Computer Algorithms Support Physician Decisions in Traumatic Head Injury

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Do not let the title of the article in this issue of *Pediatrics*, "Traumatic Head Injury and the Diagnosis of Abuse: A Cluster Analysis," by Boos et al[1] intimidate those of you who are not biostatisticians. This article is important for providers who evaluate children with head injuries in the hospital setting. Young children remain disproportionately affected by child maltreatment, with the majority of fatalities occurring as a result of abusive head trauma (AHT).[2] There has been extensive, high-quality research into clinical and radiologic findings associated with AHT,[3–5] and multicenter research networks have been formed to accelerate this important work. One of the earliest networks, the Pediatric Brain Injury Research Network (PediBIRN), has prospectively collected data on children <3 years of age with symptomatic head injury in the PICU setting to identify a valid and reliable clinical prediction rule (CPR) for pediatric AHT.[6]

The authors present a unique and important analysis of the clinical and radiologic findings of 500 young patients with acute neurotrauma from data collected by PediBIRN.[7] Their hypothesis is that well-established computer algorithms used to sort "like" data would identify subgroups of children with discreet clinical findings. Furthermore, these subgroups would have specific relationships to indicators of abuse and physician diagnoses. Why use computer algorithms when clinical variables specific to AHT are available? The application of computer algorithms to clinical data broadly characterizes these mathematical clustering methods with the goal of identifying more subtle associations less apparent to researchers and clinicians. There are examples of this approach in the medical sciences, such as identifying phenotypically different asthma groups[8] or recognizing distinct clinical subtypes of Alzheimer disease.[9] The use of computer algorithms makes this research unique, allowing elimination of potential researcher bias as the computer is blinded to physician diagnoses and previously published associations.

Several key points are integral in understanding the importance of the authors' cluster analysis. First, they used an "unsupervised" cluster analysis, meaning that computer algorithms analyzed unlabeled data and sorted data into groups without a target outcome. Next, the authors used well-established cluster modeling tools.[9,10] K-means is a partitioning cluster algorithm tool where each cluster has a center (eg, the color orange might be in a cluster with yellow and red but would not be in a cluster centered around blue). Divisive and agglomerative algorithms are hierarchical tools that either start with one larger cluster and divide like items into smaller groups or start with smaller groups and connect them back to a larger core group, respectively.

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COMMENTARY

For example, a phylogenetic tree of birds would demonstrate a closer ancestor between a falcon and an eagle rather than an ostrich.[11] Each tool has strengths and weaknesses; therefore, several tools are used to sort data and analyze cluster similarities and differences. Finally, the authors assessed data partitioned by each algorithm with the "triad," defined as the presence of 3 clinical variables: any subdural hemorrhage (SDH); any encephalopathy before presentation for care; and retinal hemorrhages (RHs) described by an ophthalmologist as dense, extensive, covering a large surface area, and/or extending to the ora serrata. The odds ratio (OR) and confidence interval are presented with respect to substantial association with high likelihood of AHT (HiAHT) (OR >10) and low likelihood of AHT (LoAHT) (OR <0.01). Many clinical findings did not strongly partition with either group but still demonstrated statistical significance.

The cluster-modeling tools optimally partitioned the data into 2 groups, one group comprised the majority of children ultimately diagnosed by a physician with AHT (therefore HiAHT). Variables that had the most significant association with the HiAHT group included signs/symptoms of significant brain dysfunction: brain hypoxemia, ischemia, and/or swelling; acute encephalopathy (persistent); respiratory compromise prior to admission (PTA); presence of SDH or fluid collection; and retinoschisis. Not surprisingly, acute encephalopathy, SDH, and extensive retinal hemorrhages (RHs) also had significant associations with triad partitioning. However, it is interesting to see that the triad, as defined by the authors, was not as sensitive a partitioning tool as the other cluster tools used in this study. Also of interest, additional injuries seen in child physical abuse, such as bruising (ear, neck, torso) and fractures (considered moderately/highly specific for abuse), were statistically significant in the cluster analysis, but did not have substantial associations with HiAHT or LoAHT.

What does this complex analysis mean? Children admitted with symptomatic traumatic brain injury (TBI) are not on a continuum in which the presentation with AHT looks similar to accidental head trauma or LoAHT. Presentations strongly associated with AHT are characterized by CNS dysfunction, including respiratory compromise PTA and persistent encephalopathy, as well as radiologic evidence of substantial brain injury and SDH that would not be described as "contact" (unilateral). Additionally, children with AHT are more likely to have extensive RHs and/or retinoschisis, fractures, bruising, and/or abdominal injury, consistent with the published literature.[12] Presentations that are lower risk for AHT, seen more often with accidental head trauma, often have contact injuries seen with impact to the head, such as a skull fracture with an associated epidural or subdural hemorrhage. These associations are in line with published literature on objective clinical findings that assist in discriminating between these etiologies.[3–5]

A single clinical finding in isolation may not discriminate between children at high or low risk for AHT. However, this analysis and the current literature illustrate the predictive probability of clinical findings seen in combination.[13,14] The results of this unique cluster analysis, demonstrating the association of clinical findings of significant brain dysfunction with AHT, will assist medical providers in the hospital setting, highlighting the importance of a comprehensive medical evaluation in children with traumatic head injury.

ABBREVIATIONS

AHT: abusive head trauma
CNS: central nervous system
OR: odds ratio
PediBIRN: Pediatric Brain Injury Research Network
PTA: prior to admission
RH: retinal hemorrhage
SDH: subdural hemorrhage
TBI: traumatic brain injury

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