Mechanical thrombectomy for acute ischemic stroke

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INTRODUCTION — Timely restoration of cerebral blood flow using reperfusion therapy is the most effective maneuver for salvaging ischemic brain tissue that is not already infarcted. There is a narrow window during which this can be accomplished, since the benefit of reperfusion decreases over time.

This topic will review the use of mechanical thrombectomy for acute ischemic stroke. The approach to reperfusion therapy for acute ischemic stroke, including the use of intravenous alteplase (recombinant tissue plasminogen activator or tPA), is reviewed elsewhere. (See "Approach to reperfusion therapy for acute ischemic stroke" and "Intravenous thrombolytic therapy for acute ischemic stroke: Therapeutic use".)

OVERVIEW OF REPERFUSION THERAPY — For eligible patients with acute ischemic stroke, intravenous alteplase (recombinant tissue plasminogen activator or tPA) is first-line therapy, provided that treatment is initiated within 4.5 hours of clearly defined symptom onset (table 1). Because the benefit of alteplase is time dependent, it is critical to treat patients as quickly as possible. Eligible patients should receive intravenous alteplase without delay even if mechanical thrombectomy is being considered. (See "Intravenous thrombolytic therapy for acute ischemic stroke: Therapeutic use".)

Mechanical thrombectomy is indicated for patients with acute ischemic stroke due to a large artery occlusion in the anterior circulation who can be treated within 24 hours of the time last known to be well (ie, at neurologic baseline), regardless of whether they receive intravenous alteplase for the same ischemic stroke event, as discussed in the sections that follow.

Two issues may limit the widespread clinical use of mechanical thrombectomy. First, only an estimated 10 percent of patients with acute ischemic stroke have a proximal large artery occlusion in the anterior circulation and present early enough to qualify for mechanical thrombectomy within 6 hours [1-4], while approximately 9 percent of patients presenting in the 6 to 24 hour time window may qualify for mechanical thrombectomy [5]. Second, only a few stroke centers have sufficient resources and expertise to deliver this therapy. However, eligible patients can receive standard treatment with intravenous tPA if they present to hospitals where thrombectomy is not an option, and those with qualifying anterior circulation strokes can then be transferred, a strategy called "drip and ship" [6], to tertiary stroke centers where intra-arterial thrombectomy is available.

EFFICACY OF MECHANICAL THROMBECTOMY — Early intra-arterial treatment with second-generation mechanical thrombectomy devices is safe and effective for reducing disability and is superior to standard treatment with intravenous thrombolysis alone for the treatment of acute ischemic stroke caused by a documented large artery occlusion in the proximal anterior circulation (figure 1 and figure 2).

Benefit of early treatment — Five multicenter, open-label randomized controlled trials (MR CLEAN [7], ESCAPE [8], SWIFT PRIME [9], EXTEND-IA [10], and REVASCAT [11]) demonstrated that early intra-arterial treatment with second-generation mechanical thrombectomy devices is safe and effective for reducing disability and is superior to standard treatment with intravenous thrombolysis alone for ischemic stroke caused by a documented large artery occlusion in the proximal anterior circulation [1,12-18]. The number needed to treat (NNT) for one additional person to achieve functional independence in these trials ranged from approximately 3 to 7.5 [7-11,19,20].

In a meta-analysis of these trials, with pooled patient-level data for 1287 subjects, the rate of functional independence (ie, a 90-day modified Rankin scale [mRS] score of 0 to 2) was significantly greater for the intervention group compared with the control group (46 versus 27 percent, odds ratio [OR] 2.35, 95% CI 1.85-2.98) [12]. Similarly, mechanical thrombectomy led to significantly reduced disability as indicated by an improvement of ≥1 points on the mRS at 90 days (adjusted OR 2.49, 95% CI 1.76-3.53). Mechanical thrombectomy was beneficial across a wide range of patient subgroups, including age ≥80 years, high initial stroke severity, and those not treated with intravenous alteplase. There was no significant difference between the mechanical thrombectomy and control groups for rates of symptomatic intracranial hemorrhage or 90-day mortality.

When the positive results of the MR CLEAN trial were announced in late 2014, the remaining trials were stopped early on the basis of positive interim efficacy analyses. All of the trials enrolled overlapping but not identical patient populations and had generally similar results:

- The open-label **MR CLEAN** trial, which was the largest and most inclusive of the five trials, enrolled 500 adults (mean age 65 years, range 23 to 96 years) with an angiographically confirmed proximal arterial occlusion in the anterior circulation and randomly assigned them to treatment with intra-arterial therapy within 6 hours of symptom onset or to usual care [7]. The method of intra-arterial therapy was left to the discretion of the local interventionalist, but mechanical thrombectomy with retrievable stents was used in 82 percent. Approximately 90 percent of subjects in both groups received intravenous thrombolysis (median time to treatment: 80 minutes) prior to randomization. Assessment was blinded, and analysis was by intention-to-treat.

  Compared with usual therapy, the group assigned to intra-arterial treatment had significantly improved outcomes at 90 days as determined by lower scores on the mRS (table 2) (adjusted common odds ratio [OR] 1.67, 95% CI 1.21-2.30). The intra-arterial treatment group had a significantly higher rate of functional independence (ie, an mRS score of 0 to 2) at 90 days compared with usual treatment (32.6 versus 19.1 percent, absolute risk difference, 13.5 percent, 95% CI 5.9-21.2). The NNT for one additional patient to achieve functional independence was 7.4.

  At two years, the benefit of intra-arterial treatment on functional outcome was similar to the results at 90 days, as determined by lower scores on the mRS (OR 1.68, 95% CI 1.15-2.45) [19].

- The **ESCAPE** trial enrolled 316 adults (no upper age limit) with disabling ischemic stroke caused by a proximal intracranial large artery occlusion in the anterior circulation up to 12 hours after symptom onset. Subjects were randomly assigned to standard care plus endovascular treatment with thrombectomy devices or standard care only [8]. Patients with large infarct core on CT scan or poor collateral circulation on CT angiography were excluded. Approximately 75 percent of subjects in both groups were treated with intravenous alteplase. Among patients assigned to the thrombectomy group, the median time from symptom onset to first reperfusion was 241 minutes. At 90 days after treatment, the thrombectomy group had a significantly higher rate of functional independence (defined as an mRS score of 0 to 2) compared with the control group (53 versus 29 percent) and a significantly lower mortality rate (10 versus 19 percent). The NNT for one additional patient to achieve functional independence was 4.2. The thrombectomy group was significantly more likely to have lower scores on the mRS (common OR 2.6, 95% CI 1.7-3.8).

  Thrombectomy appeared to be beneficial for all prespecified subgroups, including those ages >80 and ≤80 years, men and women, subjects with moderate strokes, subjects with severe strokes, and those treated or not treated with intravenous alteplase.

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The **SWIFT PRIME** trial enrolled 196 adults ages 18 to 80 years with acute ischemic stroke and confirmed occlusion of a large artery in the anterior circulation who could be treated with mechanical thrombectomy within 6 hours of symptom onset [9]. Subjects were randomly assigned to treatment with the Solitaire FR thrombectomy device or no thrombectomy. All patients in both treatment groups received intravenous alteplase (recombinant tissue plasminogen activator or tPA) within 4.5 hours of stroke onset. Patients with large areas of infarction on advanced neuroimaging were excluded. At 90 days, thrombectomy led to a shift to lower disability levels on the mRS and to a significantly higher rate of functional independence, defined by an mRS of 0 to 2 (60 versus 35 percent). The NNT for one additional patient to achieve functional independence was 4.

- The **EXTEND-IA trial** randomly assigned 70 subjects with ischemic stroke who were receiving intravenous alteplase to intra-arterial treatment with the Solitaire FR thrombectomy device or to continue alteplase alone [10]. Patients without evidence of salvageable brain tissue or core infarction volume ≥70 mL were excluded. The median time from stroke onset to reperfusion in those treated with thrombectomy was 248 minutes. At 90 days, the thrombectomy group had a significantly higher rate of functional independence compared with the control group (71 versus 40 percent). The NNT for one additional patient to achieve functional independence was 3.2.
- The **REVASCAT trial** randomly assigned 206 patients with acute ischemic stroke to medical therapy plus intra-arterial treatment with the Solitaire stent retriever or medical therapy alone [11]. Most patients in both treatment arms received intravenous alteplase, and eligibility for the study included the presence of a proximal anterior circulation occlusion 30 minutes after the administration of alteplase. Thrombectomy led to higher rates of functional independence at 90 days (44 versus 28 percent; NNT 6.3) and a reduction in disability over the range of the mRS (adjusted OR for a one point improvement in the mRS score, 1.7, 95% CI 1.05-2.8). There were no significant differences in the rates of symptomatic intracerebral hemorrhage or mortality. Similar outcomes were noted at 12 months follow-up [20].

