

Mechanical Thrombectomy in Acute Ischemic Stroke: Effectiveness, Service Gaps, and Efforts to Optimize Access

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KEYWORDS

Ischemic stroke, Thrombectomy, Management, Effectiveness, Service access

ABSTRACT

Ischemic stroke is a global health burden, including in Indonesia, where the incidence and prevalence are very high. Although the treatment of ischemic stroke has advanced, *mechanical thrombectomy* is becoming a significant interventional procedure. This research aims to review the effectiveness, safety, and challenges of implementing *mechanical thrombectomy* in real clinical practice, as well as to analyze the factors influencing treatment outcomes. The literature review was conducted using a narrative approach, with articles selected from PubMed published between 2020–2025 in English, discussing *thrombectomy* in *acute ischemic stroke*, and available in full text. Articles not meeting these criteria, including those published before 2020, case reports, and literature reviews, were excluded. Of 1,171 articles, five met the criteria for analysis. *Mechanical thrombectomy* demonstrates high effectiveness with high *recanalization* rates, often surpassing those reported in clinical trials. However, these technical advances do not always correlate with improved patient quality of life due to changes in patient profiles, such as older age, moderate vascular occlusion, and delayed treatment. While the procedure is relatively safe, expanding patient criteria and systemic factors may increase the risk of mortality. Key challenges include limited access, lack of expertise, diagnostic barriers, financial constraints, and service gaps. *Mechanical thrombectomy* is an effective treatment for ischemic stroke, significantly improving *recanalization* rates. Long-term outcomes depend on factors such as treatment timeliness, case complexity, and patient age. To optimize benefits, improving workflows, expanding access to services, and tailoring treatment strategies to individual patient conditions are essential.

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INTRODUCTION

In 2020, the global prevalence of all types of stroke reached 89.13 million cases. Of these, ischemic stroke accounted for 68.16 million cases, while intracerebral hemorrhage and subarachnoid hemorrhage accounted for 18.88 million and 8.09 million cases, respectively. The global incidence of stroke was recorded at 11.71 million people, with ischemic stroke accounting for about 65% of cases, while intracerebral hemorrhage and subarachnoid hemorrhage accounted for 29% and 6%, respectively. The death toll due to stroke reached 7.08 million people, consisting of 3.48 million due to ischemic stroke, 3.25 million due to intracerebral hemorrhage, and 0.35 million due to subarachnoid hemorrhage (Capirossi, 2023).

The burden of this disease is clearly seen in Asia, including Indonesia, where ischemic stroke is the most common type, accounting for 80–85% of cases (Pandian et al., 2023; Pepito

Mechanical Thrombectomy in Acute Ischemic Stroke: Effectiveness, Service Gaps, and Efforts to Optimize Access

& Collaborators, 2025; Rashid & Hossain, 2022; Widyasari et al., 2023; Zhang et al., 2023). Global Burden of Disease data from 2019 show that Indonesia has a very high stroke rate, with an incidence of 293.3 per 100,000 population, or around 642,943 new cases per year, as well as a prevalence of up to 4.9 million cases. Stroke causes 331,349 deaths and the loss of 8.4 million Disability-Adjusted Life Years (DALYs), the highest in Southeast Asia. Multicenter studies have also reported that 67.1% of stroke cases in Indonesia were ischemic, which is closely related to the prevalence of hypertension, diets high in salt and saturated fats, and limited rehabilitation services (Pandian et al., 2023).

The magnitude of this stroke burden prompted the search for effective therapies, even though for centuries clinicians had no meaningful treatment options (Broderick, 2026; Fan et al., 2023; Feigin et al., 2023; Popiela et al., 2022). It was not until the end of the 20th century that significant progress was made with the control of risk factors that reduced stroke recurrence, as evidenced by the Antiplatelet Trialists' Collaboration (1988) and the SALT trials. At the same time, the development of stroke units and rehabilitation programs has been proven to improve patient survival rates and quality of life. Over time, the field of interventional neuroradiology expanded by enabling the direct delivery of thrombolytic drugs to the site of the blockage. The placement of a catheter directly at the site of obstruction subsequently led to the development of a mechanical treatment technique, namely mechanical thrombectomy (Wasselius et al., 2022). Acute ischemic stroke caused by large-vessel occlusion can be effectively treated with mechanical thrombectomy, an innovative therapy that has been shown to be superior to intravenous thrombolysis in appropriately selected patients (Raha et al., 2023).

