



ORIGINAL ARTICLE

Mechanical Thrombectomy for Acute Ischemic Stroke Efficacy, Safety, Extended Time Windows, and Global Access - A Narrative Review

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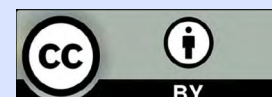
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ABSTRAKT

Purpose: In this review, our question was how well mechanical thrombectomy (MT) works in acute ischemic stroke (AIS), which patients benefit the most from this treatment, and why MT is not accessible to so many patients worldwide. We compared MT against intravenous thrombolysis (IVT), examined combination bridging therapy, explored how far the therapeutic window can be extended, and assessed its cost effectiveness.

Materials and Methods: A narrative review of the literature was conducted using predefined terms we searched PubMed/PMC, ResearchGate, and Google Scholar and included only peer-reviewed, freely accessible English-language articles published between 2015 and 2025. Studies were selected based on their relevance to predefined clinical and health economic outcomes and synthesized narratively without formal pooling of statistics. Of the studies retrieved, 24 met all criteria and formed the basis of this review.

Results: Adding MT as a standard of care almost doubles the chance of functional independence at 90 days (45.65% vs. 27.45%; RR 1.65) and significantly reduces overall mortality (RR 0.85). Performing MT without prior IVT is equally effective as combination bridging therapy in patients presenting directly to centers capable of performing MT. Trials like DAWN and DEFUSE-3 showed that selected patients can benefit from MT up to 24 hours, with a staggering odds ratio for functional independence of 5.01. Across healthcare systems, MT proves cost-effective, with a mean ICER around USD 12,000-14,000 per quality-adjusted life year. Nevertheless, fewer than 3 in 100 suitable patients receive MT, with an 88% access rate difference between wealthy and lower-income countries.

Conclusions: MT is the most effective treatment we have for stroke caused by large artery blockage; it works, its cost effective, and the technology keeps improving. The main problem is not whether it works, its making it available to people in less developed countries with worse accessibility.

KEYWORDS

mechanical thrombectomy, acute ischemic stroke, intravenous thrombolysis, large vessel occlusion, recanalization, extended time window, cost-effectiveness, global access

Introduction

Every 40 seconds, someone in the world has an AIS, with a meaningful proportion involving the large vessels that supply wide areas of cortex. The consequences are always devastating, millions of neurons begin to die within minutes. Without quick intervention, in best case patients are left with serious disabilities, in worst they do not survive. The 2016 Global Burden of Disease study is direct with its assumptions that one in four adults alive today will have a stroke at some point in their life, and regardless of improvements in reducing stroke rates, availability of new methods in most parts of the world is scarce, making the total number of people living with stroke-related disability, rise^[1].

For decades, the only pharmacological answer to acute ischemic stroke was intravenous tissue plasminogen activator, a clot-dissolving drug that became standard of care, which must be used within 4.5 hours of symptom onset^[2]. IV-tPa is useful as a standard practice drug, but due to its weakness, which is lack of reliability to dissolve larger clots in proximal arteries, with recanalization rates rarely exceeding 30%^[3]. It was known for years that IVT is not sufficient enough for patients with the most urgent and severe symptoms.

Mechanical thrombectomy was designed to fill an existing gap. Instead of trying to dissolve the clot chemically, MT physically retrieves it. Catheter is threaded through the arterial system into the cerebral arterial system, in the form of either a stent retriever that captures the clot or a powerful aspiration catheter that sucks it out, it's deployed on the impacted location and the clot is removed. Experienced specialists with the right equipment, can get remarkable effects.

In 2015 five major randomized controlled trials, MR CLEAN, ESCAPE, EXTEND-IA, SWIFT PRIME, and THRACE, reported unequivocally that MT, supplementing IVT, reaches better outcomes for patients with large anterior circulation vessel occlusions than IVT alone^[3]. Within months, international stroke guidelines were rewritten, with MT becoming the new standard of care.