Benefit of later treatment — Mechanical thrombectomy is effective when used beyond 6 hours for selected patients who have a clinical deficit that is disproportionally severe compared with the volume of infarction on imaging studies.

- The open-label **DAWN trial** enrolled 206 adults with acute ischemic stroke who were last known to be normal 6 to 24 hours earlier; all had a stroke caused by occlusion of the intracranial internal carotid artery or the proximal middle cerebral artery and had a mismatch between the severity of the neurologic deficit, as measured by the National Institutes of Health Stroke Scale (median score 17 at baseline), and the infarct volume, as measured by automated software analysis using diffusion-weighted MRI or perfusion CT (median approximately 8 mL) [21]. Approximately 55 percent of the patients in the trial had a "wake-up" stroke (ie, they were last known to be well before going to bed and stroke symptoms were first noted upon awakening). Patients were randomly assigned to thrombectomy plus standard care or to standard care alone (control). The trial was stopped early for efficacy at the first interim analysis. The following observations were noted:
  - At 90 days, the rate of functional independence, as defined by a score of 0 to 2 on the modified Rankin scale, was greater for the thrombectomy group compared with the control group (49 versus 13 percent, adjusted difference 33 percent, 95% CI 24-44). The number needed to treat for one additional patient to achieve functional independence was 3. All other efficacy outcome measures also favored thrombectomy.
  - There was no significant difference between the thrombectomy and control groups in the rate of symptomatic intracranial hemorrhage (6 and 3 percent) or 90 mortality (19 and 18 percent).
- The open-label **DEFUSE 3 trial** enrolled patients with ischemic stroke due to occlusion of the proximal middle cerebral artery or internal carotid artery who were last known to be well 6 to 16 hours earlier [22]. Patients were required to have an infarct size of <70 mL and a ratio of ischemic tissue volume to infarct volume of ≥1.8, as measured by automated software processing of diffusion-weighted MRI or CT perfusion imaging. The DEFUSE 3 trial was stopped early for efficacy after randomly assigning 182 patients to thrombectomy plus standard care or to standard care alone. Approximately one-half of the patients in the trial had a "wake-up" stroke. Patients assigned to thrombectomy were treated with stent retrievers or aspiration catheters. At 90 days, the percentage of patients who were functionally independent, defined as a modified Rankin scale score of 0 to 2, was higher with endovascular therapy compared with medical therapy alone (45 versus 17 percent, difference 28 percent), and therefore the number needed to treat for one additional patient to achieve functional independence was 3.6. There was also a trend to lower mortality with endovascular therapy (14 versus 26 percent). There was no significant difference between groups in the rate of symptomatic intracranial hemorrhage (7 and 4 percent) or serious adverse events (43 and 53 percent).

These data support the use of mechanical thrombectomy to treat acute ischemic stroke due to occlusion of the intracranial carotid or proximal middle cerebral artery for patients within 6 to 24 hours of the time last known to be well (ie, at neurologic baseline) who meet DAWN trial eligibility criteria, and for patients within 6 to 16 hours of the time last known to be well who meet DEFUSE 3 trial eligibility criteria.

Limitations to these trials include stopping early, which can overestimate treatment effects. However, this drawback is at least partially offset by the relatively large effect size demonstrated in both trials.

PATIENT SELECTION — Patients with ischemic stroke caused by a proximal large artery occlusion in the anterior circulation are candidates for intra-arterial mechanical thrombectomy if they present to, or can be transferred to, a stroke center with expertise in the use of second-generation stent retrievers for acute ischemic stroke (algorithm 1). Intra-arterial mechanical thrombectomy can be used in addition to treatment with intravenous alteplase (recombinant tissue plasminogen activator or tPA). Mechanical thrombectomy treatment should be started as quickly as possible, and should not be delayed to assess the response to intravenous tPA.

General criteria — For patients with acute ischemic stroke caused by a proximal large artery occlusion in the anterior circulation who can be treated within 24 hours of the time they were last known to be at their neurologic baseline, we recommend treatment with intra-arterial mechanical thrombectomy using a second-generation stent retriever device (algorithm 1), whether or not the patient received standard treatment with intravenous tPA, if the following general conditions are fulfilled:

- Neuroimaging (eg, CT without contrast or diffusion-weighted MRI) is consistent with a small infarct core (ie, limited signs of early ischemic change) and excludes hemorrhage
- Angiography (eg, CT angiography or MR angiography) demonstrates a proximal large artery occlusion in the anterior circulation
- Thrombectomy is performed at a stroke center with appropriate expertise in the use of stent retrievers
- The patient has a persistent, potentially disabling neurologic deficit
- Thrombectomy can be started within 24 hours of the time last known to be well

The specific criteria for patients within 6 hours (see 'Within 6 hours' below) and for patients within 6 to 24 hours from the last time known to be at neurologic baseline (see '6 to 24 hours' below) are discussed in the sections that follow.

Many patients who are eligible for mechanical thrombectomy will be treated with intravenous alteplase prior to mechanical thrombectomy. Patients who are not candidates for intravenous alteplase can still be treated with mechanical thrombectomy if otherwise eligible according to the criteria outlined here and below. As an example, patients with infective endocarditis, which is a contraindication to intravenous thrombolysis, may still undergo mechanical thrombectomy if otherwise eligible [23].

Treatment with mechanical thrombectomy should be based upon individual patient characteristics. Patients with severe comorbidities prior to stroke onset (eg, pre-existing severe disability, life expectancy less than six months) are unlikely to benefit from mechanical thrombectomy.

Within 6 hours — For patients who can start treatment (femoral puncture) **within 6 hours** of symptom onset, we suggest using the following criteria for mechanical thrombectomy (algorithm 1), which are modified from those used in the MR CLEAN trial [7]:

- A clinical diagnosis of acute stroke
- A deficit on the National Institutes of Health Stroke Scale (NIHSS) (table 3) of ≥6 points (calculator 1) or any persistent neurologic deficit that is potentially disabling (see "Approach to reperfusion therapy for acute ischemic stroke", section on 'Disabling stroke deficits')
- An Alberta Stroke Program Early CT Score (ASPECTS) score ≥6 on noncontrast brain CT or diffusion-weighted MRI (see 'ASPECTS method' below)
- Brain CT or MRI scan ruling out intracranial hemorrhage
- Intracranial arterial occlusion of the distal intracranial internal carotid artery (ICA), or the M1 or M2 segments of the middle cerebral artery (MCA), or the A1 or A2 segments of the anterior cerebral artery (ACA), demonstrated with CT angiography, MR angiography, or digital subtraction angiography
- Age ≥18 years

Others have used somewhat different, more selective criteria. As examples:

- Guidelines from the American Heart Association/American Stroke Association (AHA/ASA) recommend mechanical thrombectomy for those with no significant prestroke disability (ie, a modified Rankin scale score of ≤1) and a causative occlusion of the ICA or the M1 segment of the MCA [24].
- Both the ESCAPE and EXTEND-IA trials restricted eligibility to patients who were functioning independently prior to stroke onset [8,10].
- ESCAPE also required evidence of moderate-to-good collateral circulation, defined as the filling of ≥50 percent of the MCA territory pial circulation on CT angiography. The time window in ESCAPE was up to 12 hours from stroke onset, but few patients were enrolled beyond 6 hours [8].
- EXTEND-IA required evidence of salvageable brain tissue and an ischemic core lesion volume of <70 mL on CT perfusion imaging [10].

6 to 24 hours — The DAWN and DEFUSE 3 trials selected patients for treatment beyond 6 hours using imaging-based criteria [21,22]. For patients with ischemic stroke caused by a large artery occlusion in the proximal anterior circulation who are evaluated at stroke centers with automated infarct determination, we recommend mechanical thrombectomy when DAWN or DEFUSE criteria are fulfilled (algorithm 1).

Eligibility criteria based upon the DAWN trial for patients who can start treatment (femoral puncture) **within 6 to 24 hours** of time last known to be at neurologic baseline are as follows [21]:

- Failed or contraindicated for intravenous alteplase
- A deficit on the NIHSS (table 3) of ≥10 points (calculator 1)
- No significant prestroke disability: baseline modified Rankin scale (mRS) score ≤1
- Baseline infarct involving less than one third of the territory of the MCA on CT or MRI
- Intracranial arterial occlusion of the ICA or the M1 segment of the MCA
- A clinical-core mismatch according to age:
  - Age ≥80 years: NIHSS ≥10 and an infarct volume <21 mL
  - Age <80 years: NIHSS 10 to 19 and an infarct volume <31 mL
  - Age <80 years: NIHSS ≥20 and an infarct volume <51 mL

Eligibility criteria based upon the DEFUSE 3 trial for patients who can start treatment (femoral puncture) **within 6 to 16 hours** of time last known to be at neurologic baseline are as follows [22]:

- A deficit on the NIHSS (table 3) of ≥6 points (calculator 1)
- Only slight or no prestroke disability: baseline mRS score ≤2
- Arterial occlusion of the cervical or intracranial ICA (with or without tandem MCA lesions) or the M1 segment of the MCA demonstrated on MR angiography or CT angiography
- A target mismatch profile on CT perfusion or MRI defined as an ischemic core volume <70 ml, a mismatch ratio (the volume of the perfusion lesion divided by the volume of the ischemic core) >1.8, and a mismatch volume (volume of perfusion lesion minus the volume of the ischemic core) >15 mL
- Age 18 to 90 years

For patients with ischemic stroke caused by a large artery occlusion in the proximal anterior circulation who are evaluated at stroke centers that do not use automated infarct volume determination, we suggest mechanical thrombectomy (algorithm 1) if treatment can be started within **6 to 24 hours** of the time last known to be well and there is a clinical-ASPECTS mismatch, such as an NIHSS ≥10 and ASPECTS ≥6 (see 'ASPECTS method' below) [25]. However, this approach has not been evaluated in rigorous controlled trials.

