Mechanical thrombectomy: Evidence basis and future directions

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Background: Mechanical thrombectomy (MT) for acute ischemic stroke has been shown to be a highly effective intervention for stroke, both in preventing and reducing disability. It was an eventual success story, evolving from negative trials to positive trials and expanding the treatment window in selected patients up to 24 h. Evidence from large, pooled, multicenter trials has demonstrated superiority over the best medical treatment, an increased recanalization rate and reduced rates of both death and disability. It has expanded the cohort of patients who can undergo acute intervention, both by extending the time window and by having fewer contraindications. **Aim:** The aims of this review are to summarize and evaluate the literature base for the current applications of MT and to discuss future research avenues. **Conclusion:** In patients with large vessel occlusion causing acute ischemic stroke, MT is far better than the best medical therapy. However, there remain limits that need to be explored: occlusions of medium-sized vessels, posterior circulation stroke and distal occlusions are still not routinely treated due to the lack of clearly positive evidence. Stronger evidence is required for intervention to be recommended in guidelines so that clinical practice can change.

Keywords

Acute stroke, brain ischaemia, cerebral angiography, endovascular procedures, intracranial embolism, mechanical thrombectomy, stent retrivers, ischaemic stroke therapy, thrombolytic therapy, treatment outcome

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Both intracerebral hemorrhage and ischemic stroke continue to be the leading causes of disability and the second leading causes of death worldwide.[1,2] The burden is largest in low- and middle-income countries, which have seen rapid recent population growth. Large vessel occlusion (LVO – internal carotids, vertebrals and the proximal branches of the circle of Willis) accounts for 20% of all acute ischemic strokes (AISs) and causes large, disabling strokes.[3] Intervention for LVO provided the focus of the earlier thrombectomy trials, as thrombus was visible on available imaging and lodged in potentially accessible sites, making it a clear treatment target for mechanical thrombectomy (MT). More recent research has focused on medium-sized vessels and distal occlusions to expand the use of MT.

The publication of the National Institute of Neurological Disorders and Stroke trial in 1996 was the major turning point in acute stroke interventions in a field that had been slow to develop.[4] This trial proved that disability outcomes and mortality rates were better after early administration of intravenous alteplase (thrombolysis). This led to the inclusion of intravenous thrombolysis (IVT) in the management of AIS, which revolutionized stroke care on a global scale.[4] Implementation required highly organized, specialized services linked to neurosurgical centers and trained staff with the skills to manage patients with stroke. IVT can only be given to a limited number of patients due to a limited therapeutic window and the possibility of bleeding intracranially or systemically. These limitations added urgency to the search for alternative or adjunctive acute catheter-based intervention, which took another 10 years.[5,6] It took until 2015 for MT trials to show a positive treatment effect, and there is still work on-going to refine patient selection. Applications of advanced imaging techniques for patient selection and improving stroke services have been key in achieving positive outcomes. Implementation of MT has increased the need for skilled staff to work in an interprofessional and collaborative way. It has also exposed a need for better and accessible acute stroke pathways for delivery – this has not happened on a large enough scale yet. The goal is to have patients with stroke rapidly evaluated, given thrombolysis if not contraindicated, and transferred to a facility with the imaging capability and interventional radiologist where MT can be performed within the shortest possible timeframe. It seems that the best system is one in which patients are taken directly to a stroke center for evaluation and intervention.[7,8] This is a global challenge that needs to be addressed by the stroke community and policy makers.

The procedure itself is usually carried out by an interventional neuroradiologist who has upskilled through subspecialty training. The patient is sedated, and the femoral artery is punctured. An endovascular catheter is then passed through the cerebrovascular circulation to the clot under radiological guidance. A stent is deployed, catching the clot, and once secured, both stent and clot are pulled out using the catheter; sometimes, aspiration is required.[5,6] Early

complications include infection or hematoma at the puncture site, embolization and further stroke and vessel rupture.[6] Of course, there is the possibility of failure to retrieve the clot despite multiple passes with the catheter and of reperfusion injury. A significant part of the story of MT has been the evolution of the technical aspects of the procedure – both the techniques and the devices used in addition to the evolving landscape of evidence.[9] The growing device industry itself has rapidly expanded over the past years and is estimated to be worth over US$17 billion by 2033.[10] The cost of the procedure itself is higher than IVT alone, and commissioning for services has been a factor in the relatively low uptake globally.