Published in 2018, the DAWN and DEFUSE-3 trials, showed that the question is whether or not viable brain tissue patients have remaining, not how many hours have passed, with 6 hours treatment window left as practical approximation^[4, 5]. More recently, the debate has shifted to whether patients who can go straight to MT need to receive IVT first at all^[6, 7] and to how we might extend the benefits of thrombectomy to patients with larger infarcts, more distal occlusions, or strokes in the back of the brain^[8, 9].

With all this clinical progress, the global median MT access rate is 2.79%. In low- and middle-income countries, it falls below 0.5%^[10]. The countries where 87% of stroke deaths occur, are largely the lower-income countries. In hope of informing clinical practitioners this review tries to gather available evidence on MT's effectiveness, safety, time window flexibility, cost-effectiveness, and global access.

Material and Methods

In this review, using PubMed/PMC, ResearchGate, and Google Scholar, we searched terms like mechanical thrombectomy, acute ischemic stroke, intravenous thrombolysis, large vessel occlusion, functional outcomes, complications, cost-effectiveness, and extended time windows.

We defined clear boundaries, articles had to be peer-reviewed original research, systematic reviews, or meta-analyses, published in English between 2015 and 2025, and available in full text through open access or the PubMed Central free repository. We excluded case reports, and studies without an open access full text.

After applying these criteria, 24 articles qualified. They cover a wide spectrum of study types such as systematic reviews and meta-analyses. If studies disagreed, we presented both findings and discussed why they might differ. Only directly observed data were included in the analysis.

Results

7.1 Overview of Included Studies

This study covers a wide geographic range with research from countries like China, South Korea, United States, from Europe and Africa, with research being still skewed toward high-income countries (a limitation we return to in the Discussion). The majority of studies - 18 of 24 - were published between 2020 and 2025, reflecting just how rapidly the evidence base has been moving.

Primary conclusion was always functional independence at 90 days, defined as a modified Rankin Scale (mRS) score of 0 to 2, which means patient is either symptom-free or has only mild symptoms that do not affect his normal everyday living. As a secondary conclusions we included symptomatic intracranial hemorrhage (sICH), successful recanalization measured by the Thrombolysis in Cerebral Infarction scale

(TICI) (with TICI 2b or 3 [partial to complete reperfusion] considered a procedural success), and mortality. Results of cost-effectiveness studies were expressed as incremental cost-effectiveness ratios (ICERs) in USD per quality-adjusted life year (QALY) gained.

7.2 MT vs. IVT: Efficacy Outcomes

A meta-analysis combining 15 randomized trials found that MT added to IVT increased by nearly 100% the rate of functional independence at 90 days compared to just IVT; 45.65% of MT patients achieved independence versus just 27.45% of patients treated only with IVT, a relative risk of 1.65 ($p < 0.01$). All-cause mortality fell from 20.13% to 16.81%, a relative risk of 0.85 ($p = 0.04$)^[1]. A second meta-analysis, spanning nine trials and 2,410 patients, arrived at the same conclusion: a summary relative risk of 1.45 for good functional outcome, with a significant trend towards lowering mortality (RR 0.86; 95% CI 0.72-1.02; $p = 0.09$)^[3].

IVT fails the recanalization of large proximal clots in 70% or more of cases^[3]. In contrast to IVT, MT physically removes the obstruction with successful recanalization in around 76% of MT-treated patients^[1], compared with 30-40% in IVT-only treated patients. The HERMES collaboration, which combined individual patient data from five of the crucial trials, confirmed that benefits hold across age groups, stroke severity levels, and different imaging selection criteria, validating the treatment effects.

One tool that has become central to patient selection is the Alberta Stroke Program Early CT Score (ASPECTS), a 10-point scale rating the extent of early ischemic change on CT, allowing clinical practitioners to establish probability of brain tissue left to save, with lower scores equating for far worse outcomes. Current AHA and ESO guidelines recommend MT as a

strong indication for patients with ASPECTS of 6 or higher; the evolving question of what to do with lower ASPECTS scores is addressed in section 7.6.