Posterior circulation stroke — Although the benefits are uncertain, mechanical thrombectomy may be a reasonable treatment option for patients with acute ischemic stroke caused by occlusion of the basilar artery, vertebral arteries, or posterior cerebral arteries when performed at centers with appropriate expertise [24]. Mechanical thrombectomy is proven effective only for select patients with acute ischemic stroke caused by a proximal intracranial arterial occlusion in the anterior circulation; the trials that established the benefit of mechanical thrombectomy largely excluded patients with posterior circulation infarcts. (See 'Efficacy of mechanical thrombectomy' above.)

Data from uncontrolled observational studies and registries suggest that endovascular therapy for basilar artery occlusion leads to a higher rate of good functional outcomes (approximately 30 to 40 percent) and lower mortality (approximately 30 percent) than expected when compared with outcomes among patients who did not receive endovascular therapy [26-28]. By comparison, a systematic review identified 76 patients receiving intravenous thrombolysis with alteplase for basilar artery occlusion found that the rate of good functional outcome was approximately 22 percent, and mortality was approximately 50 percent [29].

ASPECTS method — The Alberta Stroke Program Early CT score (ASPECTS) was developed to provide a simple and reliable method of assessing ischemic changes on head CT scan in order to identify acute stroke patients unlikely to make an independent recovery despite thrombolytic treatment [30]. The ASPECTS method has also been

adopted to assess the extent of ischemia on diffusion-weighted MRI (DWI); the ability to detect early ischemic changes by ASPECTS was similar on noncontrast CT and DWI [31].

The ASPECTS value is calculated from two standard axial CT cuts; one at the level of the thalamus and basal ganglia, and one just rostral to the basal ganglia (figure 3 and figure 4) [30,32].

- The ASPECTS method divides the **middle cerebral artery** (MCA) territory into 10 regions of interest.
- Subcortical structures are allotted three points: one each for caudate, lentiform nucleus, and internal capsule.
- MCA cortex is allotted seven points:
  - Four of these points come from the axial CT cut at the level of the basal ganglia, with one point for insular cortex and one point each for M1, M2, and M3 regions (anterior, lateral, and posterior MCA cortex).
  - Three points come from the CT cut just rostral to the basal ganglia, with one point each for M4, M5, and M6 regions (anterior, lateral, and posterior MCA cortex).
- One point is subtracted for an area of early ischemic change, such as focal swelling or parenchymal hypoattenuation, for each of the defined regions.

Therefore, a normal CT scan has an ASPECTS value of 10 points, while diffuse ischemic change throughout the MCA territory gives a value of 0.

PROCEDURE — General anesthesia or conscious sedation may be used for the procedure, depending upon local preference and experience (see 'Anesthesia' below). Only second-generation stent retriever devices should be used for mechanical thrombectomy. (See 'Devices' below.)

Catheterization is performed with femoral artery puncture. The catheter is guided to the internal carotid artery and beyond to the site of the intracranial large artery occlusion. The stent retriever is then inserted through the catheter to reach the clot. The stent retriever is deployed and grabs the clot, which is removed as the device is pulled back. The initial goal is to achieve reperfusion, defined by a modified Thrombolysis in Cerebral Infarction (mTICI) perfusion grade 2b (anterograde reperfusion of more than half in the downstream target arterial territory) or grade 3 (complete anterograde reperfusion of the downstream target arterial territory) (table 4), as early as possible [24,33]. In a meta-analysis of five trials that evaluated treatment within six hours of symptom onset, over 500 patients received mechanical thrombectomy and substantial reperfusion (mTICI score of 2b or 3) was achieved in 71 percent of this group [18].

Following the procedure, most centers monitor patients in an intensive care unit setting until stable.

Devices — A number of mechanical thrombectomy devices are approved in the United States and Europe for clot removal within 8 hours of acute stroke symptom onset in selected patients. These include the first-generation Merci Retriever and Penumbra System devices, and the second-generation Solitaire Flow Restoration Device and Trevo Retriever. The first-generation Merci and Penumbra devices may increase recanalization rates in carefully selected patients, but their clinical utility for improving outcomes after stroke is unproven [34-36]. When compared directly with the MERCI retriever in small randomized trials, the second-generation Solitaire and Trevo neurothrombectomy devices achieved significantly higher reperfusion rates and better patient outcomes [37,38]. In light of these data and the positive thrombectomy trials discussed above [7-11], which preferentially used the second-generation devices, only the second-generation devices should be used to treat patients with acute ischemic stroke.

Catheter aspiration devices are another option for mechanical thrombectomy, and some data suggest that they can achieve technical rates of revascularization similar to stent retrievers [39]. However, second-generation stent retrievers are preferred for mechanical thrombectomy [24].

Anesthesia — Either conscious sedation or general anesthesia may be used for procedural sedation during mechanical thrombectomy. The anesthetic technique should be chosen based upon individual patient risk factors, preferences, and institutional experience [24].

The type of anesthesia used for mechanical thrombectomy in patients with ischemic stroke may have some impact on short- and long-term outcomes, but data are inconsistent:

- A 2017 systematic review and meta-analysis found that for six studies (including three randomized controlled trials) performed during the second-generation stent-retriever era, there was no significant difference between general anesthesia and non-general anesthesia in the odds of good neurologic outcome (odds ratio [OR] 0.84, 95% CI 0.67-1.06) or 90-day mortality (OR 1.27, 95% CI 0.93-1.75) [40]. The only randomized trial in the meta-analysis that directly tested general anesthesia versus conscious sedation in this setting included 150 patients and found no significant difference between the two types of anesthesia for the outcome of early neurologic improvement [41]. Subjects assigned to general anesthesia were more likely to achieve functional independence at three months, but small patient numbers lower the confidence in this result [41].
- Two subsequent trials (AnStroke and GOLIATH) were not included in the meta-analysis. The AnStroke trial of 90 patients treated with endovascular therapy found no difference between the general anesthesia and conscious sedation groups for neurologic outcome at three months after stroke [42]. The single-center GOLIATH trial of 127 patients treated with mechanical thrombectomy found no difference in infarct growth between the general anesthesia and conscious sedation groups, but the general anesthesia group had better clinical outcomes at 90 days, as shown by a shift to lower modified Rankin scale scores (OR 1.91, 95% CI 1.03-3.56) [43].

Blood pressure management — We suggest keeping systolic blood pressure between 150 to 180 mmHg prior to reperfusion, and targeting systolic blood pressure to <140 mmHg once reperfusion is achieved with mechanical thrombectomy. However, the optimal blood pressure range with mechanical thrombectomy is not well-defined, and there are few data to guide periprocedural management [24].

Many patients undergoing mechanical thrombectomy will have been treated with intravenous alteplase (recombinant tissue plasminogen activator or tPA) in the first hours after stroke symptom onset and should be managed accordingly, with systolic/diastolic blood pressure maintained at ≤180/105 mmHg during and for 24 hours following alteplase infusion. It is reasonable to apply this same blood pressure parameter for patients not treated with intravenous tPA, as a higher blood pressure may increase the risk of hemorrhage in ischemic brain regions even when thrombolytic agents are not used. (See "Intravenous thrombolytic therapy for acute ischemic stroke: Therapeutic use", section on 'Management of blood pressure'.)

Keeping the systolic blood pressure ≥150 mmHg may be useful for maintaining adequate collateral blood flow during the time the large artery remains occluded [8,24]. Once reperfusion is achieved with mechanical thrombectomy, a lower blood pressure (eg, systolic blood pressure <140 mmHg) is a reasonable target [21].

Adverse effects — In the MR CLEAN trial, clinical signs of a new ischemic stroke in a different vascular territory within 90 days of treatment were more common in the intra-arterial group compared with no endovascular therapy (5.6 versus 0.4 percent) [7]. Device-related serious adverse events are uncommon but include access site hematoma and pseudoaneurysm, arterial perforation, and arterial dissection [8-11]. Transient intraprocedural vasospasm is also uncommon but is sometimes treated.