Early experience with intra-arterial thrombolysis

The Prolyse in Acute Cerebral Thromboembolism (PROACT) trials in the mid- to late 1990s looked at outcomes using local intra-arterial delivery of thrombolysis via a femoral catheter through a groin puncture.[11,12] These trials are relevant as they started to establish catheter-based technical knowledge. Both trials had high rates of revascularization, but unfortunately, the intracerebral hemorrhage rate of over 10% precluded the further use of intra-arterial thrombolysis. These trials focused physicians and neuro-interventionists on exploring the role of catheter-based techniques in AIS further to identify a safer intervention.[13]

Stent retrievers

The first device to receive US Food and Drug Administration (FDA) approval was the Mechanical Embolus Removal in Cerebral Ischemia (MERCI) Retriever (Concentric Medical CA, USA). This is a stent retrieval system, a corkscrew-shaped stent is deployed, which engages with the thrombus, and then both are pulled out together.[13]

Thrombectomy using the MERCI stent retriever within 8 h of AIS had a recanalization rate of 55% in the Multi Mechanical Embolus Removal in Cerebral Ischemia (MULTI MERCI) trial, higher than in PROACT II.[12,14] The device was not without its issues: 13% of patients experienced peri-procedural complications, and 7.1% of patients developed significant hemorrhage. According to the multivariate analysis of the MULTI MERCI study, recanalization led to a higher number of patients achieving functional independence at 90 days.[14] Despite this, mortality and morbidity rates remained high, driving a search for safer and more practical alternatives.[13]

After this, a penumbra aspiration system was trialed; it was a more complex procedure, but the hope was to reduce complication rates, including thrombotic fragments embolizing during the procedure. The catheter was advanced to the proximal edge of the thrombus, and continuous aspiration was applied via a pump. The thrombus extraction ring was then used for extraction after stopping proximal blood flow.[15]

When put into practice, the Penumbra Pivotal Stroke study reported comparable outcomes and complication rates.[15] This study put the focus on patient selection rather than procedural technique. Thus, despite this difficult start in establishing catheter-based interventions, the good clinical outcomes caused a lot of excitement in the growing stroke community, which led to growing momentum and enthusiasm for further randomized controlled trials.

While promising, there was still a high rate of intracerebral hemorrhage and procedural complications, which had to be circumvented if the treatment was to be viable.

Table 1: Trials of mechanical thrombectomy from 2013 that did not show a significant reduction in disability with intervention[16–18]

Trial	MR RESCUE	IMS III	SYNTHESIS
Aims	MT/IVT	Bridging IAT/MT	MT/IAT
Size	118	656	362
Recruitment Interval	2004–2011	2006–2012	2008–2012
Centers	North America	USA/Canada Australia/Europe	Italy
NIHSS	6–29	<10	>25
Onset to groin	<8 h	<5 h	<4.5 h
Imaging criteria	Multimodal CT/ MRI but none for trial eligibility	None	None
90 days mRS 0–2 intervention versus control group	38% versus 42% p=0.2	40.8% versus 38.7% p=0.44	42% versus 46% p=0.35

The most important takeaways from these earlier negative studies were applied in upcoming trials. The future of MT was then drastically transformed by the publication of clinical studies in 2015 with better study designs, which are shown in Table 2. CT = computed tomography; IAT = intra-arterial thrombolysis; IVT = intravenous thrombolysis; MRI = magnetic resonance imaging; mRS = modified Rankin score; MT = mechanical thrombectomy; NIHSS = National Institute of Health Stroke Scale/Score.