7.3 MT vs. IVT: Safety Profile

One of the concerns in the early days of MT was that threading a catheter into an already-compromised cerebral vessel might cause hemorrhagic complications. The accumulated trial data provide considerable reassurance for standard-indication patients. In the nine-trial meta-analysis by Elgendy et al., the risk of symptomatic intracranial hemorrhage with MT was almost identical to the IVT: a risk ratio of 1.06 (95% CI 0.73-1.55; $p = 0.76$)^[3]. Procedural complications such as vessel perforation, dissection, embolization to new territories, and access-site issues do occur, but in experienced centers they are rarely reported that the benefits of the procedure outweigh the risks.

However, the picture is different for patients with large established infarcts (ASPECTS 3-5). A meta-analysis of six RCTs in this population found that MT significantly increased any intracranial hemorrhage (RR 1.94; 95% CI 1.48-2.53) and symptomatic intracranial hemorrhage (RR 1.73; 95% CI 1.11-2.69) compared with standard care^[11]. The functional benefit in this group was larger than in IVT treated patients, but the elevated hemorrhagic risk highlights why careful patient selection, and conversations about risk, continues to be critical when pushing the limits of MT eligibility.

When choosing between aspiration-based and stent retriever approaches, neither technique has demonstrated a meaningful advantage in sICH rates (OR 0.91; 95% CI 0.69-1.19; $p = 0.47$)^[9], though aspiration-based strategies appeared to reduce procedural time and the rate of cloth breaking off into previously unaffected vessel territories^[8].

Table 1. Key clinical outcomes from included meta-analyses

Outcome	MT vs. Standard Care	Bridging vs. Direct MT
Functional independence (mRS 0-2) at 90 days	RR 1.65; $p < 0.01$ ^[1]	Similar (46.0% vs. 45.5%) ^[6]
All-cause mortality	RR 0.85; $p = 0.04$ ^[1]	No significant difference ^[6, 7]
Symptomatic intracranial hemorrhage	RR 1.06; $p = 0.76$ ^[3]	No significant difference ^[6, 7]
Successful recanalization (TICI 2b-3)	~76% with MT ^[1]	Comparable ^[6, 7]

Table 1. Summary of selected outcomes comparing MT with standard medical care, and bridging IVT plus MT with direct MT alone. RR = relative risk; mRS = modified Rankin Scale; TICI = Thrombolysis in Cerebral Infarction. Sources:^[1, 3, 6, 7].

7.4 Combination bridging therapy

For a patient presented with a large vessel occlusion, the standard approach was clear; within 4.5 hours give them IVT first, then perform MT. But between 2020 and 2024, a number of randomized trials, began to question if this practice is necessary.

The core question is whether IVT before MT (bridging therapy) actually adds anything when the patient is already destined for catheterization. Six major RCTs - DIRECT-MT, SKIP, DEVT, MR CLEAN-NO IV, DIRECT-SAFE, and SWIFT DIRECT - collectively suggested it does not, at least not in centers where MT can be performed quickly. The meta-analysis by Cuadra-Canto et al. (2024) pooling these trials found direct MT to be non-inferior to bridging therapy for functional independence at 90 days^[6]. The numbers from the non-inferiority meta-analysis by Katsanos et al. (2022) tell the same story: functional independence rates of 46.0% with direct MT versus 45.5% with bridging therapy, a difference of 0.5% that carries no clinical significance^[7]. Mortality and hemorrhage rates were similarly indistinguishable between strategies.

A further meta-analysis by Hashmi TM et al. (2025), covering seven RCTs and 2,884 patients, reinforced this: excellent outcomes at 90 days (mRS 0-1) were achieved in 31.3% of the bridging group and an equivalent proportion in the direct MT group, with no difference in mortality or bleeding^[12]. For centers where MT can start immediately after imaging, skipping IVT is a reasonable choice that saves time and avoids the hemorrhagic risk, that comes with thrombolysis however small it may be.