Mechanical thrombectomy is not associated with increased rates of symptomatic intracranial hemorrhage or mortality. In meta-analysis of 5 trials, with pooled patient-level data for 1287 subjects, there was no significant difference between the intervention population and control population for 90-day symptomatic intracranial hemorrhage (4.4 versus 4.3 percent) or mortality (15 versus 19 percent) [12].

SOCIETY GUIDELINE LINKS — Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Stroke in adults".)

SUMMARY AND RECOMMENDATIONS

- Early intra-arterial treatment with second-generation mechanical thrombectomy devices is safe and effective for reducing disability and is superior to standard treatment with intravenous thrombolysis alone for ischemic stroke caused by a documented large artery occlusion in the proximal anterior circulation. (See 'Efficacy of mechanical thrombectomy' above.)

- For patients with ischemic stroke caused by a large artery occlusion in the proximal anterior circulation who can start treatment (femoral puncture) **within 6 hours** of stroke symptom onset, we recommend treatment with intra-arterial mechanical thrombectomy using a second-generation stent retriever device (algorithm 1), whether or not the patient received treatment with intravenous alteplase (recombinant tissue plasminogen activator or tPA), if the following conditions are fulfilled (**Grade 1A**) (see 'General criteria' above and 'Within 6 hours' above):

  - Neuroimaging (eg, CT without contrast or diffusion-weighted MRI) is consistent with a small infarct core (eg, limited signs of early ischemic change; an Alberta Stroke Program Early CT Score [ASPECTS] score ≥6) and excludes hemorrhage

  - The patient has a persistent, potentially disabling neurologic deficit

  - Thrombectomy is performed at a stroke center with expertise in the use of stent retrievers

- Mechanical thrombectomy can reduce disability when started 6 to 24 hours from the time last seen well for patients who have a clinical deficit that is disproportionally severe compared with the volume of infarction on imaging studies (see 'Benefit of later treatment' above). The volume of infarction can be measured directly at stroke centers with automated software, or can be estimated from noncontrast CT or diffusion MRI using the ASPECTS method at stroke centers without automated infarct volume determination. (See '6 to 24 hours' above.)

  - For patients with ischemic stroke caused by a large artery occlusion in the proximal anterior circulation who are evaluated at stroke centers with automated infarct determination (algorithm 1), we recommend mechanical thrombectomy (**Grade 1B**) if the following conditions are fulfilled:

    - Treatment can be started within **6 to 24 hours** of the time last known to be well and there is a clinical-core mismatch as defined by the DAWN trial, or

    - Treatment can be started within **6 to 16 hours** of the time last known to be well and there is an imaging-target mismatch as defined by the DEFUSE 3 trial.

  - For patients with ischemic stroke caused by a large artery occlusion in the proximal anterior circulation who are evaluated at stroke centers that do not use automated infarct volume determination (algorithm 1), we suggest mechanical thrombectomy if treatment can be started within **6 to 24 hours** of the time last known to be well and there is a clinical-ASPECTS mismatch (eg, National Institutes of Health Stroke Scale [NIHSS] ≥10 and ASPECTS ≥6) (**Grade 2C**).

- Although the benefits are uncertain, mechanical thrombectomy within 24 hours of the time last known to be well may be a reasonable treatment option for patients with acute ischemic stroke caused by occlusion of the basilar artery, vertebral arteries, or posterior cerebral arteries when performed at centers with appropriate expertise. (See 'Posterior circulation stroke' above.)

- Only second-generation stent retriever devices should be used for mechanical thrombectomy. (See 'Procedure' above.)

REFERENCES

1. Campbell BC, Donnan GA, Lees KR, et al. Endovascular stent thrombectomy: the new standard of care for large vessel ischaemic stroke. Lancet Neurol 2015; 14:846.
2. Furlan AJ. Endovascular therapy for stroke--it's about time. N Engl J Med 2015; 372:2347.
3. Cohen DL, Kearney R, Griffiths M, et al. Around 9% of patients with ischaemic stroke are suitable for thrombectomy. BMJ 2015; 351:h4607.
4. Chia NH, Leyden JM, Newbury J, et al. Determining the Number of Ischemic Strokes Potentially Eligible for Endovascular Thrombectomy: A Population-Based Study. Stroke 2016; 47:1377.
5. Jadhav AP, Desai SM, Kenmuir CL, et al. Eligibility for Endovascular Trial Enrollment in the 6- to 24-Hour Time Window: Analysis of a Single Comprehensive Stroke Center. Stroke 2018; 49:1015.
6. Sheth KN, Smith EE, Grau-Sepulveda MV, et al. Drip and ship thrombolytic therapy for acute ischemic stroke: use, temporal trends, and outcomes. Stroke 2015; 46:732.
7. Berkhemer OA, Fransen PS, Beumer D, et al. A randomized trial of intraarterial treatment for acute ischemic stroke. N Engl J Med 2015; 372:11.
8. Goyal M, Demchuk AM, Menon BK, et al. Randomized assessment of rapid endovascular treatment of ischemic stroke. N Engl J Med 2015; 372:1019.
9. Saver JL, Goyal M, Bonafe A, et al. Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. N Engl J Med 2015; 372:2285.
10. Campbell BC, Mitchell PJ, Kleinig TJ, et al. Endovascular therapy for ischemic stroke with perfusion-imaging selection. N Engl J Med 2015; 372:1009.
11. Jovin TG, Chamorro A, Cobo E, et al. Thrombectomy within 8 hours after symptom onset in ischemic stroke. N Engl J Med 2015; 372:2296.
12. Goyal M, Menon BK, van Zwam WH, et al. Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. Lancet 2016; 387:1723.
13. Marmagkiolis K, Hakeem A, Cilingiroglu M, et al. Safety and Efficacy of Stent Retrievers for the Management of Acute Ischemic Stroke: Comprehensive Review and Meta-Analysis. JACC Cardiovasc Interv 2015; 8:1758.
14. Consensus statement on mechanical thrombectomy in acute ischemic stroke – ESO-Karolinska Stroke Update 2014 in collaboration with ESMINT and ESNR. http://2014.strokeupdate.org/consensus-statement-mechanical-thrombectomy-acute-ischemic-stroke (Accessed on July 13, 2015).
15. Fransen PS, Berkhemer OA, Lingsma HF, et al. Time to Reperfusion and Treatment Effect for Acute Ischemic Stroke: A Randomized Clinical Trial. JAMA Neurol 2016; 73:190.
16. Touma L, Filion KB, Sterling LH, et al. Stent Retrievers for the Treatment of Acute Ischemic Stroke: A Systematic Review and Meta-analysis of Randomized Clinical Trials. JAMA Neurol 2016; 73:275.
17. Tsivgoulis G, Katsanos AH, Mavridis D, et al. Mechanical Thrombectomy Improves Functional Outcomes Independent of Pretreatment With Intravenous Thrombolysis. Stroke 2016; 47:1661.
18. Saver JL, Goyal M, van der Lugt A, et al. Time to Treatment With Endovascular Thrombectomy and Outcomes From Ischemic Stroke: A Meta-analysis. JAMA 2016; 316:1279.
19. van den Berg LA, Dijkgraaf MG, Berkhemer OA, et al. Two-Year Outcome after Endovascular Treatment for Acute Ischemic Stroke. N Engl J Med 2017; 376:1341.

