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Clinical Study

Emergency revascularization of acute internal carotid artery occlusion: Follow the spike, it guides you

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ABSTRACT

The present study sought to examine the incidence of the angiographic "spike sign" and to assess its predictive significance for achieving carotid revascularization in 54 patients with acute internal carotid artery (ICA) occlusions that required urgent endovascular revascularization. Clinical and imaging files of consecutive patients with ICA occlusion who were treated in a tertiary care academic medical center from 2011–2015 were retrospectively examined under Institutional Review Board approval with a waiver of the requirement for informed consent. All proximal ICA occlusions were treated by stent-assisted carotid angioplasty, and all distal embolic occlusions were managed with stent-assisted mechanical thrombectomy. The study included 24 patients with acute ICA occlusion (group 1) and 30 patients with tandem ICA-intracranial occlusions (group 2). The spike sign was seen in 16/24 patients in group 1 (67%), and successful ICA revascularization was achieved in 14/16 (88%). The sign was seen in 26/30 patients in group 2 (87%), and ICA revascularization was successful in all 26 (100%). The remaining 12 patients had no spike sign, and ICA revascularization was successful in only 7/12 (58%). The spike sign is a transient finding that represents the proximal patent remnant of the stenotic corridor in fresh clot. Acute ICA occlusion frequently leaves the spike sign as a marker of the recent thrombotic event. The spike vertex points to the "path of least resistance" for the guidewire to cross the occlusion and engage the true arterial lumen, a critical step during ICA endovascular revascularization.

1. Introduction

Acute occlusion of the extracranial internal carotid artery (ICA) occurs due to rupture of a proximal atherosclerotic stenotic plaque. Asymptomatic cases are not infrequent, as most cervical occlusions are preceded by progressive stenosis, which allows time for the development of collateral circulation. These cases are generally managed conservatively; however, when acute or subacute occlusions present with fluctuating symptoms due to hemodynamic insufficiency or with major stroke after associated intracranial major arterial occlusion (tandem extracranial-intracranial occlusion) the need for urgent revascularization is evident [1–3]. In these patients, early restoration of flow in the occluded ICA and concomitant intracranial vessels may improve the symptoms of acute stroke, prevent worsening, and reduce the long-term risk of recurrent stroke [1,3].

From a technical standpoint, revascularization of the extracranial ICA occlusion can be problematic, mainly due to limitations in crossing the atherothrombotic occlusion. In tandem occlusions, this proximal revascularization stage is now considered more challenging than performing intracranial thrombectomy [1,4,5]. At this first stage in managing the proximal ICA revascularization procedure, angiographic identification of the proximal end of the acutely occluded artery is of crucial importance. We have found that the "spike sign", a transient finding that represents the proximal patent remnant of the stenotic corridor, guides the interventionalist through the fresh clot that has complicated the atherosclerotic plaque. This is generally the "path of least resistance" to cross the occluded segment.

The present study sought to examine the incidence of the angiographic "spike sign" in patients with acute ICA occlusions that required urgent endovascular revascularization, and to assess its predictive significance in terms of achieving carotid revascularization.

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2. Material and methods

2.1. Patients

Participants were divided into two groups of consecutive patients who were managed at a single institution, the Hadassah-Hebrew University Medical Center, Israel, from August 2011 to August 2015. Group 1 included patients who presented with symptomatic acute occlusion of the ICA, without major intracranial embolic occlusion; group 2 included patients with acute ICA occlusion and an associated intracranial major vessel occlusion (tandem occlusion of the proximal ICA and middle cerebral artery [MCA] or distal ICA), who presented with major acute ischemic stroke (National Institutes of Health Stroke Scale [NIHSS] >10).

Presenting neurological status (NIHSS and Alberta Program Early CT Score [ASPECTS]), the location(s) and characteristics of acute intracranial occlusions, time from symptom onset to revascularization, technique details, procedure-related complications, and late outcome (modified Rankin Scale score [mRS]), were recorded.

All proximal ICA occlusions in the current series were treated by stent-assisted carotid angioplasty, and all distal embolic occlusions were managed with stent-assisted mechanical thrombectomy (Solitaire, ev3/Covidien, Plymouth, MN, USA; or Preset, Phenox, Bochum, Germany), with or without initial intravenous tissue plasminogen activator (IV-tPA). Patients with ICA stenosis but not complete occlusion, those with ICA dissection, and those managed with other endovascular techniques were excluded from the study. The Medical Center's Institutional Review Board approved this retrospective study with a waiver of the requirement for informed consent.

