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Review Article

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Role of Endovascular Neurosurgery in Acute Ischemic Stroke: Optimal Timing for Mechanical Thrombectomy in Extended Time Windows

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Abstract

This review discusses mechanical thrombectomy (MT) as a key treatment for acute ischemic stroke (AIS) caused by large vessel occlusions (LVOs). MT aims to rapidly restore blood flow using devices like stent retrievers and aspiration catheters. The treatment window has expanded to 24 hours based on advanced imaging. Successful MT involves reperfusion, not just recanalization, with a target of mTICI grade 2b/3. Time is critical for successful outcomes. The article also outlines patient selection, treatment strategies, and challenges, particularly in developing countries. Direct to angiosuite strategies and ongoing research are focused on improving workflows and expanding treatment options.

Keywords: Endovascular Therapy; Mechanical Thrombectomy; Acute Ischemic Stroke; Stent Retriever

Abbreviations

MT: mechanical thrombectomy; LVO: large vessel occlusions; SAH: subarachnoid haemorrhage; EVT: Endovascular thrombectomy; CTP: CT perfusion

Introduction

Stroke is the second leading cause of death and a leading cause of disability worldwide [1,2]. In 2019, there were 101.5 million people with stroke, 77.2 million of whom had acute ischemic stroke [3]. In the U.S., approximately 87% of all strokes are ischemic, while intracranial hemorrhage (ICH) accounts for 10% and subarachnoid hemorrhage (SAH) for 3% [3-5]. About 795,000 people in the United States suffer an ischemic stroke each year [6]. At least 10% of ischemic strokes are caused by a large vessel occlusion (LVO), affecting the intracranial internal carotid artery, the M1 or proximal M2 segment of the middle cerebral artery, the intracranial vertebral arteries, or the basilar artery [6]. LVOs account for approximately one-third of ischemic strokes, but are responsible for more than 60% of morbidity and 90% of mortality due to AIS [7]. The lifetime risk of having a stroke is about one in four by the age of 80.(3) Endovascular thrombectomy (EVT) has revolutionized the treatment of AIS due to LVO [1,3]. Prior to modern interventions, mortality after stroke was about 10% in the acute phase, with about half of patients developing moderate-to-severe disability. EVT has changed that, with many patients experiencing improved outcomes [3]. The primary goal of EVT is the rapid restoration of cerebral blood flow to the salvageable ischemic brain tissue at risk of infarction [3]. Early reperfusion of the ischemic penumbra is associated with favorable outcomes and reduced mortality [7]. EVT, particularly mechanical thrombectomy, has become a standard treatment for LVO strokes [6-9]. Mechanical thrombectomy involves the use of devices like stent retrievers and aspiration catheters to remove blood clots [1,6]. EVT can be effective in patients presenting up to 24 hours from their last known well, provided they meet specific clinical and imaging criteria [6,9,10]. This is because advanced perfusion imaging can identify patients with salvageable brain tissue in this extended time window [9,10].

Evolution of Endovascular Neurosurgery

Initial efforts involved surgical approaches for cervical carotid occlusions, such as thrombendarterectomy and bypass grafts [11]. In 1958, the first cases of intra-arterial infusion of fibrinolytics (fibrinolysin) to treat cerebral arterial occlusions were reported [11]. In 1983, intra-arterial fibrinolytic infusion using streptokinase through catheters was reported [11]. However, these early methods had suboptimal outcomes [1]. The development of mechanical clot disruption (thromborrhexis) with micro-guidewires or balloon maceration of the thrombus was a step forward [11]. The EKOS MicroLysUS infusion catheter, which used sonography to accelerate intra-arterial thrombolysis, was also introduced [11]. The first three multicenter, prospective, randomized controlled trials using first-generation devices (e.g. MERCI system) failed to show the benefit of intra-arterial revascularization [11]. Several landmark randomized controlled trials, such as MR CLEAN, ESCAPE, EXTEND-IA, SWIFT PRIME, and REVASCAT, demonstrated the efficacy of mechanical thrombectomy using second-generation devices in patients with large vessel occlusions (LVO) in the anterior circulation within 6 hours of symptom onset. These trials shifted the paradigm for AIS treatment [1,7,11,12]. Since 2015, nine randomized trials have shown the benefit of endovascular reperfusion [11]. There has been a move towards expanding the indications for mechanical thrombectomy beyond the initial criteria [11,13,14]. This includes patients presenting in the extended time window (up to 24 hours from last known well) using advanced imaging to select appropriate candidates [1,15]. Advanced imaging with CT perfusion (CTP) or MRI became important to assess tissue viability and identify the ischemic penumbra [1,8,9]. This allowed for better selection of patients for EVT in the extended time window [1,9]. The field has seen improvements in thrombectomy devices and techniques, including the development of stent retrievers, aspiration catheters, and balloon guide catheters [1,6,7,9,15]. Direct aspiration thrombectomy has also become an established frontline approach [7] Furthermore, the understanding of the importance of rapid recanalization has led to the development of more efficient workflows, such as the “direct to angiography” approach [7,16,17]. The field is currently focused on improving patient selection, optimizing treatment workflows, and expanding the indications for EVT to include distal occlusions, milder strokes, and posterior circulation strokes [11]. There are ongoing trials to address these areas [11]. The optimization of pre- and intra-hospital procedures is also a key area of focus [14].

