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Case study

Prediction of favorable outcome by percent improvement in patients with acute ischemic stroke treated with endovascular stent thrombectomy

Yuezhou Cao [a,c], Shuiping Wang [b], Wen Sun [a], Qiliang Dai [a], Wei Li [a], Jin Cai [a], Xinying Fan [a], Wusheng Zhu [a], Yunyun Xiong [a], Yunfei Han [a], Wenjie Zi [a], Shiquan Yang [b], Jia Chen [b], Xinfeng Liu [a,*]

[a] Department of Neurology, Jinling Hospital, Southern Medical University, Nanjing, Jiangsu, China
[b] Department of Neurology, No. 123 Hospital of the People's Liberation Army, Bengbu, Anhui, China
[c] Department of Geriatric Neurology, First Affiliated Hospital of Nanjing Medical University, Nanjing, Jiangsu, China

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ABSTRACT

Our objective was to investigate a method for assessing early improvement and its predictive value for 3-month functional outcome in patients treated with EST. A total of 97 consecutive AIS patients undergoing EST were prospectively collected and retrospective reviewed. Data on demographics, vascular risk factors, admission National Institutes of Health Stroke Scale (NIHSS) score, 24-h NIHSS score, reperfusion and collateral formation were collected. Percent improvement was defined as ([baseline NIHSS score − 24-h NIHSS score]/baseline NIHSS score × 100%), while absolute improvement was calculated by the difference between scores (baseline NIHSS score − 24-h NIHSS score). A 3-month functional outcome was assessed using the modified Rankin Scale (mRS). Favorable outcome was defined as a mRS score of 0–2. Areas under the receiver-operating characteristic (ROC) curve (AUC) for percent improvement and absolute improvement in predicting favorable outcome was compared. Finally, we investigated the independent predictors of improvement at 24 h after EST and its relationship with favorable outcome. Pairwise comparison of ROC curves revealed that percent improvement had larger AUC than absolute improvement ($p = 0.004$). Rapid neurological improvement (RNI), defined as percent improvement $\geqslant$30%, was a powerful predictor of favorable outcome (odds ratio [OR] 7.63, confidence interval [CI]: 2.65–21.96; $p < 0.001$). Good collaterals (OR 2.86; 95% CI: 1.11–7.38; $p = 0.030$) and short onset-to-reperfusion time (ORT) (OR 3.02, 95% CI: 1.17–7.80; $p = 0.022$) were independent predictors of RNI. RNI predicted 3-month favorable outcome in AIS patients treated with EST. Good collaterals and short ORT are independent predictors of RNI.

1. Introduction

The clinical benefit and safety of thrombolysis with intravenous recombinant tissue plasminogen activator (IV rtPA) in patients with acute ischemic stroke (AIS) were confirmed in randomized trials [1,2]. Despite the clinical efficacy of IV rt-PA, disappointments remained concerning low recanalization rates, ranging between 4.4% for distal internal carotid artery (ICA) occlusion, 4% for basilar artery occlusions and 30% for middle cerebral artery (MCA) M1 and M2 segment occlusions [3]. Endovascular treatment (ET), such as intra-arterial (IA) thrombolysis or mechanical thrombectomy, is more effective at opening such major cerebral artery occlusions than IV thrombolysis (IVT), but its clear advantage was not confirmed in randomized clinical trials [4–6] until the end of 2014. The management of AIS due to large vessel occlusion has been transformed by the five recently published randomized trials which predominantly used stent retrievers [7–11]. Endovascular stent thrombectomy (EST) is now the new standard of care for large vessel ischemic stroke [12].

Several studies have demonstrated that rapid neurological improvement (RNI) within the first 24 h is a strong indicator of favorable long-term outcome for patients with AIS after treatment with IVT [13–15] or ET (including IA thrombolysis and mechanical thrombectomy) [16–19]. RNI was often calculated based on the National Institute of Health Stroke Scale (NIHSS) scores, but its definition showed considerable variation. The commonly used definition of RNI is the absolute NIHSS score change from baseline to

* Corresponding author.
E-mail address: xfliu2@vip.163.com (X. Liu).

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24 h after treatment, but a previous study demonstrated that percent improvement in NIHSS scores between baseline and 24 h after treatment more powerfully predicted 3-month outcomes than absolute NIHSS score change in patients treated with IV tPA, IA urokinase or a sequential combination [16]. Identifying factors associated with RNI is of great importance to understanding and replicating this improvement. Furthermore, being able to predict good outcome at 24 h may have implications for clinical management and discharge planning. The present study aimed to (1) identify an easy and powerful method for assessing RNI in AIS patients treated with EST to predict long-term functional outcome reliably, and (2) investigate predictive factors of RNI in this specific patient population and its relationship with 3-month functional outcome.

