Upper Extremity Revascularization Proximal to the Wrist

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Upper extremity revascularization is performed most commonly for repair of traumatic or iatrogenic injuries, treatment of embolic distal occlusive disease, or treatment of proximal atherosclerotic disease. Goals of revascularization of the upper extremity include prevention of digit or limb loss and optimal long-term function. Severe occlusive disease of the great vessels is frequently best addressed by a direct approach and reconstruction via sternotomy. Alternatively, many if not most, such problems may be effectively addressed from an extrathoracic approach, and for disease isolated to the proximal subclavian artery this has become the surgical option of choice for most such patients.

Extrathoracic revascularizations of the subclavian or axillary artery is usually based on the ipsilateral carotid artery. The carotid subclavian bypass as originally described by Lyons and Galbraith and popularized by Diethrich et al. has become the preferential method of reconstruction of the occluded proximal subclavian artery. These procedures are generally performed only on patients with symptoms of arm pain with exercise or severe hand or digit ischemia. The vast majority of patients with subclavian artery occlusion do not experience upper extremity symptoms due to the development of collateral flow including subclavian steal via retrograde blood flow in the ipsilateral vertebral artery. The subclavian steal syndrome itself is usually well tolerated, depending on the status of the contralateral vertebral artery, the basilar artery, the sufficiency of carotid artery flow, and the status of the circle of Willis.

Alternative procedures for extrathoracic upper extremity revascularization include the axilloaxillary bypass and the carotidaxillary bypass with externally supported graft material (either PTFE or Dacron). Axillo-axillary bypass has the advantage of being easy and quick. Exposure may be obtained using local anesthesia. Long-term patency has been reported as good by many other investigators. However, this procedure is probably best suited to symptomatic treatment of subclavian or coronary steal syndrome (as defined as angina experienced in patients with internal mammary artery coronary bypass grafts) as opposed to upper extremity revascularization. These patients are, in general, more ill and debilitated than patients with upper extremity ischemic symptoms. The down side of axilloaxillary bypass is the superficial position of the graft and risk of overlying skin erosion, possible graft injury via subsequent sternotomy, and potential failure to prevent embolization when there is a proximal ulcerative lesion in the subclavian artery. Other investigators have reported inferior results of axilloaxillary bypass in comparison to carotid-subclavian bypass or subclavian-carotid transposition. Because of the perceived inferiority of axilloaxillary bypass, direct innominate reconstruction is usually preferable to axilloaxillary bypass in the setting of severe, symptomatic innominate occlusive disease despite the higher anticipated complication rate of exposure via median sternotomy.

Exposure of the axillary artery for subclavian bypass via a carotid inflow approach is also thought to be an inferior alternative to carotid-subclavian bypass or subclavian-carotid transposition. Graft tunneling to the axillary artery is accomplished below the clavicle. Although risk of injury to the phrenic...
nerve may be minimized by this approach,\textsuperscript{4} potential brachial plexus injuries may result. Graft tunneling beneath the clavicle may predispose to failure as compression occurs between the clavicle and first rib, although the use of externally supported graft material may minimize this problem.\textsuperscript{4} Owens and associates reported diminished graft patency rates for axilloaxillary or carotid-axillary bypass when directly compared to supraclavicular revascularization procedures.\textsuperscript{10}

In our own practice, we prefer extrathoracic subclavian revascularization procedures performed above the clavicle. Exposure of the carotid and subclavian arteries can generally be achieved via a single transverse cervical incision placed directly above the clavicle. Optimal exposure is achieved via division of the sternal head of the sternocleidomastoid muscle (Fig. 1). The anterior scalene muscle is also divided, care must be taken to avoid injury to the phrenic nerve as it lies along the lateral border of this muscle. Reported rates of phrenic injury during these procedures range to 14\% based on postoperative assessment of ipsilateral diaphragm position and mobility.\textsuperscript{10} Similarly, in the left supraclavicular fossa, injury to the thoracic duct must be avoided or promptly repaired. Lymphatic fistulas or extrapleural lymph collections may result requiring reoperation and ligation or repair. Injury to the thoracic duct is likely due to its location within the scalene fat pad.

Fig. 1. A Carotid-subclavian bypass performed with a prosthetic graft through a single supraclavicular incision. The clavicular head of the sternocleidomastoid muscle, and the anterior scalene muscle are divided for exposure. The subclavian anastomosis is usually performed distal to the internal mammary and vertebral arteries. The internal jugular vein is not shown, but the graft usually is tunneled posterior to the vein. The relationships of the great vessels to the bony landmarks are also shown. B When the carotid and subclavian arteries are in close proximity, and subclavian disease is orificial, subclavian transposition can be performed as an alternative method of improving subclavian inflow. Superb long-term patency rates have been reported following this procedure. Exposure to the proximal subclavian artery is limited from this approach, however, and care must be taken to control and oversew the vessel well below the level of the clavicle. As with the bypass procedure, care must also be taken to avoid injury to the thoracic duct in the scalene fat pad, and the phrenic nerve as it lies on the lateral edge of the anterior scalene muscle.