Goals of Mechanical Thrombectomy

The primary goal of mechanical thrombectomy is to achieve rapid, safe, and effective arterial recanalization of large intracranial vessel occlusions in order to restore blood flow to the salvageable ischemic brain tissue [3,7]. The technical goal of mechanical thrombectomy is to achieve reperfusion to a modified Thrombolysis in Cerebral Infarction (mTICI) grade 2b/3 [18,19]. The specific goals of mechanical thrombectomy include:

1. Reperfusion, not just recanalization: Mechanical thrombectomy aims to restore blood flow to the affected brain tissue, not simply to open the occluded vessel [19]. A variety of scores exist, but the mTICI score is the current assessment tool of choice, with proven value in predicting clinical outcomes [19].
2. Timeliness: Reperfusion should be achieved as early as possible within the therapeutic window [19]. The likelihood of benefit from mechanical thrombectomy decreases over time [7].
3. Functional outcome: The ultimate goal is to improve functional outcomes for the patient, which is measured using the modified Rankin Scale (mRS) [13,19]. A score of 0-2 on the mRS indicates a good functional outcome [13].
4. Reduce infarct size: Restoring blood flow can reduce the size of the infarct and reverse neurological deficits [3].
5. Prevent expansion of the ischemic penumbra: By restoring flow, mechanical thrombectomy aims to prevent the expansion of the ischemic penumbra into the infarct core [20].
6. Minimize complications: The procedure should be performed with the goal of minimizing complications such as symptomatic intracranial hemorrhage and distal embolization [7].
7. First-pass recanalization: There is a move towards optimizing techniques and devices to achieve fast and complete recanalization with one pass [7].

Mechanical thrombectomy has emerged as a powerful treatment modality for acute ischemic stroke from large vessel occlusion [1,7]. It is a significant advancement over earlier treatments such as intravenous thrombolytics, which are not effective in many cases of cerebral artery occlusion, and have a narrow treatment window and numerous contraindications [4]. In the past, early studies of mechanical thrombectomy failed to show any additional benefit compared with standard medical management, but these trials did not require confirmation of large vessel occlusion for patient enrolment [5,13]. However, studies using second-generation thrombectomy devices have demonstrated significantly better functional outcomes when combined with intravenous thrombolysis, compared to intravenous thrombolysis alone [13]. The focus of mechanical thrombectomy is on restoring blood flow quickly and effectively to the salvageable brain tissue [3]. This involves not just opening the blocked vessel but achieving successful reperfusion, ideally to a mTICI grade of 2b or 3, in order to improve the patient's functional outcome [18,19].

Indications

Mechanical thrombectomy is indicated for patients with acute ischemic stroke (AIS) caused by a large vessel occlusion (LVO), with the goal of restoring blood flow to the affected brain tissue [7,13]. The indications for mechanical thrombectomy have expanded since the first guidelines were released in 2013 [21].

General Indications

- Mechanical thrombectomy is the standard of care for patients presenting with LVO and salvageable brain tissue [7].
- Patients with a clinically suspected LVO should have non-invasive angiography (e.g., CTA) [18].
- Noninvasive intracranial vessel imaging is recommended during the initial evaluation of patients who may be eligible for mechanical thrombectomy [19].
- Extracranial carotid and vertebral artery imaging may be reasonable for planning treatment [5].