Era of negative trials

MR RESCUE

In 2013, a large randomized controlled trial, Mechanical Retrieval and Recanalization of Stroke Clots Using Embolectomy (MR RESCUE; ClinicalTrials.gov identifier: NCT00389467), was published, with two further negative trials that year.[16] MR RESCUE enrolled patients with acute stroke within the last 8 h and an NIHSS of 6–29, with large artery blockage, for intervention with MT. They used the MERCI stent retriever. As shown in *Table 1*, to determine the existence of the penumbra, all patients had pre-treatment multimodal computed tomography (CT) or magnetic resonance imaging (MRI).[16–18]

Disappointingly, it showed that intervention did not make a significant difference in outcomes; if anything, the average modified Rankin score (mRS) was higher in the embolectomy group than in the control group. However, the rate of intracerebral hemorrhage was reduced to 4%. These findings demonstrated the importance of patient selection and also the experience and skill of the interventionist in this burgeoning field.[16]

SYNTHESIS and IMS-III[18]

Final results of the Randomized Controlled Trial on Intra-Arterial Versus Intravenous Thrombolysis in Acute Ischemic Stroke (SYNTHESIS) and Interventional Manaagment of Stroke (IMS-III; ClinicalTrials.gov identifier: NCT00359424) studies were also released in 2013.[17,18] However, to the dismay of the stroke community, both found that MT did not reduce disability after stroke.[17,18]

As shown in *Table 1*, the SYNTHESIS cohort comprised patients aged 18–80 who had an ischemic stroke within a 4.5 h time window.[16–18] IVT and MT were compared for their impact on death and disability. Enrollment in these trials did not require pre-procedure vascular imaging or perfusion imaging, which was in line with current practice in most stroke services.

However, when the IMS-III protocol was altered to utilize CT angiography, they found a slight benefit from MT in patients with thrombus seen on

Table 2: Positive trials and their outcomes published throughout 2015[19–23]

	MR CLEAN	SWIFT PRIME	EXTEND IA	ESCAPE	REVASCAT
Setting/enrollment	Netherlands 2011–2014	USA and Europe 2012–2014 196 enrolled	Australia and New Zealand 2014–2015 100 enrolled	UK, USA, International 2013–2014 316 enrolled	Spain (Catalonia) 2012–October 2014 206 enrolled
Age (years)	>18	18–85	>18	>18	18–85
Time of onset to groin puncture	<6 h	<6 h	<6 h	<12 h	<8 h
Imaging modality	CTA, MRA, DSA, TCD	CTA, MRA	CTA, MRA CT/MRI mismatch	CTA/MRA	CTA, MRA
90 days mRS (0–2)	32.6%	66.6%	33.3%	53%	44%
Comments	New AIS in a different territory (5.6 versus 0.4; p=0.001)	Device-specific vasospasm was noticeable	sICH 6% versus 0% Experience /efficiency Not generalizable	Early discontinuation as interim analysis showed efficacy	The study did not include patients who responded to reperfusion tpa
NNT	7.4	4.0	3.2	4.2	6.5

AIS = acute ischemic stroke; CTA = computed tomography angiography; DSA = digital subtraction angiography; MRA = magnetic resonance angiography; MRI = magnetic resonance imaging; mRS = modified Rankin score; NNT = number needed to treat; sICH = symptomatic intracerebral hemorrhage; sICH = symptomatic intracranial hemorrhage; TCD = transcranial Doppler; tpa = tissue plasminogen activator.

computed tomography angiography (CTA), highlighting the importance of imaging in patient selection.[18]

A positive aspect from these important initial trials was an overall high rate of radiological recanalization of anything up to 81% for M1 occlusions, which was satisfying after seeing lower rates in previous trials.[18] This showed progress in both interventionalists' skills and device development.