Mechanical thrombectomy is a minimally invasive endovascular procedure for cerebral vascular recanalization in acute ischemic stroke by extracting large-vessel thrombi using specialized devices (e.g., stent retrievers or aspiration catheters) inserted through arterial access. The goal is to restore cerebral perfusion rapidly to minimize permanent neurological deficits (Zhang et al., 2025). Reperfusion from this intervention can be assessed using the Thrombolysis in Cerebral Infarction (TICI) scale, which ranges from 0 to 3. TICI 1 indicates minimal penetration with minimal perfusion, meaning thrombolytic agents or blood flow only penetrate the thrombus with little or no distal perfusion in brain tissue. TICI 2 describes partial perfusion with distal vessel filling. This category is divided into TICI 2a and TICI 2b: TICI 2a indicates reperfusion of less than 50% of the affected vascular territory, while TICI 2b indicates reperfusion of 50% or more of the affected territory but not complete perfusion. TICI 3 represents the optimal outcome of a thrombectomy procedure, characterized by full and rapid reperfusion of all affected vessels, comparable to normal cerebral blood flow (Kowalczevska et al., 2025). Acute ischemic stroke has a critical time window (the "golden period") covering the first 4.5 hours for systemic thrombolytic therapy, which significantly affects prognosis. For mechanical thrombectomy, although the optimal treatment period is ≤ 6 hours, the time window may be extended to 24 hours in patients who meet selective imaging criteria demonstrating a viable penumbra, with the best clinical outcomes achieved through recanalization as early as possible (ideally ≤ 180 minutes) (ESOC, 2025). The penumbra criterion is a quantitative measure based on perfusion mismatch that indicates the presence of salvageable tissue, provided that the ischemic core volume is small (generally < 70 mL) and there is a large

mismatch ratio (penumbra/core volume, generally ≥ 1.8), along with a significant absolute penumbra volume (generally ≥ 10 – 15 mL) (Chen et al., 2025).

Nonetheless, the main obstacle to the implementation of mechanical thrombectomy is limited geographical access to endovascular centers, which is exacerbated by a shortage of trained neurointerventional specialists. In addition, diagnostic constraints, such as the lack of routine vascular imaging and the presentation of atypical cases, often lead to delays, while financial barriers and access disparities among minority populations and uninsured patients further limit equitable implementation (Aroor et al., 2022). Finally, inefficiencies in hospital workflows, reflected by prolonged door-to-reperfusion times, hinder the optimization of the golden period for stroke treatment (Riegler et al., 2025).

This study aims to discuss thrombectomy as one of the therapeutic options for ischemic stroke to provide a more comprehensive understanding of this management strategy. The study offers insights into the effectiveness and challenges of mechanical thrombectomy in acute ischemic stroke. Its primary benefit is to support the development of strategies to improve access, particularly in areas with limited medical facilities, as well as to tailor treatment approaches according to patient conditions. This research is also expected to contribute to the development of health policies, the training of medical personnel, and the broader understanding of ischemic stroke management.

METHOD

The method used in this study was a literature review with a narrative review approach. The literature search was conducted through the PubMed database using the following inclusion criteria: English-language publications, articles published between 2020 and 2025, studies discussing thrombectomy in acute ischemic stroke, and articles available in full-text format. Irrelevant articles, those published before 2020, and those in the form of case reports or literature reviews were excluded. Of the 1,171 articles identified, five articles met the eligibility criteria and were selected for analysis.

The data obtained were then analyzed using descriptive analysis to provide an overview of the findings from the existing research. This analytical technique included the calculation of frequencies, percentages, and other descriptive statistics to present the distribution of findings from the selected articles. The results from the selected articles were subsequently compiled in the form of a table to facilitate comparison and interpretation of conclusions.

RESULTS AND DISCUSSIONS

This study uses the literature review method with a narrative review approach through data collection, analysis, and problem solving based on literature review. Literature sources were obtained from searching journals through PubMed. To facilitate the screening process, the researcher established inclusion and exclusion criteria. Inclusion criteria include English-language publications, 2020–2025 publication year, discussing thrombectomy in acute ischemic stroke, and available in full text form. Meanwhile, the exclusion criteria are articles that do not discuss thrombectomy in acute ischemic stroke, published before 2020, as well as literature review articles and case reports.