Time-Based Indications:

- Within 6 hours of symptom onset: Mechanical thrombectomy is indicated for patients with LVO in the anterior circulation presenting within 6 hours of symptom onset [13]. For patients with AIS within 6 hours of symptom onset, selection for mechanical thrombectomy based on CT and CTA or MRI and MRA is recommended in preference to additional imaging such as perfusion studies [15].
- 6-16 hours of symptom onset: In selected patients with AIS within 6-16 hours of last known well who have an LVO in the anterior circulation and meet the eligibility criteria from the DAWN or DEFUSE-3 trials, mechanical thrombectomy is recommended [7,21].
- 16-24 hours of symptom onset: In selected patients with AIS within 16-24 hours of last known well who have an LVO in the anterior circulation and meet the eligibility criteria from the DAWN trial, mechanical thrombectomy is reasonable [7,21].

There is insufficient evidence to evaluate the safety and efficacy of thrombectomy >24 hours from symptom onset [22].

Vessel Occlusion Location

- Anterior circulation LVO: This includes occlusions of the internal carotid artery (ICA) and the M1 segment of the middle cerebral artery (MCA) [17,21,23]. Mechanical thrombectomy is recommended for these occlusions [21]. M2 occlusions are also included in the LVO category [7]. There is a consensus that mechanical thrombectomy is reasonable for M2 occlusions, as they were included in most randomized trials [21,24]. Mechanical thrombectomy may be beneficial for distal MCA and anterior cerebral artery (ACA) occlusions, but these are associated with a higher risk of complications [17].
- Tandem Occlusions: Mechanical thrombectomy can be considered in patients with an occlusion or stenosis of the cervical ICA in addition to an intracranial LVO [18]. Treatment of tandem occlusions may be reasonable [15].
- Posterior circulation occlusions: Thrombectomy should be considered for basilar artery occlusions [24]. Mechanical thrombectomy may be reasonable for occlusions of the vertebral arteries, basilar artery, or posterior cerebral arteries [19].

Clinical and Imaging Criteria

Patients should be functionally independent at baseline, often defined by a modified Rankin Scale (mRS) of 0-2 [13]. Patients should have at least a moderate stroke syndrome [13], often indicated by a National Institutes of Health Stroke Scale (NIHSS) score of ≥6 [13,21]. However, thrombectomy may be reasonable in patients with an NIHSS score <6 in some cases [19,21]. Patients should not show extensive areas of early ischemia on non-contrast CT. An Alberta Stroke Program Early Computed Tomography Score (ASPECTS) ≥ 5 is often used [13]. In the early time window (within 6 hours), advanced imaging may not be required if the patient meets the clinical criteria for thrombectomy and has an ASPECTS ≥6 [15].

Patients with AIS within 6-24 hours of last known well who have LVO in the anterior circulation should have advanced imaging (CTP or DW-MRI, with or without MRI perfusion) to determine eligibility for mechanical thrombectomy, but only when patients meet other eligibility criteria from one of the RCTs that showed benefit from mechanical thrombectomy in this extended time window [13,19]. Mechanical thrombectomy is also recommended between 6 and 24 hours in patients who have a mismatch between ischemic core (by CTP or MRI-DWI) and either clinical deficits or area of hypoperfusion (by CTP or MRI-PWI) [18].

Specific Considerations

- Mild Symptoms: Although guidelines generally recommend thrombectomy for patients with more severe symptoms, thrombectomy may be reasonable for carefully selected patients with mild symptoms [19,25].
- Large Infarct Core: Thrombectomy may be reasonable within the first 6 hours of symptom onset in patients with a large core infarct volume [22].
- Age and Other Factors: Mechanical thrombectomy should be considered for a wide range of patients with LVO in the anterior circulation, regardless of age, sex, clinical severity, or intracranial location of the occlusion [26].