Time to intervention was initially 145 min and then decreased to 120 min as the trial progressed; this may be one of the factors that influenced the lack of efficacy.[18] This highlighted the issue of prolonged groin-to-intervention time again, increasing the risk of poor outcomes. SYNTHESIS interventions were not always performed with newer devices, and this heterogeneity in intervention may have contributed to negativity overall.[17]

Increasing evidence for intervention

Over the course of 2015, there was a sudden shift in the evidence base, with a run of overwhelmingly positive trials reported. This formed the solid basis for sustained change in acute stroke treatment and new clinical guidelines. This is detailed in *Table 2*.[19–23]

MR CLEAN

The multicenter randomized controlled trial MR CLEAN (Multicenter Randomized Clinical trial of Endovascular treatment for Acute ischemic stroke in the Netherlands; ISRCTN trial identifier: ISRCTN10888758) enrolled 500 patients in the Netherlands, resulting in higher numbers than seen in previous trials. The mean age was 65 years, and 89% of patients were treated with intravenous alteplase before they were randomized. A good outcome was defined as an mRS of 0–2, and this was achieved in a significantly higher number of patients in the intervention group (32.6% versus 19.1%). There were no statistically significant differences in mortality or the occurrence of symptomatic intracerebral hemorrhage. A downside was the 8% of patients who had embolization to other territories, causing recurrent stroke. This was not seen in the other trials, and the cause is not clear.[19]

ESCAPE

Patient selection methods continued to be refined to achieve a better treatment effect. This study (ESCAPE; Endovascular treatment for Small Core and Anterior circulation Proximal occlusion with Emphasis on Minimizing CT to Recanalization Time; ClinicalTrials.gov identifier: NCT01778335) used imaging selection criteria based on the Alberta Stroke Program Early CT Score (ASPECTS) score and collateral circulation in patients with an NIHSS greater than 6.[22] The rate of arterial recanalization was 72.4%, which was relatively high. An interim study found a 2.6 odds ratio for an improvement of one point on the mRS at 90 days. The categories of disability on the mRS are large, so this was significantly, in favor of MT, and there was a relatively large (23.7%) absolute difference between the number of patients who had no or mild disability in the intervention group. In the MT arm, symptomatic intracranial hemorrhage (sICH) occurred 3.6% of the time.[22] According to these findings, clinical decision-making using information such as the ASPECTS score and degree of collateralization results in lower numbers of death and disability.

EXTEND IA

This was a landmark trial conducted throughout Australia and New Zealand, which enrolled 100 patients and used advanced imaging and artificial intelligence to refine selection further. Patients were eligible if they were within the 4.5 h window with LVO.[21] They confirmed eligibility using CT and CT angiogram; in addition, CT perfusion imaging, which was processed using fully automated software, was used to identify the location and size of the penumbra. The trial was halted earlier than planned, as it clearly showed superiority of intervention. MT, when carried out at a median of 210 min after the onset of stroke, resulted in less disability at 3 days (80% versus 37%; p=0.002) and improved chances of achieving a score of 0–2 on the mRS at 90 days (71% versus 40%; p=0.01).[21] This was the trial that tipped the balance and caused guidelines to change, including MT as a validated acute intervention for stroke.

SWIFT PRIME

In this trial, stent retrievers from a more recent generation were more frequently employed. It displayed a remarkable recanalization rate of 88.0% and led to lower rates of disability.[20] Neither SWIFT PRIME (Solitaire with the Intention for Thrombectomy as Primary Endovascular Treatment for Acute Ischemic Stroke; ClinicalTrials.gov identifier: NCT04719832) nor EXTEND IA (EXtending the time for Thrombolysis in Emergency Neurological Deficits – Intra-Arterial; ClinicalTrials.gov identifier: NCT01402127) documented a significant number of

intracerebral hemorrhages, making it clearer that advanced imaging was helpful in improving the safety profile of the revascularization strategy, in addition to outcomes.[20,21]

REVASCAT

The final of the five significant randomized controlled trials published in 2015, REVASCAT (Randomized Trial of EVascAScATion with Solitaire FR Device versus Best Medical Therapy in the Treatment of Acute Stroke Due to Anterior Circulation Large Vessel Occlusion Presenting within Eight Hours of Symptom Onset; ClinicalTrials.gov identifier: NCT01692379) recruited from multiple centers in Catalonia, Spain. It was halted early after the preceding trials published overwhelmingly positive data. A lengthier time window was permitted, and patients were enrolled if they were within 8 h of onset time. Intervention with MT increased the number of patients with little or no disability, even within this longer timeframe, further adding to the literature.[23]

