

# A Technical Update in Mechanical Thrombectomy: Aspiration, Stent Retriever or Both?

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## Abstract

Recent large trials in endovascular thrombectomy have demonstrated significant benefit compared to thrombolysis alone in acute ischaemic stroke. Data comparing technical success and clinical success for various techniques is limited.

Though Stent retriever devices have been most commonly deployed in recent landmark thrombectomy trials, large bore intermediate catheters are increasingly used for direct aspiration of thrombi.

We review the literature regarding the main interventional techniques described.

Recanalization rates did not differ significantly in the first randomized study comparing aspiration with stent retriever thrombectomy.

Reported clinical outcomes appear similar for currently applied techniques though comparative studies with long term morbidity and mortality data are necessary.

Further research is required to ascertain complications rates and determine the most appropriate first line patient specific technique.

## Introduction

Improved patient outcomes have been demonstrated in five recent randomised controlled trials for patients undergoing endovascular thrombectomy when compared to standard care for the management of acute ischaemic strokes [1-5]. In most cases this is with second generation recanalization devices, primarily stent retrievers, as an adjunct to best medical management consisting of thrombolysis with intravenous (IV) alteplase [6].

Thrombectomy is recommended in non-invasive imaging confirmed large vessel intracranial occlusion (CT-A or MR-A). Further patient selection may exclude those with established large infarct cores. This may be determined on the initial non-contrast CT using the Alberta Stroke Program Early CT Score (ASPECTS) [1]. Alternatively, perfusion imaging may be performed to assess core infarct volume and the relative volume of infarct to the penumbra. Patients with a larger ischaemic core at baseline have poorer outcomes and are at increased risk of symptomatic intracerebral haemorrhage (sICH) [7].

A recent meta-analysis demonstrated that thrombectomy up to 7.3 hours after symptom onset was associated with improved outcomes [6]. In addition, delay in symptom-onset-reperfusion times were associated with increased levels of disability at 90 days. The European Stroke Organisation however currently recommends a 6 hour time window from onset of symptoms to reperfusion evidenced by the MR CLEAN [1] trial, which found treatment was not effective after 6 hours 19 minutes.

## Stent retriever

Stent retriever devices are fully recapturable and bonded to a delivery microwire [8]. The stents are deployed within the thrombus, prompting engagement before being retrieved into the associated guide catheter.

Successful revascularisation has generally been considered as restoration of flow to more than 50% of the involved brain territory at the end of the thrombectomy procedure [1]. This is quantified using the Treatment in Cerebral Ischaemia (TICI) scale as a score of 2b or 3. The success of revascularisation ranges between 59% (115/196 patients) in MR CLEAN [1] to 88% (73/83 patients) in SWIFT-PRIME [4]. There are a number of different devices available for thrombectomy, but stent retrievers (such as Solitaire FR) have demonstrated high revascularisation rates and an excellent safety profile [2-4,7].

**Table 1:** Summarised outcomes from five randomized controlled trials evaluating large vessel anterior intracranial circulation occlusions comparing endovascular thrombectomy with IV alteplase versus IV alteplase alone1-5.

| Study                    | Device  | Total Number of Patients | Successful recanalization to 2B or above | mRS 0-2 at 90 days: n (%) Thrombectomy vs control | Mortality at 90 days (thrombectomy vs control) |
|--------------------------|---|--------------------------|--|---|--|
| MR CLEAN <sup>1</sup>    | Any approved (82% stent retriever)                        | 500                      | 59% (115/196)                            | 33% vs 19%  | 21% vs 22%                                     |
| EXTEND-IA <sup>2</sup>   | Solitaire   | 70                       | 86% (25/29)                              | 71% vs 40%  | 9% vs 20%                                      |
| ESCAPE <sup>3</sup>      | Any approved (79% stent retriever of which 61% Solitaire) | 316                      | 72% (113/156)                            | 53% vs 40%  | 10% vs 19%                                     |
| SWIFT-PRIME <sup>4</sup> | Solitaire   | 196                      | 88% (73/83)                              | 60% vs 35%  | 9% vs 12%                                      |
| REVASCAT <sup>5</sup>    | Solitaire   | 206                      | 66% (67/102)                             | 44% vs 28%  | 18% vs 16%                                     |

The safety of stent-retriever thrombectomy is reassuring with no reported increase in symptomatic haemorrhage or mortality when compared to thrombolysis alone [7]. In MR CLEAN there was no difference in the incidence of adverse events between patients undergoing thrombectomy and those treated only with thrombolysis [1]. An acceptable rate of device-related non-serious events (8.4%) were reported in SWIFT-PRIME [4] which included mild or moderate episode of cerebral vasospasm, intraventricular haemorrhage, subarachnoid haemorrhage and subarachnoid contrast extravasation.