Adjunctive Treatment

- Intravenous thrombolysis (IV tPA): Patients eligible for IV alteplase should receive it even if mechanical thrombectomy is being considered [18,19]. Observation after IV alteplase to assess for clinical response should not be performed [19].
- Direct thrombectomy (without IV tPA): Some studies suggest that direct thrombectomy alone is non-inferior to endovascular thrombectomy preceded by intravenous alteplase in some patients [4,27].
- The indications for mechanical thrombectomy are based on a combination of factors including time from symptom onset, the location of the occlusion, clinical severity, and imaging findings. These criteria aim to ensure that the procedure is performed in patients who are most likely to benefit from it.

Contraindications

Absolute Contraindications:

- There is a lack of salvageable brain distal to the occluded vessel [7].
- Occlusion of small, distal intracranial arteries that, in the judgment of the operator, cannot withstand the mechanical and shearing forces of stent retriever deployment and aggressive suction aspiration [7].

Relative Contraindications and Risk Factors:

- Large Infarct Core: While not an absolute contraindication, performing EVT on patients with a large established infarct core may result in futility, indicating limited potential benefit from EVT. Recent studies suggest that an ASPECTS below 2 or a CTP-determined core volume exceeding 100-150 mL may indicate limited benefit from EVT [28].
- Advanced age or pre-existing disability: Significant pre-existing disability (mRS score > 1) often precludes favorable clinical outcomes despite successful thrombectomy.(22) Frailty, poor nutritional status, limited baseline functional capacity, or comorbidities can also diminish the potential benefit of thrombectomy [22].
- Time window: There is insufficient evidence to evaluate the safety and efficacy of thrombectomy beyond 24 hours from symptom onset [18,21].
- Specific medical conditions that contraindicate the use of intravenous thrombolysis (IV tPA) may also warrant caution before proceeding with mechanical thrombectomy. These include: Therapeutic anticoagulation, Cerebral infarction in the preceding 3 months, Any prior intracranial hemorrhage, Severe head trauma in the preceding 3 months, Unsecured vascular malformation of the central nervous system that may be associated with a high risk of hemorrhage, Stroke attributed to known or suspected endocarditis, History of anaphylaxis to alteplase, Situations in which IV tPA is contraindicated according to the 2019 AHA guidelines [27].

Patient-Related Factors

The decision to perform thrombectomy in patients with mild strokes (NIHSS 0-5) has been controversial [7,29,30]. Conscious sedation may lead to more distal emboli during thrombectomy than general anaesthesia. Patients with posterior circulation occlusions may have a higher risk of distal emboli during thrombectomy [7].

Anatomical Considerations

- Distal Vessel Occlusions: Mechanical thrombectomy for distal MCA and anterior cerebral artery (ACA) occlusions may be beneficial but are associated with a higher risk of complications such as vessel rupture, distal embolization of clot, or vasospasm [17].
- Tortuous Vessels: The presence of tortuous vessels can increase the risk of complications during thrombectomy such as inadvertent detachment of the stent retriever [7,13].

Procedure-Related Factors:

- Risk of Embolization: Embolization of clot into a new territory (ENT) is a major limitation of both major thrombectomy techniques [7,15].
- Vessel Perforation: Vessel perforation is a feared complication during thrombectomy, especially when

accessing difficult occlusions or passing the site of occlusion with a microwire or microcatheter.
- Access Problems: Unfavorable vascular anatomy and difficult aortic arches can complicate access and increase procedure time.
- Reocclusion: Intracranial atherosclerotic stenosis is a possible etiology for refractory thrombectomy or immediate reocclusion post thrombectomy.

Other Considerations:

- Technical challenges: Thrombectomy for more distal occlusions may be technically challenging [7,17].
- Thrombus Characteristics: Factors such as thrombus length and composition, especially with high von Willebrand factor content or calcification, may affect the success of thrombectomy.
- Limited Data: There is a relative paucity of data on distal vessel thrombectomy, so the benefit must clearly outweigh the risk.

It is important to note that the decision to proceed with mechanical thrombectomy is complex and requires careful consideration of the patient's individual circumstances, as well as the available resources and expertise [7,22].