Evaluating and improving efficacy

This shift from negative to positive called for a pause for evaluation of data, and a meta-analysis of eight trials confirmed that there was improved functional outcomes with MT as opposed to IVT alone, with no increase in intracranial hemorrhage (ICH) or any excess deaths.[24] The number needed to treat to achieve functional independence from the pooled analysis was calculated at 2.6.[24]

The value of CT perfusion in extended time windows was an additional finding, which also led to an expansion in the number of patients who could receive acute treatments for stroke, including those who were previously denied treatment, such as patients who woke up with ischemic stroke.[25] The next two trials employed the use of a tissue window but still aimed for quick times for reperfusion, as both IVT and MT are clearly time-dependent treatments.

Integrating the use of perfusion imaging

These studies utilized perfusion imaging to increase the window for intervention to up to 24 h after stroke onset time. They used this to define a 'tissue window' instead of a 'time window,' although perfusion imaging was not widely available at the time due to the skill required in interpreting images.

Table 3: Summary of DAWN and DEFUSE 3 trials[26,27]

MT trial	DAWN	DEFUSE 3
Countries/time	USA, Canada, Australia and Europe, 2014–2017	30 hospitals in USA, 2016–2017
Age group	18–80 years	18–90 years
Total recruited	206	182
Time to intervention	6–24 h	6–24 h
NIHSS	≥6	≥6
Imaging modality	Perfusion CT/MRI, ischemic core 31–51 mL	Perfusion imaging Ischemic core <70 mL, penumbra >15 mL
Functional independence	49% versus 13%	45% versus 17%
sICH intervention versus control	6% versus 3%	7% versus 4%

CT = computed tomography; DAWN = DWI or CTP Assessment with Clinical Mismatch in the Triage of Wake-Up and Late Presenting Strokes Undergoing Neurointervention with Trevo; DEFUSE 3 = Diffusion and Perfusion Imaging Evaluation for Underftanding Stroke Evolution; MRI = magnetic resonance imaging; MT = mechanical thrombectomy; NIHSS = National Institute of Health Stroke Scale/Score; sICH = symptomatic intracerebral hemorrhage.

DAWN trial

As shown in *Table 3*, DAWN (DWI or CTP Assessment with Clinical Mismatch in the Triage of Wake-Up and Late Presenting Strokes Undergoing Neurointervention with Trevo; ClinicalTrials.gov identifier: NCT02142283) enrolled participants within 6 and 24 h post stroke onset, followed by division into three age and core volume groups.[26] After that, patients were randomized to either standard treatment or MT; at 90 days, functional independence was 49% in those who had MT and only 13% in the control group, and the utility-weighted mRS was 5.5 in the thrombectomy group and 3.4 in the control group. Notably, among patients who were older and part of the sizable core group, the benefit of MT was very consistent.[26] This was a convincing result and added valuable information about the safety of MT over extended periods of time.

DEFUSE 3

DEFUSE 3 (Diffusion and Perfusion Imaging Evaluation for Underftanding Stroke Evolution; ClinicalTrials.gov identifier: NCT02586415) was the third iteration of DEFUSE trials, which sought to optimize intervention within an extended time window of greater than 6 h since stroke onset. Participants in this study had a relatively small ischemic core volume (less than 70 mL) and a penumbra of more than 15 mL, giving an ischemia-to-infarct volume ratio of 1.8 or higher. Again, this was a convincing result, as they found that the MT group had functional independence at a rate of 45%, significantly higher than the 17% in those who only had IVT.[27]

The rate of sICH was not statistically significantly different between MT and IVT only, but the absolute number was higher in the MT group. These were predictably seen more so in those with a large core volume (9% versus 5%; p=0.391). Despite this, the mortality in both groups was comparable (18% versus 20%; p=0.799).[27]

Again, this called for a re-evaluation of the literature, as using a tissue window and extended times for acute stroke treatment was now safe and efficacious.

