3D Illustration to Quantify Volume of Contusions

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Background

Traumatic brain injury (TBI) is a major cause of death and disability in the US[1]. Timely treatment is crucial to patient outcome. Intracerebral hemorrhage (ICH) volume is associated with patient outcome and mortality[2]. Size of hemorrhage has also been used as a criterion for surgical intervention and prognostication[3].

To estimate intracerebral hemorrhage volume, the current standard is ABC/2, in which a rough ellipsoid volume is calculated. This measurement is frequently used, but has been shown to demonstrate significant variability in precision with bleed phenotype[4].

3D illustration (3DI) allows for more precise quantification of pathology on CT. Our work applies 3DI to the measurement of hemorrhagic contusions and edema on CT.

Objectives

To apply advanced methods in semi-automated 3D illustration to the quantification of contusion volume after TBI.

To then compare these results to those using the current standard ABC/2 scale.

Methods

- Baseline CT scans collected during the ProTECTIII multicenter clinical trial were reviewed retrospectively by a neuroradiologist (n = 881). Cases in which the largest traumatic lesion was due to a contusion were selected.
- Volume of hematomas were calculated using the ABC/2 method; this was done on OsiriX (Mac) and RadiAnt (PC) machines by the radiology team.
- DICOM data were resampled into 1.5 mm thickness slices, and then symmetrized using Aquarius.
- The cerebral hemorrhagic contusions and associated edema were segmented by a research assistant blinded to ABC/2 values using 3D Slicer slicer.
- In the Editor module, a threshold was applied to the PaintEffect tool, allowing segmentation of voxels within a specified signal intensity range. The lower limit of the range for hemorrhages was set at 40-45 Hounsfield Units (HU) to include blood, but exclude healthy brain tissue. The upper limit was set at 100HU to exclude calcifications and bone. The HU range for edema was set between 0 HU and 28HU
- Agreement will be assessed via Bland-Altman.

Figure 1. Hemorrhagic Contusion Segmentation

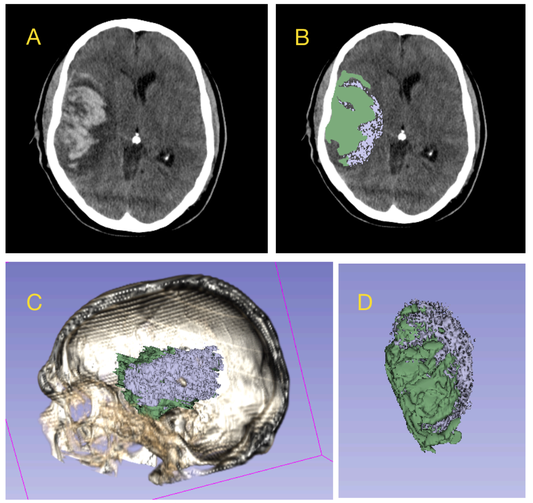

Image A: Axial section of CT scan showing hemorrhage and edema; Image B: Same axial section as A, segmented using PaintEffect on 3D Slicer; Image C: 3D model of the segmented hemorrhage and edema volumes localized in the skull; Image D: 3D model of segmented volumes in empty space

Future Directions

Machine learning is a tool for rapid identification of intracranial hemorrhage, and could serve as an important aid in triage of TBI. Machine Learning algorithms are currently being trained in our lab using this dataset.

The ProTECTIII dataset includes 3078 scans, from 881 patients. Next steps will include segmenting serial per patient images, and correlating change in hemorrhage volume with physiological variability.

References

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