Evidence-based Clinical Pathways

Patient Selection:

- Large Vessel Occlusion (LVO): MT is primarily indicated for patients with acute ischemic stroke caused by a large vessel occlusion (LVO) in the anterior circulation. This includes occlusions of the internal carotid artery (ICA), and the M1 and M2 segments of the middle cerebral artery (MCA). Some studies suggest potential benefit in basilar artery occlusions [2,7,13,17].
- Time Window: Initial trials focused on patients presenting within 6 hours of symptom onset. Later trials extended the time window to 6-16 hours with selection by perfusion imaging. Some studies show potential benefit up to 24 hours in select patients with a mismatch between clinical deficit and infarct size. There is emerging evidence suggesting that MT may be safe and effective beyond 16 hours from last known well (LKW) in the anterior circulation, but more randomized controlled studies are needed.
- Clinical Assessment: Patients should have a moderate-to-severe neurological deficit. An NIHSS score of 6 has been shown to have a high positive predictive value for any vessel occlusion. While some trials excluded patients with mild strokes (NIHSS 0-5), MT may be considered in patients with minor stroke syndromes (NIHSS 0-5) who have LVO and are at risk of early neurological deterioration.
- Imaging: CT angiography (CTA) is essential to identify LVO. CT perfusion (CTP) or MRI can help identify salvageable brain tissue and determine the extent of the infarct core, especially in extended time windows. ASPECTS (Alberta Stroke Program Early CT Score) may be used to assess the extent of early ischemic changes on CT, but there is some controversy about ASPECTS cutoffs. Patients with an ASPECTS ≤5 may still benefit from thrombectomy.

Pre-hospital Pathways:

- Drip and Ship Model: Patients are taken to the nearest primary stroke center where they may receive intravenous thrombolysis (IV tPA) and then are transferred to a comprehensive stroke center for thrombectomy. This model offers quicker access to IV tPA and refined patient selection for those transferred to comprehensive stroke centers [7,13,16,21,31].
- Mothership Model: Patients are transported directly to a comprehensive stroke center capable of performing MT.
- Direct to Angiosuite: Some centers are exploring the direct transfer of patients with suspected LVO to the angiography suite, bypassing the emergency room CT, which aims to reduce door-to-puncture time.
- Mobile Stroke Units (MSU): In some locations, Mobile Stroke Units with CT scanners and telemedicine capabilities are used to triage patients in the field and transport them to the appropriate center.

Treatment Strategies

- Intravenous Thrombolysis (IV tPA): IV tPA is the standard of care for eligible patients within 4.5 hours of stroke onset. Bridging therapy: In the "drip and ship" model, IV tPA is administered at the primary stroke center before transfer for MT. There is an ongoing debate about the necessity of IV tPA before MT in EVT capable centers. Recent data suggests that direct MT alone might be non-inferior to bridging IV tPA and MT in achieving functional outcomes. Several trials comparing direct MT and bridging therapy are underway. Some evidence suggests better reperfusion and clinical outcomes with tenecteplase as a bridging agent compared to alteplase [7,11,15,27,29,31].

Mechanical Thrombectomy Techniques:

1. Stent Retrievers: Stent retrievers are the most commonly used devices for MT. They are used to engage and remove the clot.
2. Aspiration Thrombectomy: Direct aspiration thrombectomy with a large bore aspiration catheter is also used as a primary technique or in conjunction with stent retrievers.
3. Combined Techniques: A combination of stent retrievers

and aspiration catheters is frequently used to achieve optimal clot removal.

4. Balloon Guide Catheters: Balloon guide catheters may improve the effectiveness of thrombectomy by improving proximal flow control.

- Anesthesia: The use of general anesthesia versus conscious sedation for MT is being debated. There is some evidence suggesting conscious sedation may lead to more distal emboli than general anesthesia.
- Time to Treatment: Time is crucial; faster treatment is associated with better outcomes. The time from stroke onset to groin puncture is directly associated with the quality of reperfusion. Direct transfer to the angiography suite may reduce the time to treatment.

Post-Thrombectomy Care:

- Blood Pressure Management: Intensive blood pressure management (lowering systolic blood pressure to 100-120 mmHg) in the first 24-36 hours after thrombectomy may lead to worse outcomes [7,13,28].
- Monitoring for Complications: Patients should be monitored for post-procedural complications such as symptomatic intracranial hemorrhage and distal embolization.
- Reperfusion Assessment: Successful reperfusion, classified as modified Thrombolysis in Cerebral Infarction (mTICI) 2b or 3, is associated with better outcomes.

