# Internal Cerebral Vein Asymmetry on Follow-up Brain Computed Tomography after Intravenous Thrombolysis in Acute Anterior Circulation Ischemic Stroke Is Associated with Poor Outcome

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*Background:* Identifying early predictors of functional outcome after acute ischemic stroke (AIS) is important for planning rehabilitation strategies. Internal cerebral veins (ICV) drain deep parts of brain, run parallel to each other, and consistently seen on computed tomography angiography (CTA). Even minor asymmetry in their filling can be identified. We hypothesized that venous drainage would be impaired in patients with acute occlusion of internal carotid artery or middle cerebral artery. Because systemic thrombolysis can alter the vascular findings, we evaluated the relationship between ICV asymmetry on follow-up CTA and functional outcome. *Methods:* Consecutive AIS patients treated with intravenous thrombolysis between 2007 and 2010 were included. ICV asymmetry was assessed by 2 independent blinded stroke neurologists/neuroradiologists. Functional outcome was assessed by the modified Rankin Scale (mRS) at 3 months, dichotomized as good (0-1) and poor (2-6). Data were analyzed for predictors of functional outcome. *Results:* Of 2238 patients with AIS, 226 (10.1%) anterior circulation AIS patients received intravenous thrombolysis. The median age was 65 years (range 19-92), 44% were men, and median National Institutes of Health Stroke Scale (NIHSS) score was 16 points (range 4-32). Hypertension was the commonest risk factor in 173 (76.5%) patients, whereas 78 (34.5%) had atrial fibrillation. ICV asymmetry on follow-up CTA was assessed in 103 (45.5%) patients. Admission NIHSS score (odds ratio [OR] 1.07; 95% confidence interval [CI] 1.079-1.201, $P = .046$), change in NIHSS score during first 24 hours (OR .737; 95% CI .672-.807, $P < .0001$), and ICV asymmetry on follow-up CTA (OR 20.3; 95% CI 4.67-52.07, $P < .0001$) independently predicted poor outcome at 3 months. *Conclusions:* ICV asymmetry on follow-up CTA after intravenous thrombolysis is an early predictor of poor functional outcome. **Key Words:** Acute ischemic stroke—internal cerebral vein—thrombolysis—CT angiography.


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## Introduction

A significant proportion of acute ischemic stroke (AIS) patients achieve good functional outcome with timely administered intravenous tissue plasminogen activator (tPA). However, the rate and extent of recovery remain variable. Considering scarce and costly resources, early identification of reliable predictors for functional outcome is important for planning rehabilitation strategies and placement after discharge from the hospital. Internal cerebral veins (ICVs) drain the deep parts of cerebral hemispheres and run backward to form the great cerebral vein.[1] Impaired arterial blood supply results in poor venous drainage, rendering the corresponding ICV less visible. Because the 2 ICVs are consistently seen on computed tomographic angiography (CTA) as running parallel and very close to each other, even minor asymmetry in their filling can be diagnosed easily on CTA (Fig 1).[2] We hypothesized that ipsilateral cerebral hypoperfusion because of acute occlusion of internal carotid artery (ICA) or middle cerebral artery (MCA) would impair the ipsilateral deep venous drainage and result in obvious asymmetric opacification of the ICVs. Therefore, ICV asymmetry might serve as a surrogate marker of inadequate cerebral perfusion and collateral circulation.

Because a significant proportion of intravenous tPA-treated patients achieve arterial recanalization[3] and many of them might develop sufficient collateral arteries during the early phase of AIS,[4] ICV asymmetry on the pre-tPA CTA can disappear. Therefore, ICV asymmetry on a pre-tPA CTA may not be useful for predicting the long-term outcomes. On the other hand, vascular status of the intracranial circulation is believed to acquire its near-final status in majority of AIS patients by day 2. Therefore, we aimed to evaluate whether the presence of ICV asymmetry on day 2 CTA in tPA-treated AIS patients can predict the final outcome.