20. Dávalos A, Cobo E, Molina CA, et al. Safety and efficacy of thrombectomy in acute ischaemic stroke (REVASCAT): 1-year follow-up of a randomised open-label trial. Lancet Neurol 2017; 16:369.
21. Nogueira RG, Jadhav AP, Haussen DC, et al. Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct. N Engl J Med 2018; 378:11.
22. Albers GW, Marks MP, Kemp S, et al. Thrombectomy for Stroke at 6 to 16 Hours with Selection by Perfusion Imaging. N Engl J Med 2018; 378:708.
23. Ambrosioni J, Urra X, Hernández-Meneses M, et al. Mechanical Thrombectomy for Acute Ischemic Stroke Secondary to Infective Endocarditis. Clin Infect Dis 2018; 66:1286.
24. Powers WJ, Rabinstein AA, Ackerson T, et al. 2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. Stroke 2018; 49:e46.
25. Bouslama M, Bowen MT, Haussen DC, et al. Selection Paradigms for Large Vessel Occlusion Acute Ischemic Stroke Endovascular Therapy. Cerebrovasc Dis 2017; 44:277.
26. Rabinstein AA. Treatment of Acute Ischemic Stroke. Continuum (Minneap Minn) 2017; 23:62.
27. Singer OC, Berkefeld J, Nolte CH, et al. Mechanical recanalization in basilar artery occlusion: the ENDOSTROKE study. Ann Neurol 2015; 77:415.
28. Phan K, Phan S, Huo YR, et al. Outcomes of endovascular treatment of basilar artery occlusion in the stent retriever era: a systematic review and meta-analysis. J Neurointerv Surg 2016; 8:1107.
29. Lindsberg PJ, Mattle HP. Therapy of basilar artery occlusion: a systematic analysis comparing intra-arterial and intravenous thrombolysis. Stroke 2006; 37:922.
30. Barber PA, Demchuk AM, Zhang J, Buchan AM. Validity and reliability of a quantitative computed tomography score in predicting outcome of hyperacute stroke before thrombolytic therapy. ASPECTS Study Group. Alberta Stroke Programme Early CT Score. Lancet 2000; 355:1670.
31. Barber PA, Hill MD, Eliasziw M, et al. Imaging of the brain in acute ischaemic stroke: comparison of computed tomography and magnetic resonance diffusion-weighted imaging. J Neurol Neurosurg Psychiatry 2005; 76:1528.
32. Pexman JH, Barber PA, Hill MD, et al. Use of the Alberta Stroke Program Early CT Score (ASPECTS) for assessing CT scans in patients with acute stroke. AJNR Am J Neuroradiol 2001; 22:1534.
33. Wintermark M, Albers GW, Broderick JP, et al. Acute Stroke Imaging Research Roadmap II. Stroke 2013; 44:2628.
34. Smith WS, Sung G, Starkman S, et al. Safety and efficacy of mechanical embolectomy in acute ischemic stroke: results of the MERCI trial. Stroke 2005; 36:1432.
35. Brinjikji W, Rabinstein AA, Kallmes DF, Cloft HJ. Patient outcomes with endovascular embolectomy therapy for acute ischemic stroke: a study of the national inpatient sample: 2006 to 2008. Stroke 2011; 42:1648.
36. Broderick JP, Schroth G. What the SWIFT and TREVO II trials tell us about the role of endovascular therapy for acute stroke. Stroke 2013; 44:1761.
37. Saver JL, Jahan R, Levy EI, et al. Solitaire flow restoration device versus the Merci Retriever in patients with acute ischaemic stroke (SWIFT): a randomised, parallel-group, non-inferiority trial. Lancet 2012; 380:1241.
38. Nogueira RG, Lutsep HL, Gupta R, et al. Trevo versus Merci retrievers for thrombectomy revascularisation of large vessel occlusions in acute ischaemic stroke (TREVO 2): a randomised trial. Lancet 2012; 380:1231.
39. Lapergue B, Blanc R, Gory B, et al. Effect of Endovascular Contact Aspiration vs Stent Retriever on Revascularization in Patients With Acute Ischemic Stroke and Large Vessel Occlusion: The ASTER Randomized Clinical Trial. JAMA 2017; 318:443.
40. Brinjikji W, Pasternak J, Murad MH, et al. Anesthesia-Related Outcomes for Endovascular Stroke Revascularization: A Systematic Review and Meta-Analysis. Stroke 2017; 48:2784.
41. Schönenberger S, Uhlmann L, Hacke W, et al. Effect of Conscious Sedation vs General Anesthesia on Early Neurological Improvement Among Patients With Ischemic Stroke Undergoing Endovascular Thrombectomy: A Randomized Clinical Trial. JAMA 2016; 316:1986.
42. Löwhagen Hendén P, Rentzos A, Karlsson JE, et al. General Anesthesia Versus Conscious Sedation for Endovascular Treatment of Acute Ischemic Stroke: The AnStroke Trial (Anesthesia During Stroke). Stroke 2017; 48:1601.
43. Simonsen CZ, Yoo AJ, Sørensen LH, et al. Effect of General Anesthesia and Conscious Sedation During Endovascular Therapy on Infarct Growth and Clinical Outcomes in Acute Ischemic Stroke: A Randomized Clinical Trial. JAMA Neurol 2018; 75:470.

Topic 115663 Version 9.0

GRAPHICS

Eligibility criteria for the treatment of acute ischemic stroke with intravenous alteplase (recombinant tissue plasminogen activator or tPA)

Inclusion criteria
Clinical diagnosis of ischemic stroke causing measurable neurologic deficit
Onset of symptoms <4.5 hours before beginning treatment; if the exact time of stroke onset is not known, it is defined as the last time the patient was known to be normal or at neurologic baseline
Age ≥18 years
Exclusion criteria
Historical
Ischemic stroke or severe head trauma in the previous three months
Previous intracranial hemorrhage
Intra-axial intracranial neoplasm
Gastrointestinal malignancy or hemorrhage in the previous 21 days
Intracranial or intraspinal surgery within the prior three months
Clinical
Symptoms suggestive of subarachnoid hemorrhage
Persistent blood pressure elevation (systolic ≥185 mmHg or diastolic ≥110 mmHg)
Active internal bleeding
Presentation consistent with infective endocarditis
Stroke known or suspected to be associated with aortic arch dissection
Acute bleeding diathesis, including but not limited to conditions defined in 'Hematologic'
Hematologic
Platelet count <100,000/mm^3*
Current anticoagulant use with an INR >1.7 or PT >15 seconds or aPTT >40 seconds or PT >15 seconds*
Therapeutic doses of low molecular weight heparin received within 24 hours (eg, to treat VTE and ACS); this exclusion does not apply to prophylactic doses (eg, to prevent VTE)
Current use of a direct thrombin inhibitor or direct factor Xa inhibitor with evidence of anticoagulant effect by laboratory tests such as aPTT, INR, ECT, TT, or appropriate factor Xa activity assays
Head CT scan
Evidence of hemorrhage
Extensive regions of obvious hypodensity consistent with irreversible injury
Relative exclusions/warnings¶
Only minor and isolated neurologic signs or rapidly improving symptoms$^{\Delta}$
Serum glucose <50 mg/dL (<2.8 mmol/L)$^{\diamond}$
Serious trauma in the previous 14 days§
Major surgery in the previous 14 days$^{¥}$
History of gastrointestinal bleeding (remote) or genitourinary bleeding‡
Seizure at the onset of stroke with postictal neurologic impairments†
Pregnancy**
Arterial puncture at a noncompressible site in the previous seven days¶¶
Large (≥10 mm), untreated, unruptured intracranial aneurysm¶¶
Untreated intracranial vascular malformation¶¶
Additional relative exclusion criteria for treatment from 3 to 4.5 hours from symptom onset$^{\Delta\Delta}$
Age >80 years
Oral anticoagulant use regardless of INR
Severe stroke (NIHSS score >25)
Combination of both previous ischemic stroke and diabetes mellitus

ACS: acute coronary syndrome; aPTT: activated partial thromboplastin time; ECT: ecarin clotting time; INR: international normalized ratio; PT: prothrombin time; NIHSS: National Institutes of Health Stroke Scale; tPA: intravenous alteplase; TT: thrombin time; VTE, venous thromboembolism.

* Although it is desirable to know the results of these tests, thrombolytic therapy should not be delayed while results are pending unless (1) there is clinical suspicion of a bleeding abnormality or thrombocytopenia, (2) the patient is currently on or has recently received anticoagulants (eg, heparin, warfarin, a direct thrombin inhibitor, or a direct factor Xa inhibitor), (3) use of anticoagulants is not known. For patients without recent use of oral anticoagulants or heparin, treatment with intravenous tPA can be started before availability of coagulation test results but should be discontinued if the INR, PT, or aPTT exceed the limits stated in the table.

¶ With careful consideration and weighting of risk-to-benefit, patients may receive intravenous alteplase despite one or more relative contraindications or warnings.

Δ Patients who have a persistent neurologic deficit that is potentially disabling, despite improvement of any degree, should be treated with tPA in the absence of other contraindications. Any of the following should be considered disabling deficits:

- Complete hemianopsia: ≥2 on NIHSS question 3, or
- Severe aphasia: ≥2 on NIHSS question 9, or
- Visual or sensory extinction: ≥1 on NIHSS question 11, or
- Any weakness limiting sustained effort against gravity: ≥2 on NIHSS question 5 or 6, or
- Any deficits that lead to a total NIHSS >5, or
- Any remaining deficit considered potentially disabling in the view of the patient and the treating practitioner using clinical judgment

◇ Patients may be treated with intravenous alteplase if glucose level is subsequently normalized.

§ The potential risks of bleeding with alteplase from injuries related to the trauma should be weighed against the anticipated benefits of reduced stroke-related neurologic deficits.

¥ The increased risk of surgical site bleeding with alteplase should be weighed against the anticipated benefits of reduced stroke-related neurologic deficits.

‡ There is a low increased risk of new bleeding with alteplase in the setting of past gastrointestinal or genitourinary bleeding. However, alteplase administration within 21 days of gastrointestinal bleeding is not recommended.

† Alteplase is reasonable in patients with a seizure at stroke onset if evidence suggests that residual impairments are secondary to acute ischemic stroke and not to a postictal phenomenon.

** Alteplase can be given in pregnancy when the anticipated benefits of treating moderate or severe stroke outweigh the anticipated increased risks of uterine bleeding.