Evidence Base:

- Landmark Trials: Multiple randomized controlled trials (RCTs) have demonstrated the benefit of MT in patients with AIS due to LVO. These include trials like MR CLEAN, ESCAPE, REVASCAT, SWIFT PRIME, and EXTEND IA. The HERMES meta-analysis pooled data from these trials and confirmed the efficacy of MT. The THRACE trial showed that MT after IV alteplase is better than IV alteplase alone [7,10,13,23,32,33].
- Extended Time Window Trials: Trials such as DAWN and DEFUSE 3 demonstrated the benefit of MT in patients presenting between 6-24 hours with a clinical/imaging mismatch.

Future Directions

Ongoing research is focused on: Optimizing pre-hospital pathways to reduce treatment delays, determining the optimal role of IV tPA before MT, expanding the use of MT to patients with distal occlusions and mild strokes, improving first pass recanalization rates, developing better imaging techniques to identify salvageable brain tissue [11,13,15,27,29].

This pathway is continuously evolving as new evidence emerges, but the core principle remains timely identification of LVO and rapid reperfusion with MT.

Challenges in developing countries

Several challenges exist in providing mechanical thrombectomy (MT) for acute ischemic stroke (AIS) in developing countries:

Access to Treatment:

- Limited resources: Many low and middle-income countries lag in providing access to endovascular thrombectomy (EVT) for acute stroke patients. There is a significant disparity between the number of eligible patients and the relatively low utilization of advanced treatments worldwide [1,7-9,13,32].
- Lack of infrastructure: Access to acute MRI or CT perfusion (CTP) is not readily available in many stroke centers. The lack of access to advanced imaging, such as CT perfusion, can limit the number of patients who qualify for thrombectomy.
- Geographic barriers: In rural areas, the medical service for providing EVT is limited. The distance to thrombectomy-capable centers can be a significant obstacle.
- Transportation: Delays in patient transfer, especially in urban areas with traffic congestion, can limit access to timely treatment. In rural areas, there may be difficulty with ground transport, making air ambulance necessary, which may not always be available.
- Fewer comprehensive stroke centers: Many comprehensive stroke centers and thrombectomy-capable hospitals are localized in urban areas, making access challenging for those in more rural areas.
- Cost: The cost of implementing tenecteplase into the health system is a factor that must be accounted for. The cost of RAPID software, which is used for advanced imaging, can also be a barrier, especially in resource-constrained settings.

Workflow and Time Delays:

- Multi-step approach: Current stroke systems often use a serial approach to treatment, which leads to delays in thrombectomy. In many centers, patients are evaluated in the emergency department (ED), a head CT is obtained, IV t-PA is administered if appropriate, and only subsequently does the patient undergo further imaging for thrombectomy eligibility. This can result in significant time delays [1,7,17].
- Prehospital delays: Prehospital delays are a common reason why patients miss the therapeutic window for IV tPA. A lack of specific pre-hospital protocols for stroke can further delay treatment.
- Lack of streamlined systems: Many hospitals do not have protocols designed around EVT, which can cause delays.
- Triage: There can be difficulties in the triage and

transport of patients suspected of having a large vessel occlusion (LVO).

