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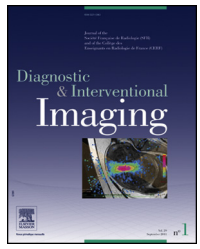

REVIEW / *Neuroradiology*

Endovascular treatment in patients with acute ischemic stroke: Technical aspects and results

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Outcome

Abstract Ischemic stroke is the primary cause of acquired disability in the world and its treatment is still a challenge. Intravenous (IV) thrombolysis with recombinant tissue plasminogen activator (rt-PA) administered within 4½ hours of the onset of the symptoms is the only approved medical treatment in the acute phase of cerebral infarction. However, its efficacy is limited where there is proximal intracranial arterial occlusion, and there are many contraindications. The endovascular approach, combined or not with IV thrombolysis, allows high rates of recanalization to be achieved within a short period of time, with a low rate of procedural complications when thrombolysis is less effective (internal carotid artery, M1 segment of the middle cerebral artery). In these situations, endovascular techniques are playing an increasing role in the treatment of these patients even though there is still no indisputable scientific proof of their efficacy. The priority at present is to finish the French THRACE study, but it is already time to think about the next one.

The treatment of ischemic stroke, which is the prime cause of acquired disability in the world, is a challenge [1]. There are no methods for establishing the diagnosis as rapidly as for myocardial infarction, the therapeutic window is short and no neuroprotective agents have been found to be effective [2].

If there is arterial occlusion, the time that elapses is of vital importance, with the death of 120 million neurons, 813 billion synapses and 714 km of neuronal fibers each hour [3]. In 1995, the National Institute of Neurological Disorders and Stroke (NINDS) rt-PA Stroke Study marked a considerable advance by being the first randomized study

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to demonstrate that a fibrinolytic agent (tissue plasminogen activator, alteplase, Actilyse®) administered intravenously (IV) within 3 hours of the cerebral ischemia occurring resulted in clinical improvement [4]. It produced recovery in 40% of the patients by 3 months (as against 25% recovery without thrombolysis). At the present time, IV rt-PA within 4½ hours of the onset of the symptoms is the only approved medical treatment in the acute phase of an ischemic stroke [5].

However, IV thrombolysis is not always effective, while literature data indicate that endovascular treatment can produce high rates of recanalization within a short time [6], with a low rate of procedural complications. Because of technological advances, endovascular techniques are playing an increasing role in the treatment of ischemic strokes even though there is still no indisputable scientific proof of their efficacy; however, there is an accumulation of data that we can present.

Intra-arterial fibrinolysis

Intra-arterial (IA) thrombolytic administration was evaluated in the PROlyse in Acute Cerebral Thromboembolism (PROACT II) study in 1998 [7]. PROACT II was a randomized prospective study that aimed to evaluate the efficacy and safety of IA pro-urokinase combined with heparin, compared to heparin alone, in patients with occlusion of the middle cerebral artery (MCA) treated during the first 6 hours of symptoms. Partial or complete recanalization was obtained in 67% of the patients in the endovascular group (as against 18% in the control group). Of the patients treated by the IA route, 40% had a favorable clinical outcome at 3 months (modified Rankin Scale, mRS, 0—2) (Table 1), compared with 25% of the control subjects ($P = 0.04$). Symptomatic intracranial hemorrhage occurred in 10% of the patients in the treated group versus 2% in the control group ($P = 0.006$).

The IA route has obvious theoretical advantages: injection of the thrombolytic agent in contact with the clot, immediate verification of the recanalization and use of a lower dose of rt-PA with a lower rate of hemorrhage. IA thrombolysis within 6 hours of the onset of symptoms has been recommended by the European Stroke Organization (ESO) since 2009 for occlusions of the MCA (class II, level B) and for basilar occlusion in selected patients (class III, level B). However, despite the recommendations of the American Heart Association (AHA) and European Stroke Organisation (ESO) who suggest IA rt-PA as a therapeutic option, only the one clinical study has confirmed the efficacy of this route and the strategy has not become widely accepted.

Table 1 Modified Rankin Scale (mRS).

Value	Symptom
0	Asymptomatic
1	Minimal symptoms, restriction of certain activities of daily living, but patient autonomous
2	Minor disability, restriction of certain activities of daily living, not allowing total autonomy
3	Moderate disability, restriction of certain activities of daily living, not allowing total autonomy
4	Moderately severe disability, notable restriction of autonomy, but not requiring continuous assistance
5	Severe disability, bedridden and incontinent, requiring continuous nursing
6	Death

Primary stenting

The use of a stent can immediately restore the flow and avoid the use of thrombolytic drugs. Instead of removing the clot, the stent compresses it against the arterial wall which prevents its becoming fragmented distally. However, placement of a stent may occlude perforating arteries by impacting the clot into their origins. In addition, the stent may re-occlude later. Use of a stent requires dual antiplatelet therapy to be initiated, which may increase the risk of hemorrhagic transformation.

Primary stenting in acute ischemic stroke has often been part of a multimodal strategy for clots resisting other methods of mechanical recanalization. Only small series have been reported in the literature. Brekenfeld et al. [8] treated 12 patients, including 7 after failure of another technique, with a success rate of 92%, and Linfante et al. [9] reported salvage procedures in 19 patients with a 95% rate of recanalization.

In the only prospective study, Stent-Assisted Recanalization for Acute Ischemic Stroke (SARIS), Levy et al. [10] reported complete recanalization in 20 patients within 6 hours of the stroke, but several other endovascular techniques were used (63.2%). A favorable clinical outcome at 6 months (mRS 0—2) was reported in 55% of the cases and a mortality rate of 35%.

Mechanical thrombectomy

The last 10 years have seen major developments in endovascular devices for removing clots in acute ischemic stroke. Two devices, the MERCI retriever (2004) and the Penumbra system (2007), have been approved by the FDA for withdrawing a thrombus in the first 8 hours after a stroke.

Thrombectomy allows more rapid recanalization of the occluded vessels. The FDA's decision was based on non-randomized studies comparing the procedure with historical control of the PROACT II data. In these studies, the rates of recanalization were higher than those reported in studies of IV rt-PA, the rates of symptomatic intracerebral hemorrhage were comparable but the rates of good functional outcome at 3 months were poorer than those of the IV studies. These results were in part explained by greater initial clinical severity and the later time of treatment. These devices are accepted as useful for withdrawing the clot in acute stroke but have not been approved by the FDA as being effective in clinical use.