That being said, what matters are the nuances. The bridging trials were conducted at places with exceptionally fast door-to-groin times, where MT takes longer to initiate, IVT-induced partial recanalization before catheterization may still help. This is why ESO-ESMINT guidelines, maintained in 2022, unless there is a specific reason to withhold IVT, it should still be offered to eligible patients. The recommendation suggests to recognize that in well-resourced, fast-moving centers, the two-step approach is not required, but does not advise to abandon bridging therapy entirely.

In some of stroke subtypes the picture is equally subtle, in basilar artery occlusion, carrying extremely high mortality rate without any treatment, a multicenter retrospective study across eight stroke centers, found no significant difference in 90-day favorable outcomes between direct MT (34.4%) and bridging therapy (39.4%; $p = 0.361$), though the bridging therapy fared better at discharges^[13]. For tandem occlusions of the anterior circulation, a 110-patient study found no meaningful difference between MT (51.0% favora-

ble at 90 days) and bridging therapy (55.7%; adjusted OR 1.17; $p = 0.743$)^[14]. The evidence consistently points that if doing IVT as fast as possible, it is just as good alone.

7.5 Extended Time Windows

The most important development in stroke medicine over the past decade was disproving of the idea that only time window, determines who can be treated. It was considered that MT is only useful within 6 hours because after that, the salvageable tissue surrounding the dead core has been lost. The DAWN and DEFUSE-3 trials disproved this assumption by demonstrating that some patients retain large volumes of at-risk but viable brain tissue regions and benefit immensely from treatment even in the 6-to-24-hour window^[4, 5].

The mechanism behind this is actually intuitive. The brain is fed by an interconnected web of collateral vessels, and in patients with robust collateral circulation, the spread of infarction can be dramatically slowed. These patients do not follow an average timeline; for them, the „clock“ runs slower. DAWN used a clinical-radiological mismatch approach, comparing NIHSS severity with CT-estimated core volume, while DEFUSE-3 used perfusion imaging mismatch. Both trials showed clear benefit, and the AURORA collaboration pooled data from six late-window trials, the result was an odds ratio of 5.01 ($p < 0.00001$) for functional independence in favor of MT over IVT, with no significant increase in mortality or sICH^[2]. That odds ratio is remarkable; it means that patients treated in the late window were five times more likely to achieve functional independence than those who received only IVT treatment. The benefit held for patients over 80 years old (OR 5.65) and was even stronger for wake-up strokes (OR 8.74)^[12].

Real-world data from a high-volume center treating 100 consecutive extended-window patients confirmed that these trial results translate to clinical practice: patients who fully met DAWN or DEFUSE-3 criteria achieved good outcomes in more than half of cases, comparable to the trial rates of 49% (DAWN) and 45% (DEFUSE-3)^[5]. What is also worth noting, the same dataset showed that patients with large established infarcts on baseline imaging, ASPECTS below 6 or more than one-third of the MCA territory involved, achieved no good outcomes at 3 months and had considerably more hemorrhagic complications^[5].

More recently, the Dutch MR-CLEAN LATE trial ($n = 502$) pushed the evidence further by using relatively simple collateral assessment on CT angiography, rather than full perfusion imaging, to select patients in the 6-to-24-hour window. The adjusted OR for

90-day favorable mRS was 1.68 (95% CI 1.21-2.33), suggesting that even simplified imaging criteria can safely identify late-window candidates^[4]. At the very frontier, preliminary case series have reported favorable outcomes (mRS 0-2 in 43% of patients) in 21 cases treated at a median of 48 hours after last known well time^[4], though these remain experimental findings and should not yet guide routine practice.