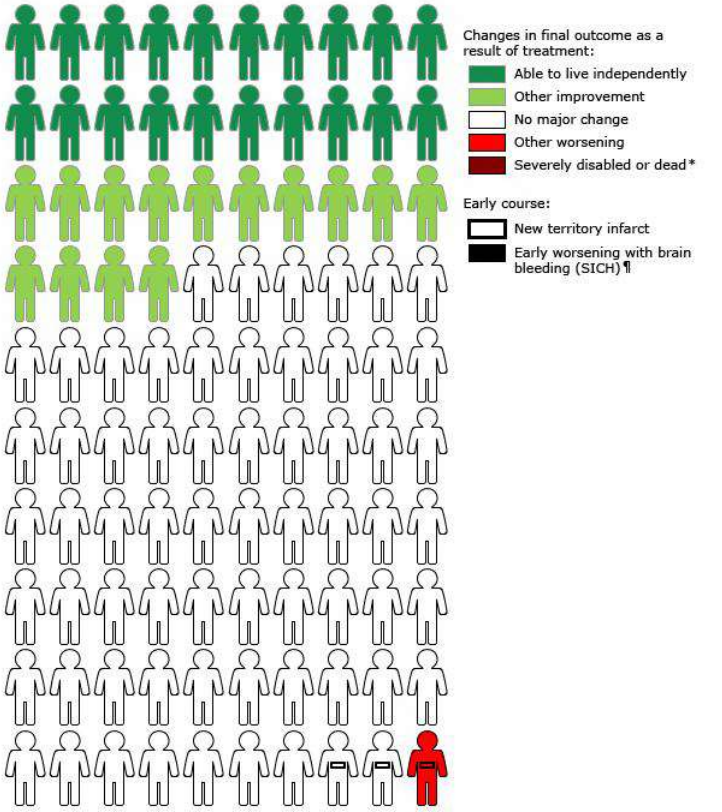
¶¶ The safety and efficacy of administering alteplase is uncertain for these relative exclusions.
ΔΔ Intravenous alteplase appears to be safe and may be beneficial for patients with these relative exclusions, including patients taking oral anticoagulants with an INR <1.7.

Adapted from:

1. *Hacke W, Kaste M, Bluhmki E, et al. Thrombolysis with alteplase 3 to 4.5 hours after acute ischemic stroke. N Engl J Med 2008; 359:1317.*
2. *Del Zoppo GJ, Saver JL, Jauch EC, et al. Expansion of the time window for treatment of acute ischemic stroke with intravenous tissue plasminogen activator. A science advisory from the American Heart Association/American Stroke Association. Stroke 2009; 40:2945.*
3. *Re-examining Acute Eligibility for Thrombolysis (TREAT) Task Force:, Levine SR, Khatri P, et al. Review, historical context, and clarifications of the NINDS rt-PA stroke trials exclusion criteria: Part 1: rapidly improving stroke symptoms. Stroke 2013; 44:2500.*
4. *Demaerschalk BM, Kleindorfer DO, Adeoye OM, et al. Scientific rationale for the inclusion and exclusion criteria for intravenous alteplase in acute ischemic stroke: A statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2016; 47:581.*
5. *Powers WJ, Rabinstein AA, Ackerson T, et al. 2018 Guidelines for the early management of patients with acute ischemic stroke: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2018; 49:e46.*

Graphic 71462 Version 19.0

Visual decision aid depicting the benefits and risks of endovascular thrombectomy added to IV tPA versus IV tPA alone

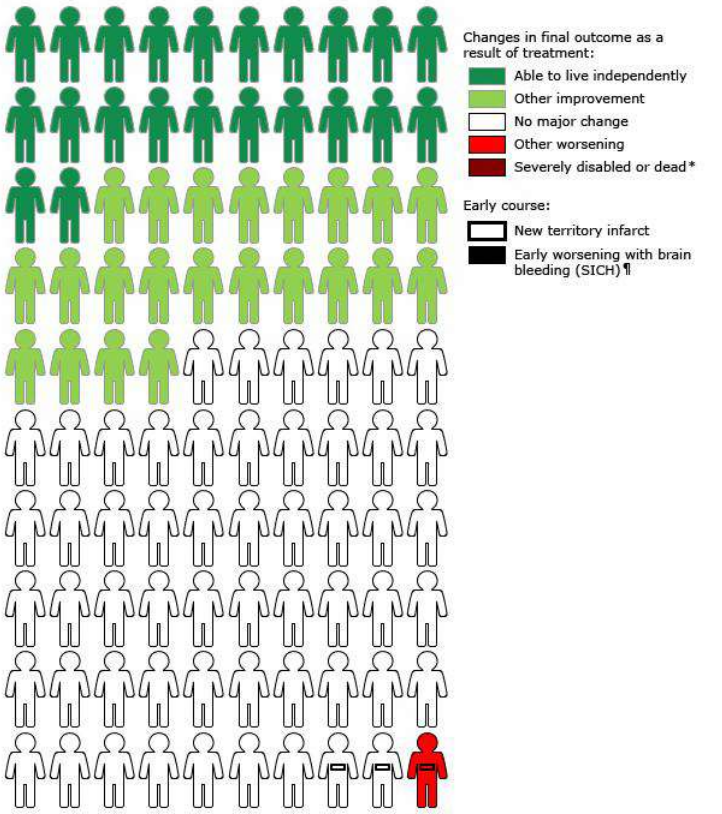


Choice consequence matrix type visual decision aid depicting the benefits and risks of endovascular thrombectomy added to IV tPA versus IV tPA alone. Dark green, attainment of excellent outcome (mRS, 0-1) as a result of thrombectomy; light green, improved disability outcome (other than excellent outcome) as a result of thrombectomy; light red, worse disability outcome (other than severely disabled/dead) as a result of thrombectomy; open rectangle, infarct in new territory as a result of thrombectomy.

tPA: tissue-type plasminogen activator; IV: intravenous; mRS: modified Rankin scale; SICH: symptomatic intracranial hemorrhage.
* None were severely disabled or dead (mRS, 5-6) as a result of thrombectomy.
¶ No differences observed in the rate of SICH due to thrombectomy.

Graphic 116247 Version 1.0

Visual decision aid depicting the benefits and risks of endovascular thrombectomy for patients ineligible for IV tPA



Choice consequence matrix type visual decision aid depicting the benefits and risks of endovascular thrombectomy among tPA-ineligible patients. Dark green, attainment of excellent outcome (mRS, 0-1) as a result of thrombectomy; light green, improved disability outcome (other than excellent outcome) as a result of thrombectomy; light red, worse disability outcome (other than severely disabled/dead) as a result of thrombectomy; open rectangle, infarct in new territory as a result of thrombectomy.

tPA: tissue-type plasminogen activator; IV: intravenous; mRS: modified Rankin scale; SICH: symptomatic intracranial hemorrhage.
* None were severely disabled or dead (mRS, 5-6) due to thrombectomy.
¶ No differences observed in the rate of SICH due to thrombectomy.

From: Tokunboh I, Vales Montero M, Zopelaro Almeida MF, et al. Visual aids for patient, family, and physician decision making about endovascular thrombectomy for acute ischemic stroke. Stroke 2018; 49:90. DOI: 10.1161/STROKEAHA.117.018715. Copyright © 2018 American Heart Association. Reproduced with permission from Wolters Kluwer Health. Unauthorized reproduction of this material is prohibited.

Graphic 116248 Version 1.0

Modified Rankin scale

Score	Description
0	No symptoms at all
1	No significant disability despite symptoms; able to carry out all usual duties and activities
2	Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance
3	Moderate disability; requiring some help, but able to walk without assistance
4	Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance
5	Severe disability; bedridden, incontinent, and requiring constant nursing care and attention
6	Dead

