Extracranial-to-Intracranial Bypass for Pressor Dependent Cerebrovascular Insufficiency: Case Report and Modified Classification

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Introduction:
There exists a population of acute ischemic stroke patients who have blood pressure dependent neurological deficits, but due to transient improvements in their symptoms, they may present outside the accepted treatment windows for chemical or endovascular revascularization therapies. Some have an identifiable pharmacologically supported blood pressure threshold over which neuronal activity can commence and neurological deficits resolve. This clinical scenario of pressor-dependent cerebrovascular insufficiency (PD-CVI) is a physiologic demonstration of eloquent penumbra teetering on the fence of cerebral function, for which another opportunity of cerebral revascularization exists to prevent infarction.

We have come to understand that timely revascularization of penumbra should be our goal for therapies in acute ischemic stroke. In patients with large vessel occlusions, this is best accomplished via endovascular mechanical thrombectomy. Less commonly, patients may present without endovascular access and may require emergent microsurgical cerebrovascular bypass, which has been reported in the literature.

We present a case of PD-CVI with tandem middle cerebral artery (MCA) and cervical internal carotid artery (ICA) occlusions who underwent a superficial temporal artery-to-middle cerebral artery bypass that we feel was indicated after the identification of a large penumbra with a small ischemic core infarct and lack of endovascular access. We attempt to refine the existing classification of cerebrovascular insufficiency to allow clearer communication of differing severities of cerebrovascular insufficiency cases and foster their continued study.
Case Presentation:

A 61 year-old right-handed female presented to our emergency department with three days of headaches and one day of left face and arm weakness and lethargy. Her initial neurological examination was significant for a left facial droop, left arm strength 3/5, and left leg strength 4-/5. Her medical history included hypertension on amlodipine, clonidine, and hydrochlorothiazide, hyperlipidemia on atorvastatin, type 2 diabetes on liraglutide (hemoglobin A1C 6.9% on admission), and coronary artery disease with three coronary stents placed 13 years ago. She was not on antiplatelet therapy because of gastrointestinal intolerance. She quit smoking 12 years prior.

Both computed tomography (CT) and Computed tomography angiography (CTA) were initially obtained and indicated basal ganglia infarction and large vessel occlusion, respectively (Figure 1). Outside the intravenous thrombolytic window, having presented 16 hours from ictus, she was admitted to the neurological intensive care unit for supportive care. She was started on 325 mg of aspirin and 75mg of clopidogrel. Magnetic Resonance Imaging (MRI) then confirmed a lenticulostriate infarct (Figure 1).
Figure 1: Initial neurovascular imaging. Non contrast head CT demonstrating right basal ganglia hypodensity (A) and trace high convexity subarachnoid blood (B). CTA three-dimensional circle of Willis reconstruction demonstrating right MCA occlusion (C) and right carotid rotational reconstruction demonstrating right ICA occlusion (D). MRI brain demonstrating right basal ganglia infarction (E). CT perfusion demonstrating right MCA cortical distribution increased mean transit time (F), slightly decreased blood flow (G), and symmetric blood volume (H).
Her blood pressure on admission was 183/87 mmHg. 12 hours after admission, her systolic blood pressure (SBP) began to normalize to 110-120 mmHg after administering her home anti-hypertensive medications. Her left arm weakness worsened to less than antigravity and she became drowsy. Intravenous phenylephrine was administered through a central venous catheter titrated between 0.5-1.0 mg/kg/min with a goal SBP of 160-180 mmHg. With this induced hypertension, her weakness improved to only a trace pronator drift and she was more alert. Continued observation demonstrated significant lability in her neurological examination directly correlated to her blood pressure, with an apparent SBP threshold of 160 mmHg.

Given the blood pressure dependent neurological examination, evident penumbra, and lack of endovascular access due to the ICA occlusion, she was taken for a right superficial temporal artery to middle cerebral artery bypass after thirteen hours of pharmacologically induced hypertension. Careful attention was taken to maintain the SBP of 160 mmHg during anesthesia induction and throughout the surgery. She tolerated the surgery well. Post-operatively she had improved motor function and required no blood pressure augmentation. The patient was discharged home on post-operative day five.
Three weeks post-operatively, she had complete resolution of her left arm and face weakness and was without a pronator drift. CTA at that time demonstrated recanalization of the MCA with persistent ICA occlusion and a patent bypass graft (Figure 2).

Figure 2: CTA three-dimensional reconstruction of the EC-IC bypass site
Discussion:

There is a unique population of acute ischemic stroke patients with large vessel occlusion and large penumbra volume who do not have endovascular access for revascularization. Generally, the time window to revascularize patients extends to 24 hours if they retain a small ischemic core. However, in patients with PD-CVI, the time window to intervene can be expanded indefinitely, as long as progression to irreversible ischemic injury can be temporized with hypertensive therapy. We suggest that EC-IC bypass should be a consideration in patients with PD-CVI who do not have endovascular access, but have a prolonged time window to allow for microsurgical revascularization.

PD-CVI is an uncommon, although potentially under recognized condition, that offers the possibility to recover ischemic penumbra if timely identified and revascularized. When due to large vessel occlusion without endovascular access, EC-IC bypass should be considered, with specific attention to perioperative blood pressure maintenance above the patient’s predefined SBP threshold.
Highlights:

1. Patients with PD-CVI require an elevated blood pressure to preserve neurological function.

2. EC-IC Bypass can be considered in treating PD-CVI with large penumbra and no endovascular access.

3. Threshold SBP must be maintained perioperatively in EC-IC Bypass for PD-CVI.

4. EC-IC Bypass can normalize PD-CVI and resolve pressor dependence postoperatively.