7.6 Special Populations

Patients with Large Ischemic Core. Patients presenting with extensive established infarcts, typically defined as ASPECTS below 6, ischemic core volume above 50 mL, or both, were deliberately excluded from the important 2015 MT trials. The concern was reasonable, reperfusion of large dead territories risks hemorrhagic transformation and may offer no functional gain if too little viable tissue remains. But excluding these patients also meant denying treatment to roughly one quarter of all LVO stroke patients. A wave of dedicated trials and a subsequent meta-analysis of six RCTs (1,665 patients, mostly ASPECTS 3-5) found that MT more than doubled the rate of functional independence in this population (RR 2.49; 95% CI 1.89-3.29) and significantly improved early neurological recovery (RR 2.22)^[11]. The hemorrhage was 1.73 times more frequent, but in most patients, the functional benefit outweighed it. For ASPECTS 0-2, the evidence remains too sparse to support routine MT outside research protocols.

Kerleroux et al. (2021) added an important qualification in their review of MT in volumetrically defined large-core patients: even when most patients did poorly, those who achieved successful reperfusion (TICI 2b-3) consistently had better odds of a functional outcome than those who did not^[15]. The quality of recanalization matters, even when the brain is badly injured.

Wake-Up Stroke and Unknown Onset. When a patient wakes up unable to speak or move one side of their body, the usual time-based calculations break down entirely, we know only that they were fine when they fell asleep. The extended-window meta-analysis showed that MT for wake-up stroke carries an odds rate of 8.74 for functional independence ($p < 0.00001$), the largest subgroup effect reported anywhere in the literature^[2]. This finding is now reflected in guidelines, advanced DWI-MRI or CT perfusion imaging should replace elapsed time as the selection tool for patients with unknown symptom onset.

Basilar Artery Occlusion. Blockage of the basilar artery, which supplies the brainstem and cerebellum, is among the most lethal stroke variants, with mor-

tality exceeding 80% without recanalization. Despite its significance, the evidence for MT in posterior circulation stroke has been slower to develop than for anterior circulation. The multicenter retrospective study by Wu et al. (2022), drawing on data from eight comprehensive stroke centers, found comparable 90-day favorable outcomes with direct MT (34.4%) and bridging therapy (39.4%; $p = 0.361$) [13]. Dedicated randomized trials for basilar artery occlusion, notably BASICS and BEST, have produced conflicting results, likely because basilar artery occlusion is not a single entity but a spectrum ranging from massive brainstem infarction to much smaller occlusions. MT is generally pursued in these patients despite the evidence gaps, simply because the lack of alternatives.

Distal and Medium Vessel Occlusions. As techniques and devices have grown more refined, there is increasing interest in applying MT to M2, M3, and other more distal occlusions. These vessels are smaller, more tortuous, and more fragile, making catheter navigation harder. Evidence from a systematic review protocol registered in 2025 (PROSPERO) suggests that MT may improve functional independence in distal medium vessel occlusions without a significant increase in sICH^[16], but the definitive RCT data is not yet available.

7.7 Contraindications and Eligibility

One of MT practical advantages over IVT is that it bypasses many of the absolute restrictions that make systemic thrombolysis unsafe. Patients cannot receive IVT if they have intracranial hemorrhage on baseline CT, have had major surgery or significant head trauma in the past three months, are taking oral anticoagulants with an INR above 1.7 or recent direct oral anticoagulants, have blood pressure above 185/110 mmHg that cannot be controlled, have a platelet count below 100,000/ μ L, or have blood glucose below 50 or above 400 mg/dL. For all of these patients, who are not rare, MT may still be an option.

MT has its own eligibility requirements. Vascular imaging must confirm LVO, without CT angiography, the procedure cannot even begin, which is itself an access barrier in resource-limited settings. MT is generally not performed in patients with pre-stroke severe disability (mRS above 4) or when the ischemic core is too large to offer a realistic chance of meaningful recovery. Relative contraindications like extreme anatomical tortuosity, very advanced age, recent myocardial infarction, require case-by-case judgment. The treatment window is a definitive advantage, IVT must be administered within 4.5 hours, while MT can be offered within 6 hours as standard and up to 24 hours

for imaging-selected patients, meaning many patients who miss the IVT window can still receive effective treatment.