The AURORA (Analysis Of Pooled Data From Randomized Studies Of Thrombectomy More Than 6 Hours After Last Known Well) investigators pooled data from 505 individuals (n=266 intervention, n=239 control; mean age 68·6 years, with equal numbers of men and women) from the following six randomized controlled trials: DEFUSE 3, DAWN, RESILIENT (Randomization of Endovascular Treatment With Stent-retriever and/or Thromboaspiration Versus Best Medical Therapy in Acute Ischemic Stroke Due to Large Vessel Occlusion Trial), ESCAPE, REVASCAT and POSITIVE (PerfusiOn imaging Selection of Ischemic stroke Tatients for endoVascular thErapy).[28] MT was associated with a higher number of patients with less disability as measured by mRS. No significant differences between intervention and control groups were found when analyzing either 90-day mortality or symptomatic intracerebral hemorrhage. This confirmed that MT outside of the 6 h usual cutoff times remained safe and effective if the right patients were selected using perfusion imaging.

Intervening within a very late window with MT in everyday clinical practice became possible – up to 24 h in selected patients. Even longer than 24 h has also been explored. Kobeissi et al. reviewed seven MT trials with a total of 569 patients and a mean time from last known well and/or onset to puncture of 46.2 h.[29] These patients had relatively large clinical deficits and an average baseline NIHSS of 13.6, with little in the way of established infarct on CT – the mean

Table 4: Summary of basilar artery ischemic stroke trials: BASICS, BEST, ATTENTION and BAOCHE[31–34]

Trial	BASICS[31]	BEST[32]	ATTENTION[34]	BAOCHE[33]
Date	2011–2019	2015–2017	2021–2022	2016–2022
Onset symptoms	0–6 h	0–8 h	0–12 h	6–24 h
Participants	300	131	340	217
Median NIHSS Intervention versus control	22/21	27/32	35/35	29/30
mRS <3 Intervention versus control	68%/55%	42%/32%	46%/22%	46%/24%
90-day mortality Intervention versus control	38%/43%	33%/38%	36%/55%	34%/45%
sICH intervention versus control	6/1	5/0	12/0	6/1

ATTENTION = Endovascular Treatment for Acute Basilar-Artery Occlusion trial ; BAOCHE = Basilar Artery Occlusion Chinese Endovascular trial; BASICS = Basilar Artery International Cooperation Study; BEST = Endovascular Versus Standard Medical Treatment for Vertebrobasilar Artery Occlusion trial; mRS = modified Rankin score; NIHSS = National Institute for Health Stroke Scale/Score; sICH = symptomatic intracranial hemorrhage.

Alberta Stroke Program Early CT Score was 7.9. They concluded that MT for very late-window AIS was associated with favorable 90-day mRS scores and with low numbers with regard to 90-day mortality and sICH.[29] Larcipretti et al. published a meta-analysis of studies including a relatively high (1,221) number of patients who presented with AIS in a very extended time window for MT – up to 155 h post onset and who had reasonable outcomes with treatment.[30] These results suggest that MT might be safe and associated with improved outcomes for very late-window AIS, although more randomized controlled trial (RCT)s and prospective comparative studies are needed to determine patient selection criteria.

Future challenges of mechanical thrombectomy

In addition to extended time windows, there are several aspects of acute intervention with MT that are yet to be clarified.

Posterior circulation acute ischemic stroke

Posterior circulation LVO was not included in these trials, which were focused on anterior circulation strokes. This had to be rectified, as they have very high mortality and are highly disabling.

Table 4 illustrates a summary of four important trials of MT as an intervention for basilar artery occlusion.[31–34] Though the overall results confirmed the efficacy of MT, there was also a relatively high rate of symptomatic ICH.[3,35] This puts the use of bridging IVT into question, and this needs to be established by RCT. Patient selection needs to be refined further, as perfusion imaging is not so accurate in the posterior circulation. MT for occlusions of the other vessels of the posterior circulation are discussed later. This did, however, provide some hope for this group of high-mortality strokes, where there was often treatment futility.

