H26 Nerve Root and Dorsal Root Ganglia (NR/DRG) Hemorrhage as an Indicator of Pediatric Traumatic Head Injury (THI)

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After attending this presentation, attendees will better understand a standardized, concise methodology for evaluating and reporting NR/DRG hemorrhage and will be knowledgeable regarding the comparison between NR/DRG hemorrhage in traumatic and non-traumatic pediatric deaths.

This presentation will impact the forensic science community by providing a powerful technique to assist in distinguishing between pediatric decedents with and without significant THI. Additionally, this study shows the importance of careful spinal cord examination in cases of suspected pediatric head trauma.

An association between pediatric THI and hemorrhage within the cervical NR/DRG was first described by Downs in 2005.[1] Matshes et al. suggest that these injuries are secondary to forces transferred to the spinal cord and adjacent NR/DRG during hyperflexion-extension of the relatively weak infant neck; the resulting damage to the C3-5 nerve roots would cause diaphragmatic paralysis and subsequent fatal anoxic brain injury.[2] Cervical nerve root injury in fatal THI was also reported by Brennan et al. and Sens et al.[3,4] In 2014, the Harris County Institute of Forensic Sciences (HCIFS) completed a small pilot study which showed correlation between cervical NR/DRG hemorrhage and THI in a pediatric population, supporting previous studies.[5,6]

To further investigate the relationship between NR/DRG hemorrhage and pediatric death, a nine-month prospective study was conducted. All infants autopsied by HCIFS meeting the age criterion (0-12 months old at time of death) were included, except for individuals with survival time greater than one week after terminal hospital admission. The spinal cord with attached NR/DRG was removed in each case via modified posterior approach as described by Peterson et al.[5,6] The tissue was fixed for two weeks in 20% formalin, then sectioned and Hematoxylin-Eosin (H&E) stained following standard methods. Each section was examined by a staff neuropathologist and a pathology resident who were both blinded to cause and manner of death.

To standardize examination, a scoring method was developed: presence of hemorrhage in each individual NR/DRG was scored on a scale of 0 to 2 (0=no hemorrhage, 1=scant hemorrhage, 2=prominent hemorrhage). Twenty-five cases were scored by two individuals to assess inter-rater agreement using the scoring methodology. A moderate level of agreement was identified between raters in all compared parameters (Cohen's Kappa=0.43). Of note, all disagreements occurred between the scores of 0 (no hemorrhage) and 1 (sparse hemorrhage).

Over the nine-month study period, 59 total cases were collected. Fifty-eight infants from birth to 11 months (median age two months) were included in the study. One case was excluded from the study because cause of retinal and NR/DRG hemorrhage could not be definitively attributed to trauma. Forty-eight infants died from natural, non-traumatic causes (non-trauma group) and ten from homicide or undetermined THI (trauma group). The number of NR/DRG recovered from each case varied. All 58 cases had multiple NR/DRG present in cervical and thoracic sections; 57 had lumbar NR/DRG, 56 had sacral NR/DRG, and 50 had cauda equina NR/DRG.

Every case in the trauma group displayed parenchymal NR/DRG hemorrhage, compared to 42% (20/48) of the non-trauma group. Hemorrhage in the trauma group was prominent (score=2) in 80% (8/10) of cases and sparse (score=1) in the other 20%. In those non-trauma group cases with hemorrhage, only 15% (3/20) showed prominent hemorrhage; scant hemorrhage was identified in the remaining 85% (17/20). Therefore, there is a significant association between increased severity of hemorrhage and presence of THI (p=.001).

These results support previous studies showing that prominent NR/DRG hemorrhage is a valid indicator of THI in infants. Moderate inter-rater agreement between two individuals at different levels of training highlights the utility of the proposed scoring methodology for general forensic practice; however, disagreement between no hemorrhage (score 0) and sparse hemorrhage (score 1) suggests the need for a stricter definition of sparse hemorrhage. Practically, only grade 2 hemorrhages, which had 100% agreement, appear to be a reliable indicator of significant pediatric head trauma. Further study is necessary to improve the scoring methodology and to more completely understand the connection between NR/DRG hemorrhage and fatal pediatric traumatic head injury.

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Traumatic Head Injury, Nerve Root, Ganglia Hemorrhage