7.8 Access Disparities and Global Implementation

The MT-GLASS survey, the first global assessment of MT availability, conducted between November 2020 and February 2021 across 75 countries through the Mission Thrombectomy 2020+ network (887 respondents), found a median global MT access rate of just 2.79% of eligible patients^[10]. In high-income countries, the median was 21.56%. In low- and middle-income countries, it was 0.48%. This is a staggering gap that represents an 88% relative difference in the probability of receiving the most effective stroke treatment based entirely on where you were born^[10]. On multivariable analysis, the strongest predictors of better MT access were national income, the existence of prehospital LVO triage protocols, and the simple presence of trained operators and equipped centers. Cultural barriers to endovascular treatment were associated with at least 50% lower odds of MT access (OR 0.41; 95% CI 0.24-0.70).

The research gap mirrors the treatment gap. A focused systematic review of MT outcomes in low- and middle-income countries screened more than 8,000 publications and found only 15 eligible studies, all from just five countries, Egypt, India, Indonesia, Iran, and Vietnam^[21]. Collectively, these studies covered 1,112 patients. The other 77 low- and middle-income countries had no peer-reviewed MT outcomes data at all. This illustrates the absence of research infrastructure, equipment and trained clinical practitioners in low- and middle-income countries.

The toll of this gap is not abstract. An estimated 87% of all stroke-related deaths and 81% of stroke-related disability worldwide occur in LMICs^[21]. Africa in particular faces what researchers have described as „a challenging future” for MT implementation, main reasons being insufficient neuroimaging capacity, almost no trained clinical practitioners, weak stroke unit networks, inadequate emergency medical services, and, in some regions, cultural barriers to invasive procedures^[22].

Inequity is not confined to low-income countries. In the United States, where emergency medical treatment must be provided regardless of insurance under EMTALA, data from the National Inpatient Sample (2016-2018) showed that Black and Hispanic patients received MT at a rate 2.8 percentage points lower than White and non-Hispanic patients (7.0% vs. 9.8%), with a 7.8% utilization gap among those presenting

with MCA or basilar artery occlusion specifically^[23]. Rural patients face additional disadvantages tied to geography, travel time, and the complex logistics of deciding whether to take a patient directly to a thrombectomy center or to the nearest hospital for IVT before transfer. These disparities exist not without reason, they are the predictable product of structural inequities in healthcare access, stroke recognition, and pre-hospital systems.

To start measuring and addressing these gaps systematically, an international expert panel recently developed the Mechanical Thrombectomy Access Score (MTAS), a 12-attribute tool, derived through modified Delphi consensus, that scores a country or region on key dimensions of MT access and provides a framework for tracking progress over time^[24].

7.9 Cost-Effectiveness

Given the intensity of resources MT requires - a catheterization unit, a trained interventionalist, specialized devices, and an experienced stroke team, it is fair to ask whether the expense is justified. The evidence says, consistently and across multiple countries that it is justified.

A systematic review of the socioeconomic literature on MT found a mean ICER of USD 14,242 per QALY across all included cost-utility analyses^[17], well under the USD 50,000/QALY threshold commonly used to define „good value” in the United States. The earliest rigorous Markov model analysis found that MT gained 0.54 additional QALYs at an additional cost of only USD 6,600 per patient, yielding an ICER of USD 12,120/QALY^[18]. The implication is that MT is not just clinically effective, it actually reduces the downstream costs of caring for severely disabled patients. It remained cost-effective for nearly all age groups, with the analysis flagging borderline cost-effectiveness only in patients over 82 (ICER USD 50,000-100,000/QALY)^[18].

In Canada, a health technology assessment modeling MT plus IVT versus IVT alone found an ICER of CAD 11,990/QALY over a 5-year horizon, with 89.7% probability of cost-effectiveness at the CAD 50,000/QALY threshold^[19]. In the late time window specifically, an analysis based on DAWN and DEFUSE-3 trial data found ICERs as low as USD 662/QALY under the DAWN model and USD 13,877/QALY under the DEFUSE-3 model, with MT being dominant (saving money while improving outcomes) in 44% of patient subgroups^[20].

