Application of high-resolution magnetic imaging in the perioperative period of mechanical thrombectomy for acute intracranial large artery occlusion

G. Liu[1#], L. Luo[2#], L. Ma[1], M. Yu[1], M. Wei[1*]

[1]Department of Neurosurgery, Tianjin Huanhu Hospital, Tianjin, China
[2]Department of Neurology, Tianjin Huanhu Hospital, Tianjin, China

► ***Short report***

***Corresponding author:**
Ming Wei, MD.,
***E-mail:** drymshhyy@163.com*

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# Guijing Liu and Leilei Luo contributed equally to this work

ABSTRACT

Background: High-resolution magnetic resonance imaging (HR-MRI) holds promise for guiding the perioperative management of acute intracranial large artery occlusion during mechanical thrombectomy. ***Materials and Methods:*** A retrospective analysis was conducted on patient data from Tianjin Huanhu Hospital, March to September 2020. Patients underwent preoperative imaging, including head CT, MRI, MRA, and HR-MRI. Surgical plans were based on HR-MRI findings, with outcomes assessed using NIHSS, ASPECT score, mTICI grading, complications, and 90-day/24-month mRS scores. ***Results:*** Among 22 patients, 19 achieved successful recanalization, with two cases halted due to calcified plaque obstruction and one due to basilar artery difficulty. No perioperative hemorrhage or mortality occurred. Discharge NIHSS median was 3.4 (range 2.7–3.8). Follow-up (median 14 months) showed no deaths or loss. Median mRS score for successful cases was 1 (range 1–3), with two new strokes and one TIA. Two patients experienced restenosis, promptly treated with stenoplasty. ***Conclusions:*** HR-MRI enhances the perioperative assessment of mechanical thrombectomy for acute intracranial large artery occlusion, aiding in lesion characterization, occlusion length determination, and identification of critical vessel relationships. This approach facilitates safer and more effective emergency thrombectomy procedures.

INTRODUCTION

Intracranial large artery occlusive lesions are a common cause of ischemic stroke (1-3), and since 2015, multiple clinical randomized trials (4-8) have demonstrated that endovascular therapy with stent embolectomy can bring significant clinical benefit to patients with reasonably selected patients with large vascular occlusive stroke. Current imaging modalities for the evaluation of intracranial artery occlusion include magnetic resonance angiography (MRA), CT angiography (CTA), digital subtraction angiography (DSA), and transcranial Doppler (TCD), which demonstrate occlusion site and associated hemodynamic factors, but do not provide information about the lumen and wall structure of closed plugged segments (9). High-resolution magnetic imaging (HR-MRI) is a noninvasive test that provides information on vascular tissue structure, wall thickness, and plaque composition through HR-MRI combined with black blood and bright blood techniques (10). Carotid plaque components identified by HR-MRI have been shown to be consistent with pathologic findings (11). The application of high-resolution magnetic imaging in the perioperative period of mechanical thrombectomy for acute intracranial large artery occlusion was no reports have been reported. This study aimed to explore the application value of high-resolution NMR in the perioperative period of emergency mechanical thrombectomy in acute intracranial large artery occlusion. The preliminary treatment experience and treatment effect of this study are reported as follows.

MATERIALS AND METHODS

Clinical data

Retrospectively analyzed the clinical case data of patients with acute intracranial large artery occlusion admitted to the Department of Neurosurgery of Tianjin Huanhu Hospital from March to June 2020, and all patients underwent head CT, MRI, MRA and high-resolution MRI (3.0T magnetic resonance instrument, Siemens AG, Germany) to evaluate the lumen and location of the occluded blood vessel and thrombus to clarify the nature of vascular occlusion and the relationship between the lesion and the perforating artery opening. After reasonable screening, a surgical plan was formulated based on the results of high-resolution MRI evaluation, and emergency mechanical thrombectomy was performed, including 15 males and 7 females. Age 42~74 years, average (55±12) years; There were 17 cases of hypertension, 6 cases of diabetes, 21 cases of hyperlipidemia, 5 cases of atrial fibrillation, 3 cases of

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stroke, and 13 cases of smoking. The included patients showed typical ischemic symptoms, such as crooked corners of the mouth, one limb sensation, motor disorders, with or without language and consciousness disorders. Alberta stroke program early CT (ASPECT) score 5 ~ 10 points, average (7. 5±1.6) points; Preoperative National Institutes of Health Stroke Scale (NIHSS) score 7 ~ 16 points, average (12.0±2.9) score. The results of CT angiography and cerebral vascular DSA showed 13 cases of M1 segment occlusion, 5 cases of ICA terminal occlusion, 3 cases of ICA initiation occlusion, and 1 case of BA occlusion. This study protocol was approved by the ethics committee of Tianjin Huanhu Hospital, and the patient or his family signed the informed consent form for surgical treatment.

