

Impact of extracranial injury on recovery after traumatic brain injury: a machine learning analysis

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Traumatic brain injury (TBI) is the most common neurological condition worldwide. It often co-occurs with extracranial injuries, but the heterogeneity and complex interactions between brain and non-brain trauma make it difficult to assess their impact on outcomes using conventional methods. This study applied an explainable machine learning framework to evaluate the influence of extracranial injury on functional outcome, accounting for injury patterns and interactions with established prognostic factors. The aims were: (1) to determine the contribution of extracranial injury to outcome prediction, and (2) to assess the relative importance of individual extracranial injuries at the patient level.

Data from patients across all TBI severities were drawn from the CENTER-TBI study. Random Forest and XGBoost models predicted 6-month outcome (unfavourable GOSE 1–4 vs favourable GOSE 5–8), using IMPACT extended model variables plus 10 extracranial injury domains. SHAP values were used to estimate individual-level contributions of each extracranial injury.

At the cohort level, adding extracranial injury improved discrimination only modestly (AUC increase of 2 percent). However, SHAP analyses revealed marked heterogeneity at the individual level: lower-extremity injuries contributed most to prognosis, followed by lumbar spine injury.

Although requiring external validation, these findings highlight that extracranial injuries add little at the group level but can strongly shape individual recovery trajectories. This underscores the potential of machine learning to advance personalised outcome prediction after TBI.