Acute ICA occlusion/tandem occlusion was demonstrated on admission cranial CT angiography and confirmed by digital subtraction angiography. MRI studies were performed for penumbra evaluation only in selected cases (those with conflicting clinical-neuroradiological findings, unclear stroke onset time) to determine whether there was indication for endovascular revascularization. Strokes were defined as minor, moderate, or severe based on NIHSS of scores 0–4, 5–10, or >10, respectively. The extent of ICA occlusion was described as focal (less than 0.5 cm) or extended (more than 0.5 cm) based on the angiographic appearance of the balloon during the predilation phase of the endovascular procedure.

Upstream thrombosis was defined as absent or present by microangiogram obtained with the microcatheter placed immediately distal to the occlusion, and after common carotid angiography demonstrated external carotid artery (ECA)-to-ICA anastomosis and some degree of ICA siphon backfilling. The degree of ECA-to-ICA anastomosis was graded as 0–2, where 0 = no visualization of ICA siphon after CCA angiogram; 1 = visualization of the siphon, ± faint opacification of ACA/MCA branches; and 2 = visualization of ICA siphon and clear supply to ACA/MCA. The severity of siphon backfilling was graded as + or ++, where + indicates that the siphon was seen only after the origin of the ophthalmic artery, and ++ indicates that backfilling allowed visualization of the ICA below the level of ophthalmic artery origin.

Carotid revascularization was considered adequate if postangioplasty residual stenosis was <30%. Patients were followed up clinically by senior vascular neurologists and with Doppler ultrasound at 1, 3, and 13 months after the intervention.

2.2. The spike sign

The spike sign was defined as the angiographically visible remnant of the proximal end of the carotid stenosis. This focal finding may present as any one of several different configurations depending on carotid plaque morphology, occlusion pattern, and latency of the acute occlusion to angiography. The most frequent spike patterns observed were a hair-like, caudally-based triangular stump, or a round stump. The spike sign was sometimes subtle and sometimes clearly depicted, and was seen at the proximal ICA occlusion on early or delayed angiography (Fig. 1). It was considered absent only when it was not detected in the course of evaluating the ICA occlusion in at least three different, clearly seen views. Special care was paid to avoid confusing the longer, irregularly shaped tract images that are classic of partial recanalization of thrombotic segments or the origins of early ECA branches for an ICA spike.

2.3. Endovascular technique

Endovascular procedures were performed in the first 96 hours after symptom onset in the first group of patients, and within 8 hours of symptom onset in those who presented to the Emergency Department with NIHSS score >10 with no cerebral hemorrhage and with no clear sign of early cerebral infarction involving more than one-third of the endangered territory.

In cases where the endovascular procedure was performed under general anesthesia, a single dose of 2500 units of intravenous heparin was given immediately after achieving femoral access. Diagnostic angiography was performed to confirm the occlusion pattern and collateral supply. Immediately after angiographic confirmation of ICA occlusion and the need for stent implant, patients who were not on antiplatelet therapy received 300 mg aspirin per nasogastric tube.

2.4. Revascularization of the proximal ICA occlusion

A 90 cm 8 French guiding catheter (Guider Softip; Boston Scientific, Natick, MA, USA) was placed at the distal common carotid artery ipsilateral to the occluded ICA. When the spike sign was identified, its vertex became the precise target for crossing the ICA occlusion with the tip of either a Transcend or a Synchro 0.014 inch microguidewire (Boston Scientific) and with the aid of an SL-10 or Rebar 18 microcatheter (eV3/Covidien). The Transcend SL-10 was used preferentially on harder plaques. In unusual cases, a stiff 0.035 inch wire was used to cross the lesion. Angiography was performed through the microcatheter to assess ICA status. Predilation of the cervical occlusion and beyond was performed repeatedly using 3.0–3.5 $\times$ 30 mm balloons. A closed-cell carotid stent (Wallstent; Boston Scientific/Target) was placed across the stenosis. In selected cases, conservative post-dilation was performed with a 4.0–4.5 $\times$ 20 mm balloon. During the last years, we stopped using cerebral protection devices for ICA occlusion angioplasty; however, this decision was dependent on the preference of the interventionalist in a specific case.

2.5. Revascularization of the distal occlusion in cases of tandem occlusion

After proximal ICA revascularization was achieved, carotid angiography was performed to assess the degree of recanalization and determine the precise location and extent of the distal occlusion. The guiding catheter was advanced through the implanted stent with the aid of single or double guidewires, or a coaxial catheter, with the catheter tip placed beyond the distal end of the stent. The guiding catheter thus caused subocclusion of the suboptimally expanded stent (the main rationale for conservative post-dilation), allowing a more effective proximal aspiration despite the fact that the guiding catheter was not balloon-tipped. This prevents stent-retriever entrapment in the implanted stent. The guiding catheter was placed distal to the carotid Wallstent,