Trans-radial versus trans-femoral access

Technical aspects of the procedure itself continue to be explored to reduce complications as a primary aim. One systematic review more recently evaluated the viability of the trans-radial artery as an access point for MT.[36] Their study indicated that existing literature evidences comparable rates of recanalization, procedural efficiency and length of stay. However, the studies were found to have been underpowered, and it is not possible to draw a conclusion that will change clinical practice.[36] Probable advantages that they cite include a reduced likelihood of complications (puncture site bleeding, pseudoaneurysm and vagal reflex), lower procedure costs, quicker recovery and earlier discharge. The downside is the inability to employ bigger diameter neuro-interventional access catheters, as well as the difficulty in traversing the sharp angle between the carotid artery and the subclavian artery in the aortic arch.[37] It can also require additional training to build sufficient technical skills and confidence.

Mechanical thrombectomy for mild strokes

Still debatable is the decision to perform MT on patients with low NIHSS scores (i.e. less than 6) and expose them to the risk of embolization, procedural complications and possible reperfusion injury. Retrospective multicenter cohort studies found a greater risk of sICH but no increase in the number of patients with good outcomes in those with so-called mild stroke who received MT.[38] The NIHSS is not always congruent with the degree of disability; for example, a hemianopia and/or significant apraxia will result in a low NIHSS but be significantly disabling in a patient who is still employed. This remains a clinician's choice, and discussion with an interventionist while decision-making is necessary, making these cases good examples of collaborative working.

Medium vessel occlusions and distal occlusions

All the positive trials of MT were of intervention for large vessel or proximal occlusions. Distal segment occlusions of the middle cerebral artery (M2, M3), posterior cerebral artery and anterior cerebral artery are yet to be established as treatment targets. These are technically more difficult to recanalize, being smaller arteries or more tortuous. Three initial negative trials of MT for M2 occlusions were disappointing, but there are several points of criticism that make it worth continuing to explore them as a treatment target.[39] First, the disability measure of mRS may not be nuanced enough to capture improvement in potentially disabling consequences, e.g. quadrantanopias or aphasia. They are more technically difficult to treat, and an increase in operator skill in combination with device development is required for the next set of RCTs. MT for posterior cerebral artery stroke is currently being investigated and is not routinely referred for intervention in current clinical practice, although it should be discussed as possible cases for intervention.[40,41]

Discussion

A high level of efficacy of MT in the treatment of intracranial cerebral artery occlusion in the anterior circulation has been clearly established by reviews of the evidence, and it is now an established treatment for AIS.[24] An expansion of the time window for possible treatment to longer than 6 h has further increased the number of patients who can be treated in centers with access to emergency perfusion imaging.[28]

The number needed to treat to achieve functional independence at 90 days varies from 7.4 in MR CLEAN to 2.8 in the DAWN trial.[42] This makes it incredibly efficacious and is currently the best treatment we can offer patients with LVO of the cerebrovascular anterior circulation. Basilar artery occlusion in the posterior circulation is also amenable to treatment within extended time frames and with careful patient selection, giving some hope to this group of patients who have often been excluded from acute treatment on the grounds of futility.[35] Medium vessel trials have not been positive yet, but there is optimism among the stroke community that this will also see the sudden shift that the anterior circulation stroke trials did, as skills and devices develop.

The development of the field of MT has been supported by a burgeoning devices industry, but service development has been painfully slow. The majority of the globe is underserved with regard to access to MT, as there are barriers in the form of funding, infrastructure and shortage of trained personnel. Lack of access ranges from no service at all to no service out of hours, or access to services that are so far away that travel time precludes their use.[43] There are not many stroke MT services that do not have some form of limitations and less than 3% of eligible patients have access.[43]

To fully realize MT service delivery, it is first necessary to establish best-functioning models of care, close access gaps and train committed, skilled personnel. Sustained development can only happen with interprofessional, collaborative working with appropriate resource allocation. The disparities and limitations of resources and capacity are even more prominent in nations with scarce resources. For the stroke community, the general public and policy makers, it ought to be a key area of concern. The future of acute stroke management seems much brighter, but there is still a great deal of distance to cover. ❑

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