Inclusion and exclusion criteria Inclusion criteria

(1) age over 18; (2) acute large vessel occlusion; (3) Non-contrast head CT scan showed no cerebral hemorrhage or subarachnoid hemorrhage, and the ASPECT score was ≥6 points; (4) NIHSS score≥ 6 points; (5) Patients with 6~24 hours of onset or unknown onset time within 6 h of onset were clearly mismatched by strict imaging screening; (6) Intravenous thrombolysis in accordance with the case of intravenous thrombolysis, bridging intravascular mechanical thrombectomy; (7) No bleeding tendency, no recent surgical history; (8) Blood pressure <180/110 mmHg after drug control. Exclusion criteria: (1) The infarct area is greater than 50ml; (2) Active bleeding or known to have obvious bleeding tendency; (3) Severe heart, liver, kidney, and dysfunction; (4) Blood glucose <2.7 mmol/L or >22 mmol/L; (5) severe hypertension that cannot be controlled by drugs; (6) The family refuses.

Treatment

After head CT was performed to rule out cerebral hemorrhage in emergency stroke patients, a green channel was opened in the emergency department and head MRI scans were performed to confirm infarction, and MRA and high-resolution MRI examinations confirmed that there were large vessel occlusions and patients who met the inclusion criteria. Siemens Prisma 3.0TMRI equipment, 64-channel phased array head and neck joint coil. Scan sequence and parameters: (1) T2*WI uses gradient echo sequence, the scanning range covers the whole brain, the repetition time is 477 ms, the echo time is 18.2 ms, the field of view is 240 mm× 240 mm, the matrix is 256×192, the number of layers is 224, the layer thickness is 5 mm, the interlayer distance is 1.5 mm, and the acquisition time is 42 s. (2) HR-MRI uses a three-dimensional fast spin echo technology based on a variable flip angle and a long echo chain based on T1 WI, and the scanning range is from the middle cerebral artery to the bifurcation of the common carotid artery, with a repetition time of 900 ms, an echo time of 15 ms, a field of view of 200 mm× 200 mm, a matrix of 320×320, a number of layers of 224, a layer thickness of 0.53 mm, and an acquisition time of 7 min. The contrast medium was meglumine gadolinium-pentetate (Gd-DTPA) (concentration 0.5 mmol/mL, Bayer HealthCare) with an injection flow rate of 2 mL/s and a dose of 0.2 mmol/kg body weight, and after 5 minutes of intravenous injection through the elbow, enhanced images were obtained by HR-MRI scanning. Image analysis was performed on the Siemens Syngo. Via workstation to record the location of the occlusion (distal intracranial segment of the internal carotid artery, proximal end of the middle cerebral artery M1 segment, and distal end of the middle cerebral artery M1 segment). The patient undergoes total cerebral angiography and mechanical thrombectomy under general anesthesia/local anesthesia. After surgery, antiplatelet, lipid regulation, blood pressure, blood sugar control and risk factor control are actively treated.

Follow-up and efficacy assessment

Follow-up methods include clinical follow-up and data-collecting imaging follow-up. Patients are observed for ischaemic stroke events associated with the responsible blood vessel, and restraining or occlusion of the recanalized vessel is assessed using head DSA or CT angiography. Clinical follow-up and imaging follow-up (DSA OR) were performed 6 to 12 months after surgery, and follow-up once a year thereafter. The standard for restenosis is ≥50 percent narrowing of blood vessels within 3 mm within the stent and at both ends of the stent and is measured using the Warfarin-Aspirin Intracranial Disease (WASID) test standard [12].

