs in Motor Vehicle Accidents (MVA), sports-related injuries, violence, child abuse, and even falls. Diffuse damage to the axons is not caused by the initial mechanical forces but, rather, by secondary biochemical cascades that cause separation of the axons and cell death. DAI is thought to occur over a spectrum of mild to severe injury; a mild form of DAI is commonly referred to as concussion and the most severe end of the spectrum is brain death.

From July 2011 to present, the Santa Clara County Medical Examiner-Coroner Office has collected six documented cases of DAI occurring in areas of the brain not commonly described in the pathologic literature. In two of these cases, subtle findings of trauma were only localized to the fornix and septum pellucidum and in these cases interpreted as DAI. In the other four cases, DAI was recorded in the fornix and septum pellucidum as well as in the typical brain locations previously reported in the literature. The septum pellucidum is a midline structure that runs from the corpus callosum to the fornix and is currently thought to have no functional purpose; the body of the fornix is important for allowing communication between the hippocampus and the hypothalamus. The findings of this study support that these midline structures may serve as a highway of communication from the cerebral hemispheres to vital inner cerebral structures such as the hypothalamus.

All the cases in which DAI was observed are homicides that specifically involve blunt head trauma. The first two cases identified only subtle injuries to the septum pellucidum and fornix in the absence of other dural and brain injuries. Following these two cases, the Santa Clara County Medical Examiner-Coroner Office office has paid more attention to analyzing these inner, midline structures when conducting formal neuropathologic examinations of blunt head trauma victims. In the remaining cases, although sometimes subtle, injuries to these midline cerebral structures were observed where other hallmarks of DAI are also apparent (i.e., cerebral gliding contusions, hemorrhage into the corpus callosum).

In the above cases where death was pronounced at the scene, the microscopic sections did not reveal axonal spheroids as rapid death prevented the necessary interval of hours for microscopic changes to occur. In cases where the survival time was hours, axonal spheroids were visualized even in the absence of β-APP staining.

In summary, the findings of this research illustrate that DAI is being observed in cases of traumatic brain injury in areas not previously or commonly mentioned in the literature. While the literature has yet to describe a function of the septum pellucidum, damage to this structure, as well as the fornix, may be a clear indicator that significant trauma has occurred to the axons in multiple structures of the limbic system and can serve as a marker for diffuse axonal injury when no other fatal injuries are observed. With research showing promise at slowing and minimizing the secondary biochemical cascades that lead to DAI, the ability to clinically diagnose DAI sooner, by focusing on more sensitive locations, can help advance its treatment. The findings of this study will motivate the medical and psychological/psychiatric communities to begin exploring how damage to these specific structures contributes to the debilitating effects of DAI. Such an understanding may have a profound impact on the way living patients suffering from sports-related injuries and veterans returning from the line of duty with head trauma are screened and undergo diagnostic testing and treatment.

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