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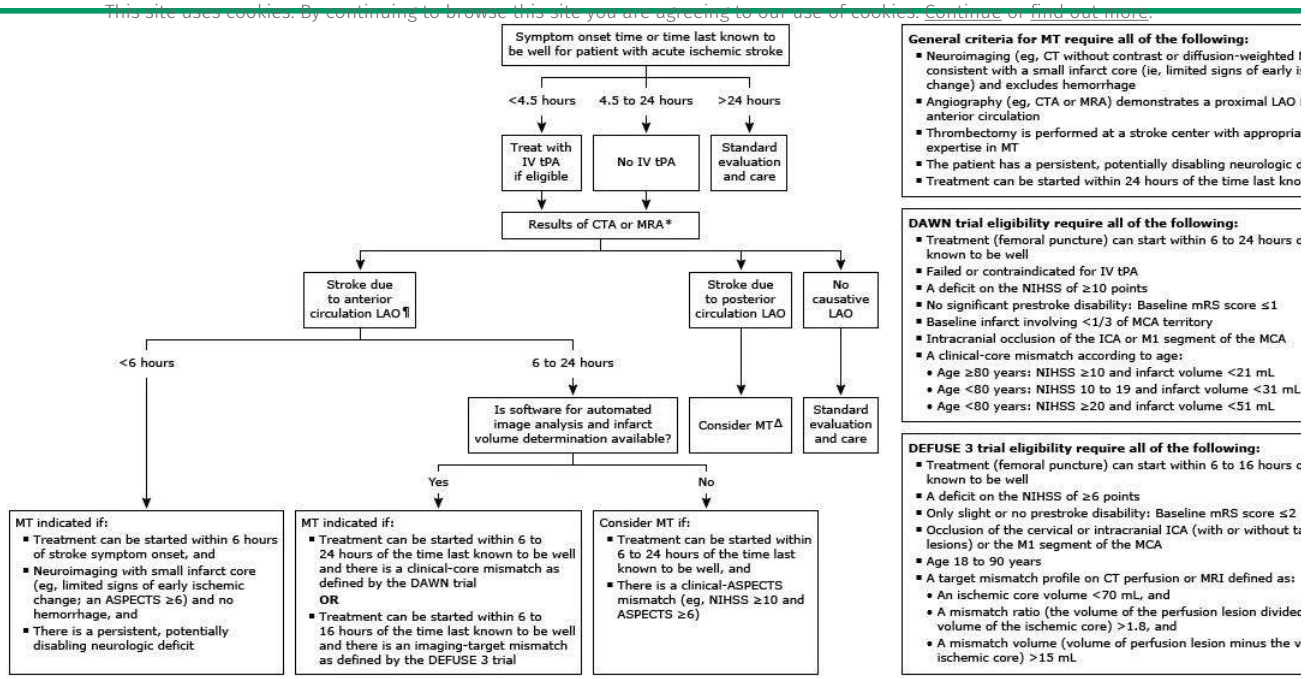
Graphic 75411 Version 12.0

Indications for mechanical thrombectomy to treat patients with acute ischemic stroke



IV: intravenous; tPA: tissue plasminogen activator; CTA: computed tomography angiography; MRA: magnetic resonance angiography; LAO: large artery occlusion; MT: mechanical thrombectomy; ASPI
Stroke Program Early CT Score; NIHSS: National Institutes of Health Stroke Scale; CT: computed tomography; MRI: magnetic resonance imaging; mRS: modified Rankin Scale; MCA: middle cerebral a
internal carotid artery.

* Usually assessed with MRA or CTA, less often with digital subtraction angiography.

¶ There is intracranial arterial occlusion of the distal ICA, middle cerebral (M1/M2), or anterior cerebral (A1/A2) artery by CTA, MRA, or digital subtraction angiography.

Δ MT may be a treatment option for patients with acute ischemic stroke caused by occlusion of the basilar artery, vertebral arteries, or posterior cerebral arteries at expert stroke centers, but benefit is

Graphic 117086 Version 1.0

National Institutes of Health Stroke Scale (NIHSS)

Administer stroke scale items in the order listed. Record performance in each category after each subscale exam. Do not go back and change scores. Follow directions provided for each exam technique. Scores should reflect what the patient does, not what the clinician thinks the patient can do. The clinician should record answers while administering the exam and work quickly. Except where indicated, the patient should not be coached (ie, repeated requests to patient to make a special effort).

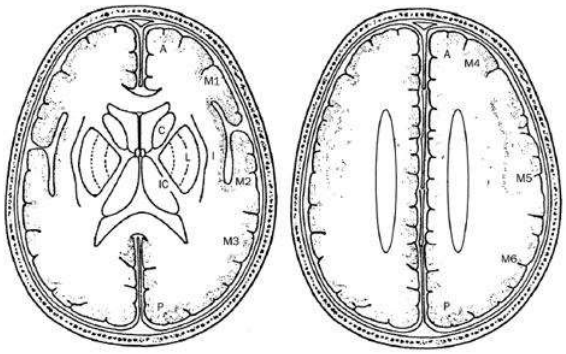
Instructions	Scale definition	Score
1a. Level of consciousness: The investigator must choose a response if a full evaluation is prevented by such obstacles as an endotracheal tube, language barrier, orotracheal trauma/bandages. A 3 is scored only if the patient makes no movement (other than reflexive posturing) in response to noxious stimulation.	0 = **Alert;** keenly responsive. 1 = **Not alert;** but arousable by minor stimulation to obey, answer, or respond. 2 = **Not alert;** requires repeated stimulation to attend, or is obtunded and requires strong or painful stimulation to make movements (not stereotyped). 3 = Responds only with reflex motor or autonomic effects or totally unresponsive, flaccid, and areflexic.	_____
1b. LOC questions: The patient is asked the month and his/her age. The answer must be correct - there is no partial credit for being close. Aphasic and stuporous patients who do not comprehend the questions will score 2. Patients unable to speak because of endotracheal intubation, orotracheal trauma, severe dysarthria from any cause, language barrier, or any other problem not secondary to aphasia are given a 1. It is important that only the initial answer be graded and that the examiner not "help" the patient with verbal or non-verbal cues.	0 = **Answers** both questions correctly. 1 = **Answers** one question correctly. 2 = **Answers** neither question correctly.	_____
1c. LOC commands: The patient is asked to open and close the eyes and then to grip and release the non-paretic hand. Substitute another one step command if the hands cannot be used. Credit is given if an unequivocal attempt is made but not completed due to weakness. If the patient does not respond to command, the task should be demonstrated to him or her (pantomime), and the result scored (ie, follows none, one or two commands). Patients with trauma, amputation, or other physical impediments should be given suitable one-step commands. Only the first attempt is scored.	0 = **Performs** both tasks correctly. 1 = **Performs** one task correctly. 2 = **Performs** neither task correctly.	_____
2. Best gaze: Only horizontal eye movements will be tested. Voluntary or reflexive (oculocephalic) eye movements will be scored, but caloric testing is not done. If the patient has a conjugate deviation of the eyes that can be overcome by voluntary or reflexive activity, the score will be 1. If a patient has an isolated peripheral nerve paresis (CN III, IV or VI), score a 1. Gaze is testable in all aphasic patients. Patients with ocular trauma, bandages, pre-existing blindness, or other disorder of visual acuity or fields should be tested with reflexive movements, and a choice made by the investigator. Establishing eye contact and then moving about the patient from side to side will occasionally clarify the presence of a partial gaze palsy.	0 = **Normal.** 1 = **Partial gaze palsy;** gaze is abnormal in one or both eyes, but forced deviation or total gaze paresis is not present. 2 = **Forced deviation,** or total gaze paresis not overcome by the oculocephalic maneuver.	_____
3. Visual: Visual fields (upper and lower quadrants) are tested by confrontation, using finger counting or visual threat, as appropriate. Patients may be encouraged, but if they look at the side of the moving fingers appropriately, this can be scored as normal. If there is unilateral blindness or enucleation, visual fields in the remaining eye are scored. Score 1 only if a clear-cut asymmetry, including quadrantanopia, is found. If patient is blind from any cause, score 3. Double simultaneous stimulation is performed at this point. If there is extinction, patient receives a 1, and the results are used to respond to item 11.	0 = **No visual loss.** 1 = **Partial hemianopia.** 2 = **Complete hemianopia.** 3 = **Bilateral hemianopia** (blind including cortical blindness).	_____
4. Facial palsy: Ask - or use pantomime to encourage - the patient to show teeth or raise eyebrows and close eyes. Score symmetry of grimace in response to noxious stimuli in the poorly responsive or non-comprehending patient. If facial trauma/bandages, orotracheal tube, tape or other physical barriers obscure the face, these should be removed to the extent possible.	0 = **Normal** symmetrical movements. 1 = **Minor paralysis** (flattened nasolabial fold, asymmetry on smiling). 2 = **Partial paralysis** (total or near-total paralysis of lower face). 3 = **Complete paralysis** of one or both sides (absence of facial movement in the upper and lower face).	_____
5. Motor arm: The limb is placed in the appropriate position: extend the arms (palms down) 90 degrees (if sitting) or 45 degrees (if supine). Drift is scored if the arm falls before 10 seconds. The aphasic patient is encouraged using urgency in the voice and pantomime, but not noxious stimulation. Each limb is tested in turn, beginning with the non-paretic arm. Only in the case of amputation or joint fusion at the shoulder, the examiner should record the score as untestable (UN), and clearly write the explanation for this choice.	0 = **No drift;** limb holds 90 (or 45) degrees for full 10 seconds. 1 = **Drift;** limb holds 90 (or 45) degrees, but drifts down before full 10 seconds; does not hit bed or other support. 2 = **Some effort against gravity;** limb cannot get to or maintain (if cued) 90 (or 45) degrees, drifts down to bed, but has some effort against gravity. 3 = **No effort against gravity;** limb falls. 4 = **No movement.** UN = **Amputation** or joint fusion, explain:_____ **5a. Left arm** **5b. Right arm**	_____
6. Motor leg: The limb is placed in the appropriate position: hold the leg at 30 degrees (always tested supine). Drift is scored if the leg falls before 5 seconds. The aphasic patient is encouraged using urgency in the voice and pantomime, but not noxious stimulation. Each limb is tested in turn, beginning with the non-paretic leg. Only in the case of amputation or joint fusion at the hip, the examiner should record the score as untestable (UN), and clearly write the explanation for this choice.	0 = **No drift;** leg holds 30-degree position for full 5 seconds. 1 = **Drift;** leg falls by the end of the 5-second period but does not hit bed. 2 = **Some effort against gravity;** leg falls to bed by 5 seconds, but has some effort against gravity. 3 = **No effort against gravity;** leg falls to bed immediately. 4 = **No movement.** UN = **Amputation** or joint fusion, explain:_____ **6a. Left leg** **6b. Right leg**	_____
7. Limb ataxia: This item is aimed at finding evidence of a unilateral cerebellar lesion. Test with eyes open. In case of visual defect, ensure testing is done in intact visual field. The finger-nose-finger and heel-shin tests are performed on both sides, and ataxia is scored only if present out of proportion to weakness. Ataxia is absent in the patient who cannot understand or is paralyzed. Only in the case of amputation or joint fusion, the examiner should record the score as untestable (UN), and clearly write the explanation for this choice. In case of blindness, test by having the patient touch nose from extended arm position.	0 = **Absent.** 1 = **Present in one limb.** 2 = **Present in two limbs.** UN = **Amputation** or joint fusion, explain:_____	_____
8. Sensory: Sensation or grimace to pinprick when tested, or withdrawal from noxious stimulus in the obtunded or aphasic patient. Only sensory loss attributed to stroke is scored as abnormal and the examiner should test as many body areas (arms [not hands], legs, trunk, face) as needed to accurately check for hemisensory loss. A score of 2, "severe or total sensory loss," should only be given	0 = **Normal;** no sensory loss. 1 = **Mild-to-moderate sensory loss;** patient feels pinprick is less sharp or is dull on the affected side; or there is a loss of superficial pain with pinprick, but patient is aware of being touched.	_____