RESULTS

Among the 22 surgical patients in this study, 19 were successfully recanalized; the two cases showed calcified plaque by HR-MRI and the stump was blunt during the operation, and the operation was terminated because the guidewire could not pass through the occlusion segment. One case of acute occlusion of the basilar artery was terminated because it was difficult for the microcatheter to pass through the occluded segment after the guidewire passed during surgery. Patients had no perioperative bleeding or death. The patient had a NIHSS score of 0 ~ 12 at discharge, with a median score of 3. 4(2. 7, 3. 8) points. The median follow-up time of 14 (3, 25) months among the 19 successful patients was 14 (3, 25) months, there were no deaths and loss to follow-up, and the median mRS score was 1 (1, 3), 2 new strokes and TIAs; Two patients developed symptomatic restenosis 6 months after surgery, and were admitted to the hospital for stenoplasty, and the

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patients had no clinical aggravation, and re-imaging 12 months after surgery, showing that the stent had no restenosis. The median follow-up of the three patients who failed surgery was 12 (3, 21) months, there were no deaths and loss to follow-up, the median mRS score was 2 (2, 3), 1 had a new stroke, and 2 had TIA.

Typical cases

The patient, a 48-year-old male, was admitted to Tianjin Huanhu Hospital on June 30, 2020 mainly due to "left limb weakness with speech disadvantage for 3 hours". Previous history of hypertension and diabetes. Emergency physical examination: clear mind, unfavorable speech, response to the topic, double pupil L: R =2:2 mm, light reflex (+), eye movement, no nystagmus, no drooping eyelids, symmetrical nasolabial folds without shallowness, unbiased corners of the mouth, tongue extension centered, neck soft and no resistance, left limb muscle strength grade II, right limb muscle strength class V, left Pap sign (+). Emergency head MRI non-contrast scan: right basal ganglia, right paraventricular DWI hyperintensity, consider acute infarction (figure 1a). MRI angiography shows that the distal M1 segment of the right middle cerebral artery and its distal development are not visible (figure 1b); MRI perfusion imaging showed that uneven hypoperfusion changes were visible in the right basal ganglia area and right ventricle paraventricular (figures 1c, d); High-resolution MRI angiography showed that the occlusion of the M1 segment of the right middle cerebral artery did not uniformly strengthen the solid signal, which was considered a solid thrombosis signal. The M1 segment is uniformly solid signaled with a distal lumen, and is strongly altered, which is considered a slow blood flow signal (figure 1e). Diagnosed as: acute ischemic cerebrovascular disease, right middle cerebral artery occlusion, right basal ganglia acute cerebral infarction, hypertension grade 3 very high risk, type 2 diabetes. Cerebral angiography + right middle cerebral artery embolectomy was performed in the emergency department. DSA shows the distal M1 segment of the right middle cerebral artery and its distal development (figure 1g); During the operation, the Transend 200cm microguidewire guided Rebar-18 microcatheter successfully passed through the occlusion segment to the right MCA M2 segment microcatheter distal unobstructed, and the Solitair 4*20 stent was pushed through the microcatheter and placed in the M1 horizontal section, and the contrast TICI grade 1 (figure 1h). The fixed stent and stent catheter pushed Navien to the end of the internal carotid artery, and the negative pressure aspirator continued to suction Navien while pulling the stent out of the body, showing obvious blood tethering on the stent. Reimaging showed severe stenosis in the horizontal segment of MCA M1, decided to dilate the balloon, Transend 300 cm microguidewire replacement microcatheter, introduced the Gateway 2.0 mm balloon to the most severe stenosis, dilated balloon pressure to 6AT, the distal expansion of the balloon was complete, the balloon was well dilated, and after the balloon was released, the contrast showed that the stenosis of the MCA M1 segment was improved, and the TITI grade 3. 15nin post-contrast angiography confirmed that blood vessels were patency after dilation. Femoral artery puncture point suture completed. The operation process was smooth and the patient's vital signs were stable after the operation, and the physical examination was the same as before the operation. Postoperative follow-up head MRI non-contrast scanning showed no increase in the core infarction area (figure 1J). MRI angiography showed the patency of the M1 segment of the right middle cerebral artery (figure 1k); MRI perfusion imaging showed that the right basal ganglia area and right paraventricular hypoperfusion were significantly better than before surgery (figure 1l, 1m); High-resolution MRI angiography showed that the middle M1 segment of the right middle cerebral artery was significantly thickened with the distal tube wall, involving the peripheral wall, the lumen was unobstructed, and the M2 segment collapsed with the distal lumens (figure 1n).

