Intracranial Hemorrhage Localization in a Population of Patients using Registration-based Techniques in CT Imaging

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Abstract

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1 Introduction

1.1 ICH is Bad

Intracranial hemorrhage (ICH) results from a blood vessel rupturing into brain tissues and possibly the ventricles. Bleeding causes distension of brain structures and increases the likelihood of intracranial pressure (ICP) elevation. ICH accounts for 10-15% of all strokes, corresponding to approximately 80,000 annual cases [11], 30,000 deaths in the US [26], and 5 million cases worldwide [15]. CT scanning is widely available and is the most commonly used diagnostic tool in patients with ICH [31]. Clinicians utilize CT to define the location of bleeding, clinically assess severity, and plan patient management.

Despite robust correlation of cerebral location and functional performance in normal humans, location of ICH surpisingly is not an important factor in predicting severity of injury or prognosis [6, 8, 9, 10, 12, 13, 17, 18, 23, 25, 28, 32]. Furthermore, recent clinical trials do not demonstrate an important role for location as a factor associated with beneficial clinical outcome [1, 3, 19, 20].

1.2 Problems with Visual Inspection

The classification of hemorrhage location is complicated for even the best-trained neuroimage scientists. For example, a hemorrhage may extend into multiple brain areas, distend tissues altering anatomic relationships, and may break through the ventricular wall. Evaluating these anatomic possibilities challenges even the best clinicians, thus routine practice identifies a single location as the primary affected anatomic region (e.g. caudate, putamen, etc.) or describes the location of the edge of the hemorrhage in relation

to a given landmark [41]. Outcome is strongly associated with hemorrhage volume; importantly, the modulation of the relationship between volume and location has not been studied. To investigate these anatomic issues, detailed localization information can be obtained by registering scans to a common template to provide refined anatomical localization information.

1.3 Previous CT Registration Work

Registration to template space is a crucial first step for any across-patient analysis; this allows each patient's scan to be located in the same stereotaxic space so information may be combined spatially across scans. Moreover, brain atlases with spatially-defined anatomic structures are available in template space. Recently, Rorden et al. [30] released the first publicly available CT template of healthy adults in MNI (Montreal Neurological Institute) space. We propose to utililize CT images from patients enrolled in our clinical trials which have been acquired in a standardized manner via the MISTIE (Minimally Invasive Surgery plus recombinant-tissue plasminogen activator (rtPA) for Intracerebral Evacuation) trial protocol and register them to template space. This design provides a simple registration of the reference and template images in a single imaging modality as opposed to more complex referencing systems [16, 24, 35].

1.4 Hypothesis

We propose to use CT images from the MISTIE and ICES (Intraoperative CT-Guided Endoscopic Surgery) trials to investigate the benefit or lack thereof in utilizing anatomic location as a biologically plausible predictor of ICH severity. Thus, we propose to test the hypothesis that routine clinical anatomic localization was no different than quantitative localization derived from registered-to-template images with atlas-based labeling for prediction of severity of injury.