Mechanical Thrombectomy in Acute Ischemic Stroke: Effectiveness, Service Gaps, and Efforts to Optimize Access

Search on PubMed using the keywords "thrombectomy", "ischaemic stroke", and "mechanical thrombectomy". From the search results, 1171 articles were obtained, then filtered based on the availability of free full text, type of article (Clinical Trial, Meta-Analysis, Randomized Controlled Trial, Systematic Review), and the year of publication 2020–2025, so that there are 50 articles left.

Furthermore, screening was carried out by reading the title and abstract according to the inclusion and exclusion criteria, and 5 articles were selected to be used as sources for this research library. The next stage is to analyze and summarize the findings of the selected articles in the form of a table, then draw conclusions based on the formulation of the problem, this research is focused on answering the following two main questions:

1. Does mechanical thrombectomy provide comparable or better effectiveness and safety than clinical trial results and what factors may affect acute ischemic stroke patients in real clinical practice?
2. What are the key challenges in the implementation of mechanical thrombectomy and how are effective strategies to expand access to services evenly across different levels of healthcare facilities?

Table 1. Results of the literature review used

Author & Year	Journal	Location	Study Design	Key Results
Kristoffersen ES, Seiffge DJ, Meinel TR (2025)	Journal of Neurology	International (Europe, America)	Narrative Review	Intravenous Thrombolysis (IVT) and Mechanical Thrombectomy (MT) are safe in selected patients with a history of Direct Oral Anticoagulant (DOAC) in the last 48 hours. An individual risk–benefit assessment approach is needed.
Money O, Hall C, Malik A, et al. (2023)	BMJMED	International	Narrative Review	Mechanical Thrombectomy (MT) has a number needed to treat (NNT) of 2.6. There have been significant improvements in extended time window (6–24 hours), direct MT, and basilar thrombectomy.
Riegler C, Rucker V, von Renneberg R, et al. (2025)	Frontiers in Neurology	Germany (8 centers)	Prospective cohort	The 2017–2021 period showed older MT patients, lower NIHSS, and more Medium Vessel Occlusion (MeVO). Functional outcomes deteriorate even as the rate of recanalization increases.

Mechanical Thrombectomy in Acute Ischemic Stroke: Effectiveness, Service Gaps, and Efforts to Optimize Access

Rai AT, Link PS, Domico JR (2023)	Journal of Neurointerventional Surgery	United States	Population-based analysis	There are 718,191 acute ischemic stroke patients per year. MT was performed in 5% of the entire AIS and 27% of patients with vascular occlusion, with slowed growth of MT action.
Aroor SR, Asif KS, Potter-Vig J, et al. (2022)	Journal of Stroke	United States	Narrative Review	There are three main barriers to MT access, namely information/diagnostic, physical/geographical, and financial. A comprehensive strategy is needed to improve access.

Source: Data collected from selected articles according to the established inclusion criteria (2022-2025)

A. Effectiveness and safety of mechanical thrombectomy in clinical practice compared to evidence from clinical trials, and factors influencing patient outcomes

1. Comparison of Clinical Trial Results and Clinical Practice

Clinical practice data show that mechanical thrombectomy remains effective and in line with the results of controlled clinical trials, although there are some differences. Raha et al. (2023) reported a recanalization success rate of 71% in the Highly Effective Reperfusion evaluated in Multiple Endovascular Stroke trials (HERMES), while clinical practice data varied between 75–88% depending on the patient profile and hospital facility. A German Stroke Registry study by Riegler et al. (2025) noted an increase in successful recanalization from 83.9% in 2017 to 85.5% in 2021, with full recanalization rising from 46.7% to 54.2%, meaning that field results can match or exceed clinical trial findings.

2. The Gap Between Technical Success and Improved Quality of Life Achievement

Technicalities are not always directly proportional to the improvement of the patient's quality of life. Riegler et al. (2025) found that although patients now come with relatively milder strokes (the median National Institutes of Health Stroke Scale (NIHSS) dropped from 15 to 13), the proportion who achieved good quality of life (modified Ranking Scale (mRS) ≤ 2) actually decreased from 36.0% to 34.9% in the 2017–2021 period. This figure is lower than the HERMES meta-analysis which reported 46% of patients with good outcomes, compared to 26.5% in the control group (Raha et al., 2023). This confirms that factors beyond the success of recanalization participate in determining the improvement of quality of life patient.