when a severe or total loss of sensation can be clearly demonstrated. Stuporous and aphasic patients will, therefore, probably score 1 or 0. The patient with brainstem stroke who has bilateral loss of sensation is scored 2. If the patient does not respond and is quadriplegic, score 2. Patients in a coma (item 1a=3) are automatically given a 2 on this item.	2 = **Severe to total sensory loss;** patient is not aware of being touched in the face, arm, and leg.	
9. Best language: A great deal of information about comprehension will be obtained during the preceding sections of the examination. For this scale item, the patient is asked to describe what is happening in the attached picture, to name the items on the attached naming sheet and to read from the attached list of sentences. Comprehension is judged from responses here, as well as to all of the commands in the preceding general neurological exam. If visual loss interferes with the tests, ask the patient to identify objects placed in the hand, repeat, and produce speech. The intubated patient should be asked to write. The patient in a coma (item 1a=3) will automatically score 3 on this item. The examiner must choose a score for the patient with stupor or limited cooperation, but a score of 3 should be used only if the patient is mute and follows no one-step commands.	0 = **No aphasia;** normal. 1 = **Mild-to-moderate aphasia;** some obvious loss of fluency or facility of comprehension, without significant limitation on ideas expressed or form of expression. Reduction of speech and/or comprehension, however, makes conversation about provided materials difficult or impossible. For example, in conversation about provided materials, examiner can identify picture or naming card content from patient's response. 2 = **Severe aphasia;** all communication is through fragmentary expression; great need for inference, questioning, and guessing by the listener. Range of information that can be exchanged is limited; listener carries burden of communication. Examiner cannot identify materials provided from patient response. 3 = **Mute, global aphasia;** no usable speech or auditory comprehension.	_____
10. Dysarthria: If patient is thought to be normal, an adequate sample of speech must be obtained by asking patient to read or repeat words from the attached list. If the patient has severe aphasia, the clarity of articulation of spontaneous speech can be rated. Only if the patient is intubated or has other physical barriers to producing speech, the examiner should record the score as untestable (UN), and clearly write an explanation for this choice. Do not tell the patient why he or she is being tested.	0 = **Normal.** 1 = **Mild-to-moderate dysarthria;** patient slurs at least some words and, at worst, can be understood with some difficulty. 2 = **Severe dysarthria;** patient's speech is so slurred as to be unintelligible in the absence of or out of proportion to any dysphasia, or is mute/anarthric. UN = **Intubated** or other physical barrier, explain:_____	_____
11. Extinction and inattention (formerly neglect): Sufficient information to identify neglect may be obtained during the prior testing. If the patient has a severe visual loss preventing visual double simultaneous stimulation, and the cutaneous stimuli are normal, the score is normal. If the patient has aphasia but does appear to attend to both sides, the score is normal. The presence of visual spatial neglect or anosognosia may also be taken as evidence of abnormality. Since the abnormality is scored only if present, the item is never untestable.	0 = **No abnormality.** 1 = **Visual, tactile, auditory, spatial, or personal inattention** or extinction to bilateral simultaneous stimulation in one of the sensory modalities. 2 = **Profound hemi-inattention or extinction to more than one modality;** does not recognize own hand or orients to only one side of space.	_____
		_____

Adapted from: Goldstein LB, Samsa GP, Stroke 1997; 28:307.

Graphic 61698 Version 4.0

ASPECTS study form

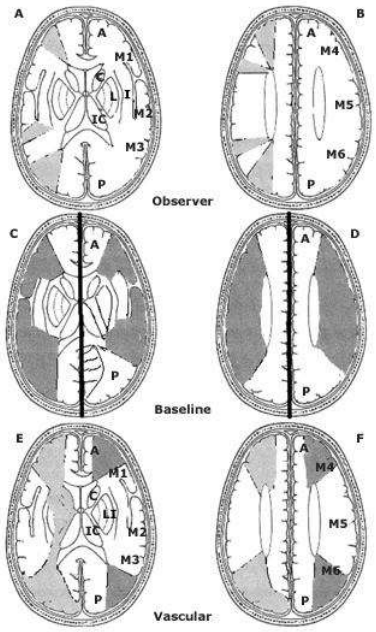


The ASPECTS value is calculated from two standard axial CT cuts: one at the level of the thalamus and basal ganglia (left), and one just rostral to the basal ganglia (right). A: anterior circulation; P: posterior circulation; C: caudate; L: lentiform; IC: internal capsule; I: insular ribbon; MCA: middle cerebral artery; M1: anterior MCA cortex; M2: MCA cortex lateral to insular ribbon; M3: posterior MCA cortex; M4, M5, and M6 are anterior, lateral, and posterior MCA territories immediately superior to M1, M2, and M3, rostral to basal ganglia

Reproduced with permission from: Barber, PA, Demchuk, AM, Zhang, J, Buchan, AM. Validity and reliability of a quantitative computed tomography score in predicting outcome of hyperacute stroke before thrombolytic therapy. ASPECTS Study Group. Alberta Stroke Programme Early CT Score. Lancet 2000; 355:1670. Copyright © 2000 The Lancet.

Graphic 72190 Version 1.0

ASPECTS study form and MCA variants



(A and B) Right hemisphere, observer variations: lower and upper ASPECTS slices show as shaded areas the minimal and maximal variations in size of the cortical areas of the MCA (M1-M6) chosen by six expert observers. Left hemisphere, ASPECTS study form: A = anterior circulation; P = posterior circulation; C = caudate head; L = lentiform nucleus; IC = internal capsule; I = insular ribbon; MCA = middle cerebral artery; M1 = anterior MCA cortex; M2 = MCA cortex lateral to insular ribbon; M3 = posterior MCA cortex; M4, M5, and M6 are anterior, lateral, and posterior MCA territories, respectively, approximately 2 cm superior to M1, M2, and M3, respectively, rostral to basal ganglia. **(C and D)** Cortical MCA area variations with change of baseline. In the right hemisphere, the baseline is parallel to the inferior OML; in the left hemisphere, the baseline is the superior OML. OML=orbitomeatal line. **(E and F)** Normal vascular variations in MCA size on the two ASPECTS slices. The right hemisphere shows the larger normal variations described by van der Zwan* (light shading). The left hemisphere of each shows the smaller, textbook•, variations (dark shading).

References

** van der Zwan, A, Hillen, B, Tulleken, AF, et al. Variability of the territories or the major cerebral arteries. J Neurosurg 1992; 77:927.*

• Osborn, AG. Neuroradiology, Mosby, St. Louis 1995.

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Modified Treatment In Cerebral Ischemia (TICI) scale

0	No reperfusion
1	Flow beyond occlusion without distal branch reperfusion
2a	Reperfusion of less than half of the downstream target arterial territory
2b	Reperfusion of more than half, yet incomplete, in the downstream target arterial territory
3	Complete reperfusion of the downstream target arterial territory, including distal branches with slow flow

This relates to capillary-level reperfusion as measured on catheter angiography.

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Contributor Disclosures

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