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Association of Intracranial Injury Patterns with Inpatient Rehabilitation Outcomes Following Pediatric Traumatic Brain Injury

Background: Traumatic brain injury (TBI) is a leading cause of death and disability in children. Motor vehicle crashes (MVCs) and gunshot wounds (GSWs) are common mechanisms of pediatric TBI and can cause intracranial injuries, including diffuse axonal injury (DAI) and traumatic intracranial hemorrhage (ICH), that may influence functional outcomes. We sought to determine impact of injury type and mechanism on functional outcomes for patients with severe TBI who survived to inpatient rehabilitation (IPR).

Methods: We performed a single-institution retrospective review of patients aged ≤ 18 years admitted to pediatric IPR following TBI between January 2018 and June 2026. Outcomes included discharge disposition, return to school, and Pediatric Functional Independence Measure (WeeFIM) progression.

Results: Of 107 patients, 37 had combined DAI and ICH, 48 had ICH only, 14 had DAI only, and 8 had neither. MVCs accounted for 86.3% of DAI, including 13 of 14 DAI-only cases (93%; $p < 0.001$). Fourteen of 15 GSWs resulted in ICH ($p = 0.001$). Severe initial Glasgow Coma Scale (GCS) scores (3-8) were more common with combined DAI and ICH and after MVC ($p = 0.049$ and $p = 0.043$). Neurosurgical intervention was more common with ICH only than DAI only (67% vs 7%; $p = 0.0002$) and after GSW than MVC (87% vs 28%; $p < 0.0001$). Return to school was 88% overall, with no association with injury pattern or mechanism ($p > 0.05$). Admission WeeFIM did not differ across injury patterns ($p > 0.05$), but total improvement did ($p = 0.006$) and was greatest with combined DAI and ICH compared to patients with neither injury (42.9 ± 25.5 vs 12.9 ± 20.6). Patients with neither injury had lower discharge self-care ($p = 0.009$), cognitive ($p = 0.026$), and total scores ($p = 0.023$) compared to patients with DAI or ICH. Adjusting for admission WeeFIM, age, and IPR length of stay, patients with neither injury improved 23.6 points less in total WeeFIM than those with ICH only ($\beta = -23.6$; $p = 0.005$). After further adjustment for GCS and neurosurgery intervention, this difference was attenuated ($p = 0.058$), although cognitive and self-care improvement remained lower in patients with neither DAI nor ICH ($p = 0.029$ and $p = 0.047$). Each additional year of age was associated with 2.1 points greater total improvement ($\beta = 2.1$; $p < 0.0001$). Across fully adjusted injury-pattern and mechanism models, higher admission WeeFIM predicted less total improvement ($\beta = -0.46$ and -0.44 ; $p = 0.004$ and $p = 0.003$). Mechanism was not associated with WeeFIM admission, discharge, or progression.

Conclusion: Intracranial injury pattern, but not mechanism, was associated with WeeFIM progression. Patients with neither DAI nor ICH improved least despite comparable admission function; this difference was attenuated after full adjustment, although cognitive and self-care differences persisted. Findings should be interpreted cautiously, as only eight patients had neither injury.