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Techniques for endovascular treatment of acute ischemic stroke

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ABSTRACT

Early recanalization of occluded vessels in patients with acute ischemic stroke (AIS) by either intravenous thrombolysis (IVT) or endovascular revascularization has been shown to be associated with improved clinical outcomes and reduced mortality. Since the initial report regarding endovascular treatment (EVT) of AIS in 1983, endovascular techniques have been tremendously improved, advancing from intra-arterial administration of thrombolytic drugs to stent retrievers. IVT has been evaluated in several large randomized trials and has been shown to improve clinical outcomes at 90 days if treatment was initiated within 3 h of stroke onset, while its benefit at 3–4.5 h was subsequently demonstrated in the European Cooperative Acute Stroke Study (ECASS) III. Thus, EVT had to be evaluated against IVT. The first randomized controlled trials (RCTs) were published in 2013, and demonstrated no major differences between IVT and EVT for AIS, although these trials had important limitations. The positive results of the Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke (MR CLEAN) in the Netherlands, followed by five other positive RCTs, finally established the efficacy of mechanical thrombectomy (MT) with stent retrievers (also called 'stentrievers') in AIS due to large vessel occlusion within 6 h of stroke onset. Currently, the European and US guidelines recommend MT with stent retrievers as a first-line treatment in the management of AIS. The recent publication of the DWI or CTP Assessment with Clinical Mismatch in the Triage of Wake-Up and Late-Presenting Strokes Undergoing Neurointervention (DAWN) trial is expected to lead to extension of the time window for patients carefully selected by imaging. Thus, optimizing the selection of patients as well as the EVT procedures and techniques used is still an important goal to be evaluated in further trials.

Early recanalization of occluded vessels in patients with acute ischemic stroke (AIS) by either intravenous thrombolysis (IVT) or endovascular revascularization has been shown to be associated with improved clinical outcomes and reduced mortality [1]. Since the initial report regarding endovascular treatment (EVT) of AIS in 1983, endovascular techniques have been tremendously improved, advancing from intra-arterial administration of thrombolytic drugs to stent retrievers [2,3].

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During this time, IVT has been evaluated in several large randomized trials and has been shown to improve clinical outcomes at 90 days if treatment was initiated within 3 h of stroke onset, while its benefit at 3–4.5 h was subsequently demonstrated in the European Cooperative Acute Stroke Study (ECASS) III [4,5].

Thus, EVT had to be evaluated against IVT. The first randomized controlled trials (RCTs) were published in 2013, and demonstrated no major differences between IVT and EVT for AIS, although these trials had important limitations [6–10]. The positive results of the Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke (MR CLEAN) in the Netherlands, followed by five other positive RCTs, finally established the efficacy of mechanical thrombectomy (MT) with stent retrievers (also called 'stentrievers') in AIS due to large vessel occlusion within 6 h of stroke onset [11–18]. Currently, the European and US guidelines recommend MT with stent retrievers as a first-line treatment in the management of AIS [19,20].

The recent publication of the DWI or CTP Assessment with Clinical Mismatch in the Triage of Wake-Up and Late-Presenting Strokes Undergoing Neurointervention (DAWN) trial is expected to lead to extension of the time window for patients carefully selected by imaging [21]. Thus, optimizing the selection of patients as well as the EVT procedures and techniques used is still an important goal to be evaluated in further trials.

1. Mechanical thrombectomy with stent retrievers

Stent retrievers combine two mechanisms of action:

- deployment of the stentriever within the clot immediately restores blood flow;
- the mesh of the stentriever embedded within the clot serves to capture and retrieve the clot.

From a technical point of view, a microcatheter is placed distal to the clot. The stentriever is deployed at the occlusion site for 1 to 2 min. Thereafter, the stentriever and microcatheter are retrieved, then aspiration (either manual or with a pump) is performed through the guiding catheter. Several passes with the stentriever to the occluded site may be necessary.

Meta-analysis of the RCTs in which only stent retrievers were used in the EVT arm (SWIFT-PRIME, ESCAPE, EXTEND-IA, REVASCAT) shows that MT was associated with a high rate of revascularization [modified tissue thrombolysis in cerebral ischemia (mTICI) 2b-3 in 71.1%] [22]. Independent functional outcomes [modified Rankin Scale (mRS) scores 0–2] at 3 months were reported in 54.0% compared with 31.5% in patients treated exclusively with medical treatments, including IVT ($P < 0.0001$). The rate of deaths was lower in patients treated with MT (12.0% compared with 16.3% in the medical arm), but not significantly ($P = 0.16$), whereas the rate of symptomatic intracranial hemorrhage was similar in patients treated with stent retrievers and medical treatment (2.5% and 2.8%, respectively; $P = 0.58$).

Complications of MT were analyzed in MR CLEAN and consisted of embolization in new territories (8.6%), procedure-related vessel dissection (1.7%) and vessel perforation (0.9%) [11]. Emboli in the distal territory of the initially occluded vessel can also arise. The appearance of emboli in distal or new territories has led to the use of adjunctive techniques such as balloon guide catheters and aspiration. Several stentrievers are now available for MT, but direct comparisons among these devices are still lacking.

2. Aspiration

There are at least two types of aspiration according to where the aspiration is to be performed:

- proximal aspiration is performed through a guide or aspiration catheter placed proximally to the large vessel occlusion, usually in the cervical portion of the internal carotid artery (ICA) or vertebral artery (VA);
- distal aspiration is usually performed through an aspiration catheter placed immediately in contact with the clot.

Aspiration catheters are large-bore flexible catheters that can be navigated through the arteries of the circle of Willis.

Aspiration may be manual or pump-driven and is, in fact, always associated with MT with a stent retriever. Application of an aspiration pump or vacuum syringe during retrieval of the stent has been performed in most case series, with the benefit of reducing clot fragmentation and the number of distal emboli, while increasing the amount of clot harvested. Manual aspiration combined with thrombectomy has been a useful addition to the armamentarium of EVT for AIS [23], while the superiority of pump aspiration has not been demonstrated.

Distal aspiration is sometimes the first step of MT – the technique is called by some authors 'a direct aspiration first-pass technique' (ADAPT) – and may also be combined with a stent retriever at the beginning of the procedure. A randomized trial (THERAPY) was conducted to compare aspiration after IVT vs. IVT alone in patients with large vessel ischemic stroke where thrombus length was ≥ 8 mm [24]. The trial was prematurely stopped after publication of the MR CLEAN results and the number of patients included was small (108 patients). However, there was no significant difference between the two study groups in terms of functional independence (mRS scores 0–2) at 3 months (aspiration: 38%, medical treatment: 30%; $P = 0.52$), symptomatic intracranial hemorrhage (aspiration: 9.3%, medical treatment: 9.7%; $P = 1.0$) or mortality (aspiration: 12%, medical treatment: 23.9%; $P = 0.18$).

A more recent trial (ASTER) compared distal aspiration and a stent retriever as the frontline approach to large vessel occlusion [25]. The rate of successful reperfusion after the frontline strategy alone was slightly higher with the stent retriever (67.7%) than with distal aspiration (63.0%), but not significantly ($P = 0.33$). Use of adjunctive treatment was also slightly more frequent with aspiration (32.8%) than with stent retriever (23.8%; $P = 0.053$). However, a similar rate of successful

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