2. Patients and methods

2.1. Patient selection

We performed a retrospective review of prospectively collected thrombectomy databases across two stroke centers (Jinling Hospital, Southern Medical University and No. 123 hospital of the People's Liberation Army) for all consecutive patients with AIS who received EST with the Solitaire AB device between April 2012 and November 2015. Both stroke centers maintained similar endovascular procedure registries, which included demographic and clinical information, risk factors profile, radiological and angiographic imaging data, and procedural component. EST was performed with the consent of the patient or family members if: (1) sudden focal neurological deficit attributable to a large artery occlusion in the anterior circulation artery was confirmed by computed tomography angiography (CTA) or digital subtraction angiography (DSA); (2) age was $\geqslant$18 years; (3) baseline NIHSS score was $\geqslant$2 points; (4) intracranial hemorrhage on non-contrast computed tomography (CT) was excluded; (5) EST could be initiated within 6 h of symptom onset; (6) hypodensity of 1/3 or less of the middle cerebral artery (MCA) territory was present on the baseline CT. The study was approved by the institutional review board of both hospitals.

2.2. Clinical evaluation

Information about baseline demographics and vascular risk factors was obtained from both prospective endovascular procedure registries. In our hospital (Jinling Hospital), the evaluation of neurological deficits was conducted using the NIHSS at admission and at 24 h after EST by a certified neurologist (Xinying Fan), who was blind to imaging and clinical information. In the No. 123 hospital of the People's Liberation Army, a neurologist (Jia Chen) who had completed the training program in our hospital and certified in the use of NIHSS performed NIHSS scoring at baseline and at 24 h, also blind to imaging and clinical information. Functional clinical outcome was assessed 90 days after EST using the modified Rankin Scale (mRS). Follow-up was conducted in the clinic or during hospital admission on the scheduled day. If patients could not visit the hospital at 90 days because of severe disability or other causes, the mRS score was measured by a telephone interview. Favorable outcome was defined as a mRS score of 0–2. To identify a reliable and powerful parameter of RNI that could predict favorable long-term functional outcome, percent improvement was compared with absolute improvement. Percent improvement was defined as ([baseline NIHSS score − 24-h NIHSS score]/baseline NIHSS score × 100%), while absolute improvement was calculated by the difference between scores (baseline NIHSS score − 24-h NIHSS score). Major neurological improvement (MNI) was defined as an improvement in NIHSS score of $\geqslant$8 points or an NIHSS score of 0 or 1 at 24 h.

2.3. Treatment

2.3.1. Intravenous thrombolysis

IV r-tPA was performed on all eligible patients with AIS presented within 4.5 h after symptom onset according to the national guideline [20]. For the patients who presented within 4.5 h after symptom onset but were ineligible for IV r-tPA or the patients who presented between 4.5 h and 6 h after symptom onset, direct EST was performed.

2.3.2. Endovascular stent thrombectomy

All procedures were carried out under local anesthesia/conscious sedation. Access was obtained by a standard transfemoral approach. Following DSA demonstrating a major cerebral artery occlusion in the anterior circulation, a 6-F or 8-F guiding catheter was introduced through a femoral sheath into the ICA (related to the ischemic vascular territory). The thrombus was passed with a 0.014-in microwire over which a microcatheter was navigated distal to the point of occlusion. After passage of the clot, microcatheter contrast injection was injected to verify the microcatheter position 1 cm distal to the clot. The stent retriever (Solitaire AB, ev3) was then advanced to the distal tip of the microcatheter and deployed within the impacted thrombus at the occluded vessels by withdrawal of the microcatheter. A control angiogram was performed after successful unfolding of the stent device to evaluate re-establishment of flow. After 3–5 min, the unsheathed Solitaire stent and microcatheter were removed as a system into the guide catheter, while the assistant produced suction by placing a 50-mL syringe at the 'Y' valve of the guiding catheter to reduce the likelihood of distal migration of the captured thromb. After removal of the device and microcatheter, another 30–50 ml blood was aspirated from the guiding catheter to prevent re-embolization of possibly lost clot. Angiographic runs was repeated following retrieval of the Solitaire device and the procedure was repeated up to six times or until recanalisation was achieved. For the patients with tandem lesions, the intracranial occluded artery was treated with EST, while combined ipsilateral cervical carotid occlusion was treated with stent placement when necessary. Carotid stenting was performed before or after thrombectomy according to the ICA status or at each interventionist's discretion. For the residual stenosis in cases with in situ thrombosis, balloon angioplasty or electrolytical detachment of stent was performed after EST at the discretion of the operator. For the patients treated with stent, all who were not on an antiplatelet medication before the intervention received a loading dose of 300 mg clopidogrel and 300 mg aspirin. Patients with daily aspirin medication before the intervention did not receive an aspirin loading dose. The dual antiplatelet medication with aspirin (100 mg/-day) and clopidogrel (75 mg/day) was continued for 3 months followed by a life-long antiplatelet monotherapy with either aspirin or clopidogrel.

2.4. Image review and analysis

A CT or MRI scan was obtained 24 h after treatment or in any case of clinical deterioration. Symptomatic intracerebral hemorrhage (ICH) was defined as hemorrhagic transformation within 24 h of the intervention that was associated with a 4-point increment in NIHSS score or death. Two independent stroke neurologists (Wen Sun and Qiliang Dai) who were masked for clinical outcome assessed all DSA for occlusion site, collateral formation and reperfusion. The site of artery occlusion was categorized as follows: ICA, MCA or tandem occlusion which was defined as multiple