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Review

The emerging age of endovascular treatment of acute ischaemic stroke and the role of CT angiography in patient work-up: a guide for the radiologist

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Recent trial evidence suggests that for patients suffering large-vessel occlusive stroke, endovascular therapy based on the stent-retriever technique is associated with superior clinical outcomes when compared to intravenous thrombolysis alone. The challenge now is how this service is to be delivered. This may involve both centralisation of services around large cities and development of robust networks to receive patients from district general hospitals situated further afield. Both diagnostic and interventional neuroradiology will need to expand. Furthermore, we suggest that it would be advantageous for radiology departments in those hospitals receiving hyperacute stroke patients to perform computed tomography (CT) angiography in addition to non-contrast CT, which also has implications for service delivery in these units. This could swiftly aid identification of patients who might benefit from thrombectomy and improve decision-making through demonstration of occlusive thrombus and of collateral status.

Introduction

Ischaemic stroke results in a high burden of neurological disability and death. In England and Wales approximately 53,000 people die each year after a stroke, and more than 450,000 people survive with severe disability, at an annual cost of £7 billion.[1] Many variables influence clinical outcome, including the site of vessel occlusion, extent of thrombus, quality of collateral blood flow, clinical condition at presentation,[2–4] and importantly, the timing and effectiveness of arterial recanalisation. Early recanalisation is associated with a four- to fivefold increase in the chance of a person being able to function independently and a four- to five-times reduction in the odds of death.[5]

Until very recently, the standard treatment for patients presenting up to 4.5 hours after the ischaemic ictus was intravenous tissue plasminogen activator (IV tPa)[6]; however, the prognosis for patients with clinically severe strokes secondary to large-vessel occlusions (LVO), involving the terminal internal carotid artery (TICA), proximal middle cerebral artery (M1 MCA), or basilar artery (BA)

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remains poor[7–9]; 60–80% stroke patients with an anterior circulation LVO die within 90 days or fail to regain functional independence, despite IV tPa. IV tPa has limited ability to break down large thrombotic occlusions; transcranial Doppler studies have shown that only 44%, 29%, and 10% of distal MCAs, proximal MCAs, and TICAs, respectively, achieve complete recanalisation, 2 hours after treatment.[10] For this reason, there has been a continuous drive to develop more effective therapies, principally using endovascular techniques.

Endovascular therapy initially involved intra-arterial delivery of tPa or microguidewire disruption, snare devices, and clot retrieval systems that are no longer routinely employed.[11] Although, anecdotally, these techniques showed promise, they failed to show clear benefit over IV tPa in three major randomised, controlled trials published in 2013.[12–14] The design and recruitment of these studies have been heavily criticised as some included large numbers of patients without proven LVO, protracted time delay to treatment, and use of out-dated technology.[15] Nevertheless, current National Institute for Health and Care Excellence (NICE) guidance continues to recommend endovascular treatment of hyperacute stroke principally within a research setting.[16]

During the time that these trials were recruiting, thrombectomy technology progressed and the principal technique now employed is the use of stent retrievers, initially proven in two randomised studies to show superior radiological and clinical outcomes compared to older endovascular technologies[17,18] as stent retrievers achieved faster and higher rates of recanalisation. Now, five international multicentre randomised, controlled trials have unanimously demonstrated the benefits of endovascular therapy in addition to IV tPa in patients with LVO[19–23] (Table 1). Three of the trials, ESCAPE,[20] EXTEND-IA[21] and SWIFT-PRIME,[22] were stopped early because of efficacy following the results of the MR CLEAN trial.[19] The trials demonstrate an absolute benefit of endovascular therapy over IV tPA alone in terms of a 90-day functional outcome (modified Rankin scale 0–2) of 13.5–31%. This translates into the number needed to treat for benefit as low as three, with a maximum of seven. The maximum time to intervention varied from 6–12 hours. The results of these trials have laid the path for a transformation in acute stroke management for patients with an acute LVO.

The dilemma now facing the radiology and stroke community in the UK is how to deliver this service. Stroke medicine/neurology and interventional neuroradiology (INR) units at neuroscience centres will have to expand, and there will, likewise, need to be an expansion and reorganisation in the provision of diagnostic neuroradiology to allow this; how acute stroke services are organised is critical. Realistically, this might involve some degree of centralisation in and around large cities with the construction of robust networks to allow swift patient transfer for those presenting directly to district general hospitals situated further afield.

In metropolitan areas, centralisation of stroke services has led to improved clinical outcomes.[24] Intuitively, triaging patients directly to a centre with an established stroke setup will improve time to recanalisation, and this could translate to diverting all stroke patients within a metropolitan area to comprehensive centres with INR units. Studies consistently demonstrate better patient outcomes in centres with higher numbers of neurological endovascular procedures[25,26]; however, for populations served by large district general hospitals situated further from INR units, a hub and spoke model with "drip and ship" philosophy employed could best fit.[27] Patients presenting to their local emergency department could be diagnosed, commence IV tPA, and be referred to the INR unit. Several studies have demonstrated comparable outcomes of patients transferred through "drip and ship" to those presenting directly to comprehensive centres.[28,29] Prompt, confident radiological diagnosis is essential, which could impact on provision of radiology services and radiological

Table 1
Summary of the recent endovascular acute stroke trials

RCT	Inclusion criteria: CTA occluded vessels	Imaging exclusion criteria: infarct core and collaterals	Maximum time from symptom onset to initiation of recanalisation (hours)	Functional independence at 90 days (Rankin score 0–2). % (*n*)		Absolute benefit %	p-value/adjusted odds ratio/risk ratio
				EVT plus tPA	tPA only		
MR CLEAN[19]	Distal ICA M1 M2 A1 A2	No criteria	6	32.6 (76/244)	19.1 (51/267)	13.5	Adj OR=2.16
ESCAPE[20]	ICA M1 M2	NCCT AS <6 <50% pial collaterals	12	53 (87/164)	29.3 (43/147)	23.7	Adj OR=1.7 p<0.001
EXTEND-IA[21]	ICA M1 M2	RAPID CT perfusion software Core: <30% cerebral blood flow Penumbra: TMax >6 seconds	6	71 (25/35)	40 (14/35)	31	Adj OR=4.2 p=0.01
SWIFT-PRIME[22]	ICA M1	NCCT AS < 6 MRI DWI AS < 6 > 1/3 MCA territory involved	6	60 (59/98)	35 (33/93)	25	RR=1.7 p <0.001
REVASCAT[23]	ICA M1	NCCT AS < 7 MRI DWI < 6	8	43.7 (45/103)	28.2 (29/103)	15.5	Adj OR=2.1

ICA, internal carotid artery; NCCT, non-contrast computed tomography; MRI DWI, magnetic resonance imaging with diffusion-weighted imaging; AS, ASPECTS score; EVT, endovascular therapy.