Three-dimensional finite element analysis of subdural hematoma

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摘要

Abstract

Background: Head motion, an important factor in acute subdural hematoma (ASDH), can be broken down into translational and rotational elements. We used three-dimensional finite element analysis to examine the thresholds of angular and tangential acceleration required to tear bridging veins in humans during head impact. Methods: The lengths of midsagittal and parasagittal bridging veins were calculated first. To assess the effect of translational and rotational acceleration, the strain of each vein was then computed under three different motions. The threshold of ASDH was expressed in terms of tangential and rotational acceleration. Results: Deformation-angle histories of the midsagittal and parasagittal bridging veins showed that veins that drain forward into the superior sinus at a 130-degree angle incurred the greatest stretch strain during occipital impact. In the midsagittal plane, pure rotation induced greater stretch strain on these veins (14.4%) than pure translation (2.5%) or combined translation and rotation motion (10.4%). A tangential acceleration of 3,912.9 G or an angular acceleration of 71.2 krad/s2 seemed to approximate the threshold for ASDH in the human midsagittal plane, whereas 5,010.9 G and 97.4 krad/s2 approximated the threshold in the parasagittal plane. Conclusion: Impact direction and orientation of bridging veins are both important factors in ASDH. Threshold criteria for ASDH can be expressed in terms of tangential and rotational acceleration.