Trials detailed in Table 1 mostly use the modified Rankin Scale (mRS) score at 90 days as the primary clinical outcome measure of thrombectomy efficacy. They demonstrated a significant reduction in disability at 90 days in patients receiving thrombectomy combined with IV alteplase, versus IV alteplase alone [7]. The number needed to treat to achieve an additional patient with an independent functional outcome is in the range of 3.2-7.1 [7].

In a recent UK based cost-utility analysis, the cost of thrombolysis with IV alteplase is estimated to be £1214 when compared to mechanical thrombectomy at £8365 [9]. Despite the higher initial costs of mechanical thrombectomy, when combined with IV alteplase it leads to overall savings in stroke pathway when longterm medical

and social care is considered. This is reflected by improved outcomes and is estimated to save 1 life for every 14 thrombectomies performed [9].

## Aspiration

Most recent key trials have involved a stent retriever based approach. Evolution of the design of large bore intermediate catheters specifically designed for aspiration has yielded results comparable and sometimes superior to stent retriever trials [10-14]. Aside from direct aspiration, these flexible, atraumatic catheters can be used as conduits for further devices such as retrievable stents [10-15]. In "A Direct Aspiration First Pass Technique (ADAPT) [10] for thrombectomy", the aspiration catheter is guided over a microwire and reperfusion catheter to engage the thrombus. It is then connected to an aspiration pump or a syringe vacuum [13]. Lack of blood return at that point indicates that the clot is appropriately engaged, and return of flow suggest that the clot has been aspirated. The procedure can be repeated as multiple passes are often required [10]. In cases not successfully recanalized, a stent retriever can then be used [10,14].

The THERAPY trial [16] comparing aspiration after IV alteplase compared to aspiration alone was halted early feeling it

**Table 2:** Summarised outcomes from aspiration thrombectomy studies. \*no separate figures quoted, #at discharge rather than 3 months, (NQ: Not quoted).

| Study       | Technique                          | Total Number of Patients | Anterior/posterior (%/%) | Successful recanalization to 2B or above: n (%) | Average time to recanalization in minutes | MRs 0-2 at 90 days: % | Mortality at 90 days: n (%) |
|-------------|------------------------------------|--------------------------|--------------------------|---|---|-----------------------|-----------------------------|
| Vargas [10] | Aspiration                         | 145                      | 89.5/10.5                | 141 (97.2)                                      | 30.1                                      | 57.7                  | 13.9                        |
|             | Rescue                             | 43                       |                          | 36 (83.7)                                       | 61.4                                      | 43.2                  | 18.2                        |
|             | p                                  |                          |                          | NQ  | 0.00000201                                | 0.12                  | 0.47                        |
| Comai [11]  | Aspiration                         | 11                       | 81/19                    | 10 (90.9)                                       | 47  | 64.6                  | 27.2                        |
|             | Rescue                             | 5                        |                          | 4 (80)  | 115                                       | 40                    | 20                          |
|             | p                                  |                          |                          | NQ  | NQ  | NQ                    | NQ                          |
| Minami [12] | Aspiration                         | 22                       | 97.7/2.3                 | 16 (72.7)                                       | 69  | 31.8                  | 4.7% *                      |
|             | Adjunct                            | 21                       |                          | 11 (52.4)                                       | 74  | 28.6                  |                             |
|             | p                                  |                          |                          | 0.177   | 0.26                                      | 0.831                 | NA                          |
| Son [13]    | Aspiration                         | 18                       | 0/100                    | 18 (100)  | 62.3                                      | 44                    | 39                          |
|             | Solitaire                          | 13                       |                          | 11 (85)   | 101.9                                     | 39                    | 46                          |
|             | p                                  |                          |                          | 0.168   | 0.044                                     | 1                     | NQ                          |
| Kowoll [14] | Aspiration                         | 30                       | 91/9                     | 29 (97)   | 30  | 53#                   | 3 #                         |
|             | Aspiration+3D separator (Solumbra) | 24                       |                          | 21 (88)   | 65  | 38 #                  | 21 #                        |
|             | p                                  |                          |                          | 0.3   | 0.0004                                    | 0.3                   | 0.08                        |
| Kang [13]   | Aspiration                         | 22                       | 81.8/18.2                | 18 (81.9)                                       | 40.2                                      | 45.5                  | 13.6                        |