This pattern highlights a genuine challenge in LMIC settings: the economic case for MT is strongest over the long term, but healthcare systems under fi-

nancial pressure may struggle to make large upfront investments in catheterization infrastructure on the promise of long-run savings. Closing this financing gap is as important a policy problem as closing the access gap itself.

Discussion

When you step back from the individual studies and look at the body of evidence as a whole, what is striking is not how much the data vary, it is how consistent they are. Across meta-analyses conducted in different continents, using different device generations, enrolling patients through different imaging criteria, the treatment effect of MT on 90-day functional independence points in the same direction, with RRs clustering between 1.45 and 1.65 and odds ratios around 2 to 2.5. That kind of consistency, across heterogeneous populations and methodologies, is as close to certainty as clinical medicine gets^[1, 3].

What the Data Actually Tells Us About Safety.

The finding that MT does not significantly increase sICH in appropriately selected patients is one of the most important conclusions in the literature. It challenges the conclusion that mechanically manipulating an ischemic cerebral vessel carries a high hemorrhagic risk. For standard-indication patients, it does not, however hemorrhagic risk is elevated in patients with large established infarcts^[11], which is why careful imaging assessment before MT is a required part of protecting patients. The consistency across aspiration based and stent retrievers based, of which both produce similar sICH rates^[9], gives clinicians flexibility to use the technique best suited to each patient's anatomy, without taking the risk that one choice is safer than the other.

The Bridging Therapy Question in Context. The conclusion that direct MT is non-inferior to bridging IVT plus MT is one of the most clinically impactful findings of the past five years, but it needs careful contextualization. All six of the non-inferiority trials that reached this conclusion were conducted at centers with very short door-to-device times, places where MT can begin within minutes of CT angiography confirming LVO. In these circumstances, the 20-30 minutes that IVT administration adds to the process, can be detrimental to patients health, and IVT's limited efficacy against large proximal thrombi means additional potential risks, and does not justify that delay. But this is emphatically not an argument for universal abandonment of bridging therapy. In settings where MT initiation takes longer like in small-

er hospitals, transfer situations, centers still building their programs, IVT may buy important time. In 2022 ESO-ESMINT guidelines stated; maintain IVT as the standard for eligible patients unless the specific context makes it counterproductive, which was the right balance^[6, 7].

The Time Window Revolution and Its Unfinished Business. The shift from a time-based to a tissue-based selection paradigm is arguably the single most revolutionary development in stroke care since 2015. By recognizing that the ischemic penumbra contracts at different rates in different patients, depending on collateral circulation, clot characteristics, baseline physiology, and probably factors we have not yet identified, the DAWN and DEFUSE-3 investigators reframed the entire clinical problem^[4]. The question is no longer „how long ago did this happen?“ but „how much viable brain is still at stake?“ The new question is clinically more accurate and scientifically more accurate. It also has a practical consequence; up to 40% more AIS patients may be eligible for MT under tissue-based criteria than under the old 6-hour clock alone^[4].

The challenge is that acting on this insight requires advanced perfusion CT or DWI-MRI, technology that is expensive, requires trained radiologists to interpret, and is frequently unavailable in rural hospitals, smaller centers, and most LMIC facilities. The MR-CLEAN LATE trial's suggests that simpler collateral assessment on standard CTA may be sufficient for late-window selection, and if confirmed in larger populations, it could simplify the extended window selection without requiring perfusion imaging infrastructure in LMIC.

Technology, First-Pass Rates, and What They Mean. The improvement in MT outcomes over the past decade is not only attributed to better trial design and patient selection. Modern thrombectomy devices achieve TICI 2b-3 recanalization in 76-97% of procedures, compared with 30-44% for the earliest generation of mechanical retrievers^[8, 9]. The concept of the first-pass effect, achieving complete or near-complete reperfusion in a single device deployment, has emerged as a quality metric. Patients who achieve TICI 2c or 3 on the first pass have consistently better functional outcomes and lower resource utilization than those who require multiple attempts^[8, 9]. Whether the approach used is aspiration-first, stent-retriever-first, or a combined technique depends on vessel anatomy, clot characteristics, and the operator's experience; what matters most is getting to good reperfusion quickly.