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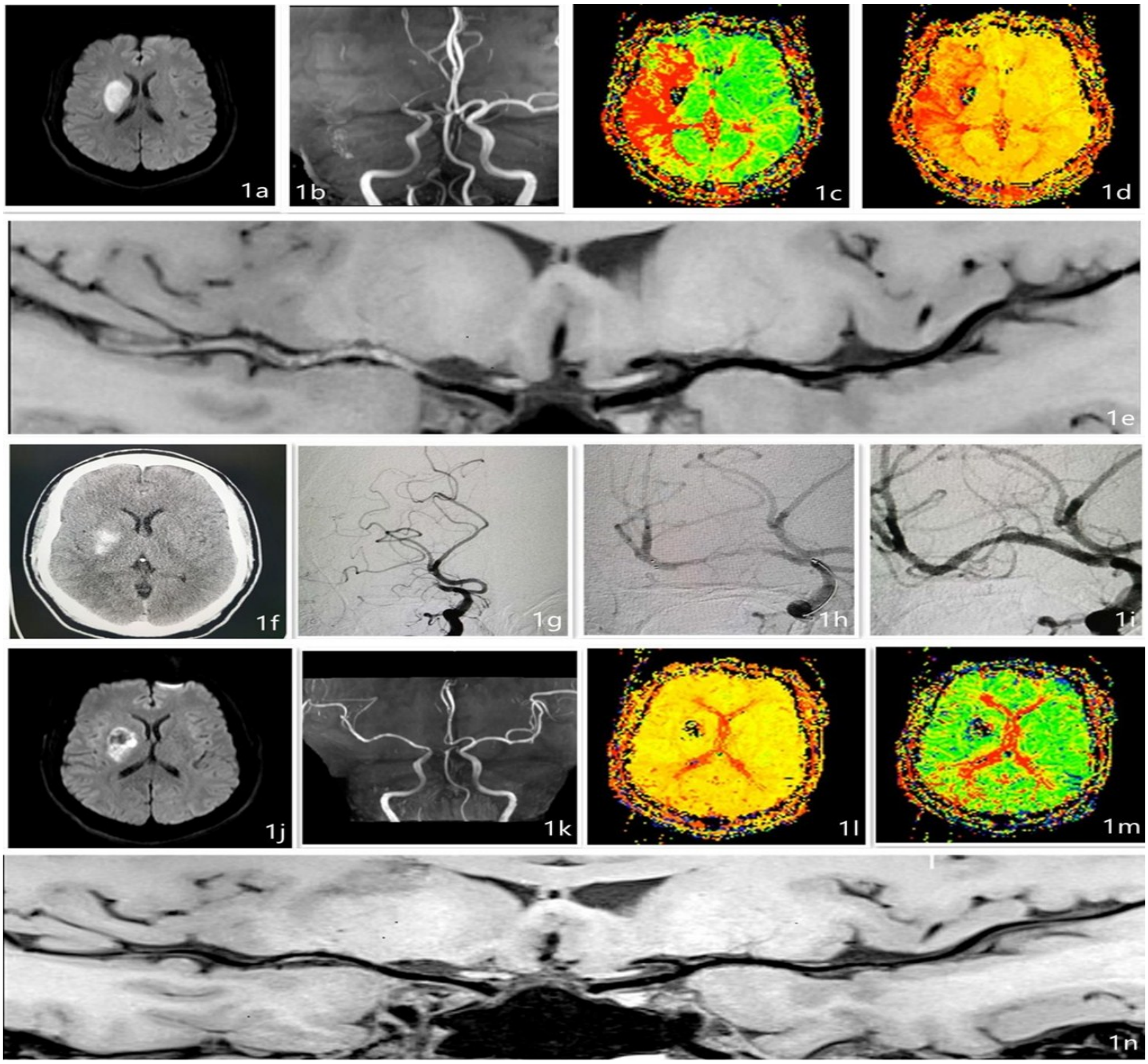