3. Bleeding Risk and Increasing Mortality Trends

From a safety perspective, mechanical thrombectomy in clinical practice is generally consistent with clinical trial data, although there are variations according to patient characteristics. Kristoffersen et al. (2025) noted that intracranial hemorrhage in patients using Direct Oral Anticoagulant (DOAC) is in the range of 2.5–4.8%, a figure that is still considered reasonable. However, Riegler et al. (2025) reported an increase in mortality in hospitalization from 14.1% to 20.8% and 3-month mortality from 25.3% to 34.7% throughout 2017–2021. This

Mechanical Thrombectomy in Acute Ischemic Stroke: Effectiveness, Service Gaps, and Efforts to Optimize Access

suggests that although the procedure is relatively safe, the long-term outcomes are influenced by broader systemic factors.

4. The Impact of Expanding Patient Criteria (Samples) in Clinical Practice

The expansion of patient criteria in clinical practice also affects outcomes. Riegler et al. (2025) reported an increase in the median age of patients, an increase in medium vessel occlusion (MeVO) cases from 16.1% to 28.1%, as well as more patients treated past 6 hours after onset (22.0% to 28.3%). Rai et al. (2023) estimated that only 27% of patients with large and moderate occlusion eventually received thrombectomy, indicating an opportunity to expand thrombectomy services. Changes in indications (older age, onset >6 hours, MeVO) made the quality of life of post-stroke patients lower than in clinical trials, because the patients treated were more diverse and complex.

5. Accessibility Challenges and Service Gaps

Another challenge is in service access and gaps. Aroor et al. (2022) reported that only 49.6% of the United States population can reach an endovascular center in 60 minutes, while there is a racial gap, with the therapeutic rate being 2.8% lower in black/Hispanic patients than in whites. Rai et al. (2023) also noted a slowdown in the growth of thrombectomy procedures, from a 24% compound annual growth rate to just 4–9% in recent years, signaling that the market is starting to saturate and the need for new strategies to expand access.

6. A More Comprehensive Approach

Overall, clinical practice data show that mechanical thrombectomy remains effective and fairly safe, but to improve good outcomes requires a broader approach. Kristoffersen et al. (2025) emphasize the importance of individualized risk-benefit assessments, especially in patients with special conditions such as anticoagulant users. According to Raha et al. (2023), thrombectomy needs to be supported by technological innovation and the expansion of scientific-based indications, including in MeVO and large core stroke. The greatest benefits can be achieved when the diagnosis is faster, the treatment flow is shorter, the access to services is more even, and therapy is tailored to the patient's character.

B. The main challenges in the implementation of mechanical thrombectomy and strategies to overcome them.

After discussing the effectiveness and safety of mechanical thrombectomy, the following sections review the various implementation challenges and strategies for improving service access.

1. Geographical Access Barriers and Service Coverage Improvement Efforts

Geographic access is still a major obstacle in the implementation of mechanical thrombectomy. Aroor et al. (2022) reported that about one-third of the United States population lives within a 60-minute drive to an endovascular service center, with 27.3% of patients having to go through an interhospital referral. Only 49.6% of the population can reach an Endovascular Treatment (EVT) facility within 60 minutes by ground transportation. The suggested efforts include increasing the number of EVT service centers, implementing a "bypass" model so that patients are taken directly to a comprehensive stroke center, and strengthening the referral system with better referral protocols.

2. Limitations of Experts and Human Resource Development Strategies

The limitation of experts is a complication. Aroor et al. (2022) highlight the lack of neuro-intervention training positions, and without an increase in the number of elective procedures, the availability of these neuro-interventions will not increase much. The proposed improvement options include expanding the training program, opening access to training for vascular neurologists who also treat non-Large Vessel Occlusion (LVO) patients, as well as the use of robotic surgery to reach areas with limited resources.

3. Diagnostic Challenges and Utilization of Technology for Early Detection

Diagnostic constraints. Aroor et al. (2022) emphasized that atypical presentations, such as basilar artery occlusion, are often missed, while vascular imaging has not been routinely performed in many hospitals. Raha et al. (2023) reported an increase in the use of CT perfusion from 40.9% to 59.1% in 2017–2021. Suggested strategies include a Computed Tomography Angiography (CTA) protocol for all stroke patients within 24 hours, the use of artificial intelligence (AI) for rapid detection of LVO, as well as training emergency responders using the LVO recognition scale.

