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Case Reports

Computed Tomography Perfusion Imaging in the Selection of Acute Stroke Patients to Undergo Emergent Carotid Endarterectomy

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Severe acute stroke patients with critical carotid stenosis or occlusion without intracranial thrombus typically do not undergo emergent carotid thromboendarterectomy (CEA) because of the risk of reperfusion-related intracranial hemorrhage. Past studies have not consistently demonstrated benefit of early operative intervention. Cerebral computed tomography (CT), cervical and cerebral CT angiography (CTA), and cerebral CT perfusion (CTP) imaging may identify a subset of acute stroke patients without intracranial thrombus who may benefit from emergent CEA. Acute stroke patients underwent unenhanced brain CT imaging to exclude pathology that would contraindicate emergent therapy. Emergent CTAs of the intracranial and extracranial vessels were utilized to identify patients who presented with stroke symptoms based on the presence of isolated extracranial carotid disease in the absence of intracranial thromboembolism. CTP was then used to assess the extent of potentially reversible cerebral ischemia (penumbral tissue). Patients with isolated extracranial carotid lesions with significant reversible ischemia in the absence of large areas of irreversible cerebral damage underwent emergent CEA to salvage ischemic penumbra. In 1 year, 3 patients presented with large acute strokes in which CTA disclosed symptomatic extracranial internal carotid artery preocclusive or occlusive lesions without intracranial thromboembolic occlusions. CTP indicated a large area of ischemic penumbra with limited permanent injury. Mean age, time to presentation, and National Institutes of Health stroke score (NIHSS) were 66 years, 4.2 hr, and 19.3. All patients underwent emergent CEA with cervical carotid thrombectomy. Average time from stroke symptom onset to revascularization was 12.5 (range 5.9–19.0) hr. There were no perioperative deaths. At day 5, the mean NIHSS decreased to 7.6 and at day 30 was 4.7. The modified Rankin scale score dropped from a post-stroke, preoperative level of 5 to 2.3 by day 30. Emergent CEA should be considered in patients presenting with large acute strokes based on favorable CT, CTA, and CTP findings. Emergent clot localization and physiological assessment of brain "tissue at risk" relative to irreversible cerebral infarction using CT, CTA, and CTP is now available. Utilization of this information by an experienced stroke team of neurologists, radiologists, and surgeons may aid in the recognition of a select group of patients in which emergent CEA may drive to improved outcomes.

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INTRODUCTION

Acute extracranial carotid occlusions have traditionally been managed nonoperatively, as early series have documented a lack of statistically significant clinical improvement and high rates of hemorrhagic transformation and death. Pooled analysis from published operative series from 1980 to 2008 reported absolute risks of stroke and death after urgent carotid thromboendarterectomy (CEA) was high in patients with stroke-in-evolution (20.2%, 95% confidence interval [CI]: 12.0−28.4).[1] Similarly, multivariate logistic regression modeling of 2714 patients undergoing 3092 primary CEAs between 2003 and 2007 demonstrating emergency CEAs were associated with increased postoperative stroke or death (odds ratio 7.0, 95% CI: 1.8−26.9; $P = .004$).[2] Historically, some authors have proposed a role for emergent CEA, but have not been able to differentiate which patients would benefit most from intervention.[3] Poor outcomes in early series have likely resulted from the inability to discern which patients had concurrent large intracranial thromboemboli and large volume cerebral infarction, rather than ischemic, potentially reversible, ''penumbral'' tissue. Neurointerventional therapy for hyperacute stroke was ushered in by Food and Drug Administration clearance of the Mechanical Embolus Removal (MERCI) device in 2004[4] and has been aided by computed tomography angiography (CTA) for lesion localization and CT perfusion imaging (CTP) for penumbral pattern recognition. Despite the publication of negative clinical trials utilizing early generation thrombectomy devices and limited neuroimaging selection criteria,[5,6] neurointerventional treatment for hyperacute stroke has become increasing accepted at many major medical centers throughout the world. The adoption of this technology was driven by the results of numerous studies showing statistically significant improvement in morbidity and mortality in patients undergoing successfully endovascular thrombectomy for intracranial occlusions.[7−13] Recent clinical trials with third-generation devices (SOLITAIRE and TREVO stentrievers) demonstrate good clinical outcomes in over 50% of patients and low symptomatic intracranial hemorrhage (ICH) rates.[11−13] Approximately 10% of hyperacute stroke patients undergoing neurointervention in these series have required combined carotid angioplasty, with or without stenting, and intracranial thrombectomy for tandem extracranial and intracranial disease with excellent clinical outcomes. In some centers, particularly located in the ''Stroke Belt'' of the United States, the incidence of tandem occlusions is as high as approximately 30% of large hemispheric strokes.[8] There is now extensive focus in emergency departments (EDs) on rapid neurologic examination and cerebrovascular imaging to determine which acute stroke patients are candidates for neurointerventional therapy. In this context, a small subset of patients with large, potentially reversible, acute stroke syndromes because of isolated extracranial internal carotid artery (ICA) disease are being identified at the time of presentation to the ED. Given the complexity of some of these extracranial carotid lesions, making them poor candidates for emergent carotid artery stenting (CAS), and the absence of simultaneous intracranial occlusions, emergent carotid endarterectomy (CEA) may be the favored therapeutic approach. Even if the carotid lesion is amenable to CAS, the increased risk of secondary hemorrhage by starting aggressive antiplatelet therapy, typically done after CAS, may make CEA the preferred treatment option in some patients. Thus, the role of revascularization in hyperacute stroke patients with extracranial cervical carotid occlusions and profound neurologic deficits is being revisited.

METHODS

In all patients, imaging was performed on a 64-slice helical CT scanner. Unenhanced CT was initially performed followed by CT perfusion acquisition with 5-mm thin slices during intravenous injection of 50 cc iohexol (350 mgI/mL). CT angiography was performed with 0.5−0.625 mm thin slices during intravenous injection of 100 cc iohexol (350 mgI/mL). Perfusion maps were then calculated using software from Vital Images (Minnetonka, MN). Mean transit time (MTT) prolongation was considered significant if ipsilateral/contralateral ratio was greater than 1.5, indicating potential extent of ischemic penumbra. Cerebral blood volume ipsilateral/contralateral ratio less than 0.5 was considered an indication of the extent of the ischemic core. Candidacy for emergent CEA was determined based on review of patient history, severity of neurologic symptoms, analysis of head CT, head and neck CTA, and head CTP imaging, and consensus of best treatment option among the stroke neurologist, interventional neuroradiologist, and vascular surgeon.

CASE SCENARIOS

The results of 3 patients who underwent emergent CEA for large hemispheric strokes are presented below. Patient demographics, times to presentation and intervention, and clinical outcomes are summarized in Table I.