Figure 1. Examples of imaging images in typical cases: **(a)**, is a preoperative MRI non-contrast DWI image; **(b)**, is an MRA image showing right middle cerebral artery occlusion; **(c-d)**, shows MRI perfusion imaging; **(e)**, shows the location of the occlusion and the length of the intravascular thrombus (arrows are located at the proximal and distal ends of the occlusion) on HR-MRI non-contrast scan; **(f)**, shows no obvious bleeding on postoperative CT, and the contrast effusion is considered in the core area of the infarct due to high density; **(g-i)**, are before the opening of the intraoperative blood vessels; **(j)**, shows that the core area of the microinfarct is not enlarged by postoperative MRI DWI images; **(k)**, shows recanalization after right middle cerebral artery occlusion shown by postoperative MRA; **(l-m)**, shows the obvious improvement of ischemia in the right middle cerebral artery supply area on postoperative MRI perfusion images; and **(n)** shows the patency of the lumen of the occluded vessel by HR-MRI after non-contrast HR-MRI.

DISCUSSION

Secondary prevention of ischemic stroke relies on determining stroke pathogenesis [13]. However, traditional clinical, laboratory, and imaging methods often fail to determine the cause of stroke [14]. High-resolution enhanced vascular magnetic resonance imaging is an emerging method to identify the causes of intracranial artery occlusion in stroke, such as intracranial atherosclerosis [15-17], central nervous system vasculitis [17-19], and reversible cerebral vasoconstriction syndrome [18]. The use of high-resolution magnetic imaging in acute intracranial large artery occlusion and intravascular thrombectomy has rarely been reported. This study found that high-resolution MRI before emergency arterial embolectomy can provide more information on the occlusion lumen and wall of lesion segments, which is helpful to evaluate the difficulty and risk of surgery before emergency embolectomy, and determine the need for balloon dilation or stenoplasty in advance, which is of great significance for increasing the success rate of thrombectomy, reducing serious complications and reducing the hospitalization cost of patients. In addition to sufficient experience in endovascular thrombectomy, it is necessary to make a necessary preoperative preparation for effective judgment of the length of the vascular occlusion segment, the nature of the occlusion, and the stability of the plaque. By cooperating with the MRI room and DSA room to build a green channel for intravascular thrombectomy, our center fully improves the preoperative MRI and CTA evaluation, which is of great significance to reduce the risk of surgery, improve the success rate of vascular recanalization and reduce complications. In our experience, radiographic occlusion segments shown on preoperative CTA and/or MRA examination do not equate to true anatomically occluded segments. The length of the occlusion shown on imaging consists of three components: anatomically occlusive segment (true occlusion segment), subtotal occlusion segment (with potential gap), and delayed flow zone [(20)], so true occlusion segment tends to be shorter than the segment shown on MRA or CTA. Therefore, the difficulty of opening the occlusion section is that the guidewire passes through the anatomical occlusion segment, and once it passes through the anatomical occlusion segment, it will easily pass through the other two segments. High-resolution MRI can clearly display the information of the true occlusion segment, combined with the patient's medical history (atrial fibrillation, hypertension, diabetes, previous cerebral infarction), which is helpful to screen out patients with acute intracranial artery occlusion with a high possibility of intraluminal recanalization before surgery, and preliminarily determine the nature of occlusion and guide the operation in the book, which is of great significance for increasing the success rate of surgery, reducing serious complications and controlling medical costs. In summary, for patients with acute intracranial large artery occlusion, high-resolution magnetic imaging technology evaluates the occlusion length, lesion nature and potential space of the occlusion segment, combined with the evaluation of other clinical features of the patient, screens suitable cases, and implements mechanical thrombectomy and recanalization treatment is safe and feasible, quickly restores blood flow to large vessels, and reduces the disability and mortality rate. It is believed that with the advancement of MRI scanning technology and the accumulation of experience in the future, magnetic resonance imaging scanning technology will play an increasingly important role in preoperative evaluation and surgical strategy formulation. In addition, this study has certain limitations, including a small number of participants, lack of pathological verification of narrowed arteries, and the review and analysis of magnetic resonance images can only be based on previous research experience.

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Ethical consideration: This study protocol was approved by the ethics committee of Tianjin Huanhu Hospital, and the patient or his family signed the informed consent form for surgical treatment.

Authors' contributions: G.L., L.L.: Conceptualization, methodology, writing original draft preparation. L.M., M.Y.: Investigation, software, statistical analysis. M.W.: Reviewing and editing, funding acquisition, supervision. All authors read and approved the final manuscript.

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