Where Guidelines Stand, and Where They Need to Go. The findings of this review are broadly con-

sistent with current AHA/ASA and ESO-ESMINT guidelines recommending MT within 6 hours for standard candidates and within 24 hours for DAWN/DEFUSE-3-eligible patients. The emerging evidence on large-core stroke and distal vessel occlusions is beginning to appear in 2023-2024 guideline updates, reflecting a field that is still actively evolving. Several important gaps, however, have not yet been adequately addressed by guidelines or trials. We do not have reliable RCT data on MT for ASPECTS 0-2 patients. The question of tenecteplase versus alteplase as the IVT agent in bridging therapy remains unresolved (being studied in BRIDGE TNK and related trials). MT for truly distal occlusions awaits definitive randomized evidence. And perhaps most importantly, nearly all of the data underpinning current guidelines comes from high-income country populations, the transferability to LMIC settings, where patient profiles, time-to-treatment, and imaging availability differ substantially, is essentially untested^[21].

The Access Crisis Cannot Be Solved by Clinical Evidence Alone. The most troubling finding synthesized in this review is not clinical, it is the 88% gap in MT access between high-income and low-income countries^[10]. Every number reported in this article about functional independence, mortality, and cost-effectiveness is essentially inaccessible to the majority of stroke patients on earth. Understanding that MT is cost-effective in a Markov model is cold comfort when the catheterization unit does not exist, when there is no trained neurointerventionalist within 500 kilometers, when there is no functioning emergency medical system to transport patients in time, and when treatment costs must be paid out of pocket. The solutions to this crisis are not primarily clinical, they are structural, financial, and political. They require national stroke plans, government-funded catheterization units at regional hospitals, telemedicine links to remote rural populations, training programs that build local expertise rather than dependency on visiting specialists from abroad, and inclusion of MT in universal health coverage packages so that the out-of-pocket cost does not determine who receives life-changing treatment^[23, 25]. The Mechanical Thrombectomy Access Score provides a useful starting framework for measuring progress^[24], but measurement alone does not create change.

The limitations of this review itself deserve acknowledgment. We restricted our search to freely accessible articles, which likely introduces selection bias toward English-language, high-income-country publications, the same skew that characterizes the MT literature as a whole. We performed a narrative synthe-

sis rather than a formal meta-analysis, so we cannot offer our own pooled estimates; instead, we report the numbers as the original authors calculated them. And the evidence base continues to evolve rapidly enough that some conclusions here may be outdated by data published between the time of writing and the time of reading.

Conclusions

Mechanical thrombectomy is the most effective treatment for acute ischemic stroke caused by large vessel occlusion. MT almost doubles the rate of functional independence at 90 days, significantly reduces mortality rate, and does not effectively increase hemorrhagic risk in appropriately selected patients. The debate about bridging therapy has been concluded for fast-moving centers within which direct MT is equally effective, and skipping IVT saves time. The treatment window is now understood as a tissue left to save question rather than a time question, and advanced imaging can identify patients who are good candidates, up to 24 hours after the stroke. MT is cost-effective in every healthcare system that has been studied, saving money over the long term, by preventing years of severe disability that requires full-time care.

All of the statistics are irrelevant, if worldwide only 3 in 100 eligible patients receive MT, and in low- and middle-income countries, the ratio is below 1 in 200, where stroke mortality is significantly higher. Extending availability and closing that gap between regions should be the main mission of stroke units worldwide.

The clinical evidence is robust, the technology works and the economics are favorable. What is left is the political will and financial commitment to build the infrastructure, train clinical practitioners, and change of the systems that determines who gets treated.

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