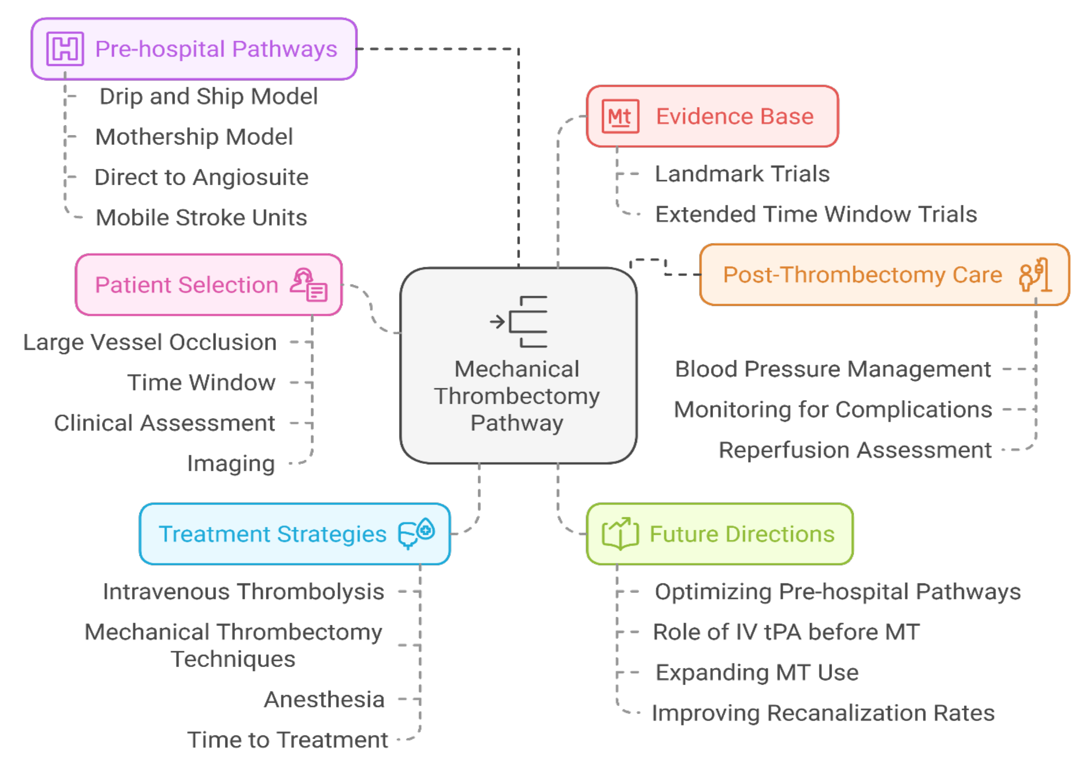

Figure 1: Evidence-based Clinical Pathways for Endovascular Therapy of Acute Ischemic Stroke.

Other Challenges:

- Limited training: There may be a lack of training for medical and surgical residents/fellows in EVT, although simulation models could help [1,3,7,13,19].
- Equipment and expertise: Thrombectomy trials have been conducted in resource-rich centers with access to neuroradiologists and advanced imaging techniques. A lack of experienced personnel in endovascular procedures may limit access to treatment.
- Research: There are difficulties in conducting prospective studies for AIS beyond 24 hours, including randomized controlled trials (RCTs), due to financial issues, patient enrollment challenges, and the difficulty of verifying statistical differences.
- General awareness: There is a lack of stroke awareness in some populations, and there are disparities in stroke awareness based on race.
- Cultural barriers: Cultural factors and reliance on treatments without strong evidence, such as herbal remedies, can impede access to and acceptance of evidence-based treatments.
- Socioeconomic factors: Socioeconomic status (SES) has been identified as a potential catalyst for prehospital delays, especially in urban areas.
- Specific Populations: There is a need for more research to address practice gaps in treating strokes in specific populations, such as those with sickle cell disease.
- Data Collection: There is a lack of comprehensive stroke data in some countries.

Need for Improvement:

System-based approaches that aim to reduce times from stroke onset to reperfusion are a priority. There is a need for intelligent systems to be developed as a state policy, to achieve national solutions for stroke. There is a need to translate available data into clinical practice and funnel funds to provide EVT to as many stroke victims as possible. There is a need for worldwide collaboration involving global strategies, campaigns, and effectiveness measurement of global preventive initiatives, especially in low- to middle-income countries. These challenges highlight the complexity of implementing effective stroke care in developing countries and emphasize the need for multifaceted solutions that address infrastructure, training, and economic barriers [1,7,32].

Conclusion

Endovascular neurosurgery has established mechanical thrombectomy (MT) as the standard for Acute Ischemic Stroke (AIS) due to Large Vessel Occlusion (LVO). MT improves patient outcomes compared to medical management alone. The treatment window has expanded up to 24 hours based on imaging, particularly CT perfusion or MRI to identify salvageable tissue. Rapid reperfusion is crucial, and direct-to-angiosuite strategies are being explored. Stent retrievers are commonly used, often with aspiration catheters. The role of pre-MT IV thrombolysis is debated, with direct MT showing promise. Ongoing research focuses on optimizing patient selection, techniques, and workflows.

Conflict of Interest

No conflict of interests to report.

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