4. Financial Constraints and Financing System

Financial barriers are not immediately felt by patients in the United States because of the Emergency Medical Treatment and Labor Act (EMTALA) guarantees, but concerns about reimbursement often make hospitals not develop intervention services. Aroor et al. (2022) noted that more than three-quarters of health financing in developing countries is still borne by patients directly. Proposed improvements include increased government financing support, system-based cost-effectiveness analysis, and the use of more cost-effective techniques such as aspiration.

5. Access Gaps Based on Patient Background

Access to health facilities is still uneven. Aroor et al. (2022) showed that black/Hispanic patients, which were 7%, received thrombectomy, which was 2.8% lower than white patients, which was 9%. Uninsured patients are also less likely to get an action. Proposed strategies in the form of health promotion include stroke education for minority communities, increased use of renewable emergency facilities in hard-to-reach areas, and reducing clinical bias in LVO diagnosis.

6. Shifting Patient Characteristics and Their Implications for Research and Practice

There is a change in the determination of the research sample. Riegler et al. (2025) reported changes in the criteria for patient samples between 2017–2021: the median age increased from 76 to 77 years, the NIHSS score dropped from 15 to 13, and the proportion of moderate vascular occlusion increased from 16.1% to 28.1%. Kristoffersen et al. (2025) reviewed the controversy related to the safety of Intravenous Thrombolysis (IVT) in patients who have recently taken DOAC. Improvements are focused on risk assessments tailored to each patient's condition, conducting research to see possible new indications, and creating uniform selection criteria so that they are consistent in all service centers.

Mechanical Thrombectomy in Acute Ischemic Stroke: Effectiveness, Service Gaps, and Efforts to Optimize Access

7. Hospital Workflow Inefficiencies and the Importance of Optimizing Optimization Time

Workflow in hospitals. Riegler et al. (2025) noted increased door-to-groin puncture (64 to 71 minutes) and groin-to-reperfusion (41 to 45 minutes) times. Rai et al. (2023) emphasized that every 10-minute delay in repatriation can reduce the disability-free life expectancy by up to 40 days. Improvement strategies include the implementation of direct-to-angiography protocols, efficiency of anesthesia flows, and the use of mobile stroke units.

8. Slowing Growth of Long-Term Procedures and Strategies

Thrombectomy growth also shows a slowdown. Rai et al. (2023) recorded a combined annual growth rate of 24% in 2015–2021, but it tends to slope after 2018. Currently, mechanical thrombectomy procedures account for 5% of all acute ischemic strokes, 27% of all vascular occlusions. The increase in the number of mechanical thrombectomy procedures in the future is expected to continue to rise, but the rate of increase is lower than when it first appeared. The increase is projected to be around 5 to 10% every year. To maintain it, the suggested strategies include a focus on the elderly population, expansion of indications to distal and medium vessel occlusion, improvement of early detection methods, workflow efficiency, as well as the development of neuroprotective therapies.

CONCLUSION

Based on the analysis of five journals included in this literature review, mechanical thrombectomy was found to be effective in increasing recanalization rates and moderately improving the quality of life of patients with acute ischemic stroke. The degree of improvement was influenced by several factors, including patient age, the timeliness of intervention, and case complexity. These findings suggest that mechanical thrombectomy has strong potential to serve as a primary therapy in the management of acute ischemic stroke when supported by appropriate technology, efficient clinical workflows, and equitable access to endovascular services. Therefore, institutions such as YARSI University are encouraged to promote further research on mechanical thrombectomy in ischemic stroke management, supported by enhanced training for healthcare professionals, increased availability of neurointerventional specialists, and improved early diagnostic capabilities. Future research should involve larger patient populations, multicenter studies, and investigations into workflow optimization and access disparities to further strengthen the evidence base and improve the effectiveness and accessibility of mechanical thrombectomy in clinical practice.

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M. Usama Royhul Azhar*, Karina Dewi, Mery Krismanto

Mechanical Thrombectomy in Acute Ischemic Stroke: Effectiveness, Service Gaps, and Efforts to Optimize Access

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