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REVIEW

# Current status of mechanical thrombectomy for acute stroke treatment

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**Summary** Acute ischemic stroke is a morbid and disabling medical condition with a significant social and economic impact throughout the world. Intravenous thrombolysis (IVT) has been the first line treatment for patients presenting up to 4.5 hours after symptom onset for many years. Endovascular stroke treatment has been used successfully as rescue therapy after failed IVT; in patients with contraindications to rtPA or presenting outside the 4.5-hour window. The effectiveness of IVT is high for distal thrombi but significantly lower for proximal occlusions. Endovascular treatment has been revolutionized by the evolution from intra-arterial thrombolysis and first generation mechanical devices to the current generation of stent retrievers and aspiration systems with large bore catheters. These devices have been associated with excellent revascularization, improved clinical outcomes, shorter procedure times and reduced device and procedure related complications. We report the current literature, clinical standards and perspectives on mechanical thrombectomy in acute ischemic stroke.


## Introduction

Acute ischemic stroke (AIS) accounts for the highest morbidity and mortality in the aged population worldwide and is an important social and economic issue for the public health system [1,2]. AIS treatment has a potential to reverse presenting neurological deficits and improve patient's outcome [1,3]. Its success is dependent on time and therefore requires a well-developed management strategy within local organizations [5—8].

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**Table 1** Mechanical thrombectomy results with the new generation devices on recent multicenter studies.

| | Retrospective | SWIFT (Rand SFR group only) | TREVO | TREVO 2 (Rand Trevo group only) | ADAPT FAST | STAR |
|---|---|---|---|---|---|---|
| *n* | 141 | 58 | 60 | 88 | 100 | 202 |
| Age | 66.3 ± 13.1 | 67.1 ± 12.0 | 65 (median) | 67.4 ± 13.9 | 66 ± 15.7 | 68.4 ± 12.5 |
| Male | 56% (79/141) | 48% (28) | 45% | 45% | 54% | 40% |
| Baseline NIHSS, median | 18 | 18 | 18 | 19 | 17.2 | 17 |
| % ICA occlusions | 28% | 21% | 21.7% | 16% | 23% | 18% |
| % VBA occlusions | 11% | 1.7% | 8.3% | 8% | 5% | N/A |
| Successful recanalization | 85% (TICI ≥ 2b) | 68.5% (TIMI ≥ 2) 75.9% (TICI ≥ 2b) | 78.3% (TICI ≥ 2a) | 86% (mTICI ≥ 2) | 78% (TICI 2b/3) | 84.2% (160/190) or 79.2% (160/202) (TICI ≥ 2b) |
| mRS ≤ 2 at 3 months | 55% (77/141) | 36.4% (20/55) | 55.0% | 40% | 40% | 57.9% (117/202) |
| Mortality at 3 months | 20% (20/141) | 17.2% (10/58) | 20% | 33% | 20 | 6.9% (14/202) |
| Symptomatic ICH at 24 hours | 4% (5/141) | 1.7% (1/58) | 5% (3/60) | 7% | 0 | 1.5% (3/202) |

AIS treatment became widespread in the nineties with the introduction of IV thrombolysis (IVT) [1]. It was shown to be an intuitive and simple treatment option requiring an appropriately trained team but no exceedingly sophisticated medical infrastructure [1,9,10]. The efficacy of IVT has been shown to be greatest for distal occlusions and the approved time window is restricted to 4.5 hours [11].

Endovascular treatment for acute stroke commenced with intra-arterial thrombolysis that was shown to be superior compared to placebo up to 3 hours after stroke symptoms in the PROACT II study [12]. This approach consisted of navigation of a micro catheter to the occluded vessel and local injection of alteplase (rtPA) or urokinase. This method extended the therapeutic window but was still limited to patients with no contraindications to thrombolytics. This was followed by the introduction of mechanical thrombectomy devices as rescue therapy [13] and subsequent introduction of the Merci (Concentric Medical, Mountain View, California), Phenox (Phenox, Bochum, Germany) and Catch (Balt, Montgomery, France) devices as well as the Penumbra aspiration system [14—16]. These devices were reported to improve recanalization rates up to 80% in some of the latest studies from experienced centers, however failed to demonstrate significant improvement in clinical outcomes [14—16]. Mechanical thrombectomy was then revolutionized by the advent of a new generation of devices based on intracranial stenting (Table 1) [3,7,17—19]. The Solitaire stent was the pioneer of this technology, however subsequently companies engineered devices using a similar concept leading to the development stent retrievers. The stent retrievers led to improved classifications of cerebral revascularization and established high standards with regards to procedure times and clinical outcome [7,20—24]. The improved results meant that other systems used for mechanical thrombectomy such as the aspiration system, had to improve the technology, namely the large bore catheters, to match the degrees of recanilization and reduced procedure times [25]. In this article, we review the current status of mechanical thrombectomy using the new generation devices.

## Brief history of mechanical thrombectomy

Mechanical thrombectomy started with use of a micro guidewire to macerate the thrombus inducing fragmentation and lysis. Although well recognized as a technique, there is no literature evaluating its efficacy as the sole method of treatment, however it is easy to imagine the degree of distal emboli and low recanalization rates related to this technique. Despite this, it was one of the main methods used on the Synthesis trial for thrombectomy [26]. The Merci (Concentric Medical, Mountain View, California) was the first device widely used [16]. It can be classified as a distal device since it cross the thrombus and recanalizes the vessels from distal to the occlusion. MERCI and MULTIMERCI studies reported recanalization results of 59 and 68% respectively in patients treated up to 8 h after the stroke onset harboring 7 and 5% complication rates and good clinical outcomes of 28 and 36% respectively [16,27]. Mortality rates were still quite high ranging from 34 to 44% probably related to poor patient selection and high rates of incomplete revascularization [28]. Other distal revascularisation technologies including Catch (Balt, Montgomery, France) and Phenox (Phenox, Bochum, Germany) devices followed and these demonstrated similar results to the MERCI device in single center series [13,14,29]. In parallel, techniques approaching the clot proximally started being used, becoming widespread with the introduction of the Penumbra aspiration system (Penumbra, Alameda, USA) [13,14,30]. Recanalization rates reached 80% with these aspiration techniques, however the clinical outcomes did not match. Good