**Table 3:** Summarised outcomes from Solumbra Thrombectomy studies. (NQ: Not quoted)

| Study                 | technique  | Total Number of Patients | Anterior/posterior (%/%) | Successful recanalization to 2B or above | Average time to recanalization in minutes | MRs 0-2 at 90 days: % | Mortality at 90 days |
|-----------------------|--|--------------------------|--------------------------|--|---|-----------------------|----------------------|
| Stampfl [20]          | Solumbra (SOFIA and Solitaire/trevo/ embotrap (aspiration alone successful in 17 patients) | 115                      | 84.3/15.7                | 86.90%                                   | 73.2                                      | NQ                    | NQ                   |
| Humphries [21]        | Solumbra (Penumbra or Navien and solitaire or Trevo)                                       | 105                      | 90.5/9.5                 | 88%                                      | 54  | 44.1                  | 27.6                 |
| Wong [22]             | Solumbra   | 31                       | 87.9/12.1                | 94%                                      | 46.4                                      | NQ                    | NQ                   |
| Delgado almandoz [15] | Solumbra (Penumbra and solitaire)  | 55                       | 100/0                    | 84%                                      | 51  | 31                    | 29                   |
|                       | ADAPT (Penumbra) (requiring solumbra salvage in 13 cases)                                  | 45                       |                          | 89%                                      | 50  | 56                    | 18                   |
|                       | p  |                          |                          | 0.6                                      | 0.8                                       | 0.015                 | 0.24                 |

would be unethical to continue after presentation of the MR CLEAN [1] outcomes. It did however demonstrate a trend towards benefit of aspiration compared to IV alteplase alone.

In the largest cohorts (n=100<sup>17</sup>, n=191<sup>10</sup>) aspiration alone achieved recanalization to TICI 2b and above in over 74% of cases. Time to recanalization was often significantly shorter [10,13,14,17]. The use of adjunct devices was associated with longer procedure times [10,17].

These cohorts had a greater proportion of anterior circulation strokes see Table 2. However, the technique has also been used in the posterior circulation. As part of a series of n=100 posterior circulation strokes [18], 42 were intervened on as primary aspiration (with 48% of those requiring further use of stent retriever) with no significant difference in recanalization rate or clinical outcome when compared to stent retriever use. Overall recanalization to 2b or above was seen in 80%, and a mRS of 2 or less in 35%. A further comparative study on a smaller cohort of posterior circulation stroke (Son et al [13], see table 2) demonstrated significantly shortened recanalization time and a trend towards improved TICI scores.

The aspiration technique yields ICH rates of 4 [14] to 9.1% [13], but no significant difference was demonstrated compared to IV tPA alone [16]. Overall complications were not significantly different to stent retriever approaches.

The ASTER clinical trial, a randomised multicentre study comparing aspiration with stent retriever thrombectomy found no statistical difference in recanalization rates [19]. 363 patients with anterior circulation strokes were included. Use of rescue therapy and adverse effects did not differ significantly between the two groups. Though the primary endpoint was focused on technical outcomes, no significant difference in clinical endpoints was demonstrated.

Additionally Comai et.al [11] demonstrated significant cost saving using the sequential endovascular thrombectomy approach based on first line aspiration.

## Solumbra

The Solumbra technique involves aspiration via an intermediate catheter simultaneously used with stent retrieval. Using this method with a SOFIA intermediate catheter (n=115), TICI 2b or greater was achieved in 86.9% of cases [20]. Further studies are included in Table 3 below.

A good clinical outcome (mRS 2 or less) was demonstrated more frequently in the ADAPT group compared to Solumbra

(see table 3) though procedure times were similar. sICH in Solumbra was seen in 13% vs 2% (p=0.07) with ADAPT [15]. Other Solumbra cohorts quote symptomatic ICH rates of 4.6% [21] to 6.1% [20].

ADAPT required significantly more passes (3.3 vs 2.2 for Solumbra; p=0.02), therefore the authors recommend multiple aspiration passes before deploying a stent retriever [15] (other studies have reported 1.7 [22] to 2.3 [21] average number of passes using the Solumbra technique).

No significant differences in Embolization to New Territory (ENT) were seen between ADAPT and Solumbra when compared (p=0.6) [15]. Amongst larger cohorts ENT was reported in 5.7% using Solumbra [21], and none with aspiration [10,17]. This compares to 4.9% [5] to 8.6% [1] ENT when using stent retrievers.

## Conclusion

Similar recanalization rates and clinical outcomes have been observed across all techniques. The shorter recanalization times made possible by aspiration tie into the overall aim of reducing time from symptom onset to reperfusion time.

Further studies comparing the three techniques described above may help guide the first line choice, and gain a greater understanding of the complications. However, the results demonstrated above and the ability to easily proceed to the other two methods make ADAPT a sensible first line approach in many cases. Solumbra or stent retriever only approaches can be used to further improve recanalization rates. More comparative data on functional outcomes is required to determine the most beneficial technique for patients.

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