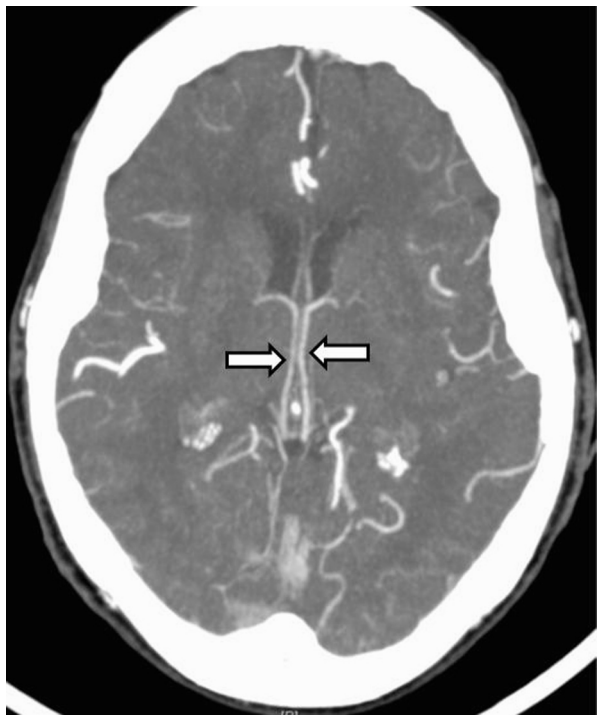

**Figure 1.** *Axial maximum intensity projection image showing the ICVs running posteriorly, parallel, and close to each other. Both ICVs show symmetrical opacification (arrows). Abbreviation: ICV, internal cerebral vein.*

## Subjects and Methods

In this retrospective cohort study, we analyzed the data from consecutive AIS patients treated with intravenous tPA between January 2007 and July 2010. Data were entered prospectively in the AIS thrombolysis registry maintained at our tertiary care center. Because the arterial supply via the vertebrobasilar system is not drained by the ICVs, patients with posterior circulation stroke were excluded from this study. The ethics committee at our institution approved the study.

Urgent noncontrast CT scan of the brain was performed for all patients suspected of having an acute stroke to exclude intracerebral hemorrhage and other mass lesions. A considerable proportion of patients considered eligible for intravenous thrombolysis at our center undergo CTA to identify the site of intracranial arterial occlusion. High-resolution brain CTAs were performed on a 64-slice multidetector helical scanner (Philips, Inc., USA) in patients without any evidence of intracranial bleeding and no contraindication for CTA (contrast medium allergy or serum creatinine levels $> 110$ μmol/L). CTA images were acquired with a bolus injection of 70-100 mL of contrast with a "bolus-tracking" technique, using a threshold level of 800 Hounsfield units (HU). Scan parameters at our institution were slice thickness, 1 mm; no slice gap; field of view, 200 mm; matrix, $512 \times 512$; 230-250 mAs. Coverage was from the base of skull to the vertex. The source images were reformatted into 3-mm-thick axial, coronal, and sagittal projections.

Majority of the neurologically and hemodynamically stable patients without contraindications for radiocontrast underwent CTA on day 2 after intravenous tPA to assess the status of arterial patency. ICVs were assessed on the reformatted maximum intensity projection images on axial sections. We defined ICV asymmetry as a unilateral attenuation of the ICV with lower density (reduced filling) than that of the "normal" side. In this study, ICV asymmetry was assessed on the initial CTA and the day 2 CTA by 2 independent readers, both blinded to patient clinical data or outcome. In the event of any discrepancy, consensus was later achieved by reviewing the scans together. The absolute values for HU of individual ICVs were estimated by placing the cursor probe on the digital imaging and communications in medicine images of CTAs. We calculated the ICV asymmetry index for each CTA (HU of ICV on affected side/HU of contralateral